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Dear friends,

This is a special commemorative issue of "APOS Trends in Orthodontics" (the Journal of the Asian Pacific Orthodontic Society) for the 10th APOC in Bali, Indonesia.

The Journal's 6th Volume is online, and is available at www.apospublications.com. All archived 28 issues and 227 articles since the inception of the journal (2011) till date (Aug 2016), are available as free PDF downloads.

The Special Issue is a compendium of all Editorials, Expert Corners, Special Features and Critical Reviews published online in the Journal. The Editorial team thanks pioneers from the specialty who have written for the journal and invites contributions for future issues from researchers and clinicians across the world.

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APOS Trends in Orthodontics

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APOS Trends in Orthodontics

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CONTENTS

CONTENTS Contd . . .

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What can my Professional Organization give me?

Readers of our journal are Orthodontists who are members of their respective specialty organizations. Most of the organizations serve to organize conferences, have study groups activities, do voluntary work for the society, print journals, publish newsletters and represent professional groups on international bodies.

What does all of this give to the ordinary member? A question to this effect is often asked. Let's look at this issue a little differently.

The growth of most Professional Organizations needs to be carefully evaluated. Most modest study groups and associations have started by meeting up at the member's offices, or clubs as a small cohesive group. Today, our orthodontic organizations follow a model where meetings are rotated every year or periodically to different venues. Hotels and convention centers today, due to increased volumes, have replaced the offices/restaurants and clubs as venues. However, have the "goals" that founded these organizations changed?

The classic model of a successful organization would perhaps be the Bombay Orthodontic Study Group. The Bombay Orthodontic Study Group formed in 1965 merged to form the Indian Orthodontic Society with just seven founder members. Today the IOS has more than 5000 (Student + Life) members, is about to organize its Golden Jubilee conference in 2015, runs a successful journal, is an affiliate of the Asian Pacific Orthodontic Society (APOS) and the World Federation of Orthodontists, has more than 25 regional study groups, has hosted an APOC and has members who contribute to the global orthodontic knowledge base. It has a governance structure where, elections are held for almost every position, which is reflective of a culture where more and more people want to be counted and contribute to the running of the organization.

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How and why did this organization grow so successful? Was it playing populist cards, harboring on seniority making decisions, giving sops to its members who form an electorate or was the "goal" different?

The primary goal of all Orthodontic bodies always has been to provide a forum for scientific fraternal interactions. They did start out being a small group of likeminded professionals who desired to discuss practice management issues, clinical protocols, get peer help in preparing for Board Certifications, or find collective solutions to problems associated with specific clinical scenarios. As national organizations look at larger events, study groups or local city/province bodies still provide a platform for CE, Clinical Pearl Presentation and interaction that can provide a forum for group clinical problem solving. It increases peer interaction and fraternal bonhomie is another advantage altogether.

Then why is it that while some bodies have grown on to becoming successful organizations, others have withered along the way. When organizations struggle to get members to attend its meetings and then slowly stop having them, leading to a silent death of the professional body, what could be the cause?

As discussed, most study groups or organizations build their foundations on scientific exchange, guided in place by progressive leadership who envision the future. When regulators who only aim to adorn positions and reward anything other than meritocracy, rule the roost, degenerative changes occur in the organization. Ayn Rand in "Atlas Shrugged, 1957, beautifully describes this phenomenon. "When you see that in order to produce, you need to obtain permission from men who produce nothing – You may know that your society is doomed."

Most professional bodies or study groups that have grown from strength to strength, despite modest beginnings have done so because of lofty ideals, focused leadership and commitment towards their core vision and "goals." Being focused on original goals, despite an increase in strength is critical to any group/organization's vibrancy. For us, the core ingredient of all professional interactions will always be scientific and small groups as well as large organizations that progress; will only do so,

when this tenet is adhered to. As Bryce Lee, Secretary General: APOS, most aptly puts it "The road to our goal is less important so long as we all have the same goal in mind".

APOS has made an effort for its member organizations, by providing a world-class journal that disseminates peer-reviewed information without any commercial agenda to it. This is its second scientific effort, after the Asian Pacific Orthodontic Congress that it hosts every 2 years; showcasing the best scientific activity the region has to offer.

Being an Association of Associations, what motivates individuals who offer voluntary services to this organization? Fraternal brotherhood, a sense of belonging to the region or the organization, a desire to provide the best possible environment for international scientific interactions, or something else!

The journal and conferences are growing in stature due to the unstinted efforts of people, who didn't ask "what's in it for me?"

For professionals, who still contemplate whether it's really worth their time updating records, publishing one's clinical or research information, share know-how with colleagues, spend a weekend attending CE events or do voluntary work for professional bodies, an interesting quote from a very senior orthodontist should provide some insight on this issue. "There have been times when I've felt whether it's really worth getting my slides ready for CE events, or organizing them is worth my time, but then the take home from all these events, the new ideas and techniques from other colleagues that helps me become a better professional and a better clinician, is all worth the effort".

Professional Organizations follow a simple principle of "what goes around comes around." Be it leadership, voluntary work or scientific activity; remember organizations give us plenty, only if we give them unstinted efforts and commitment, a plenty!

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Yes we can!

A factor that is often underestimated is the value of intersection between science and commerce. Whether it is research grants for academicians, or measures of successes in orthodontic practices, financial sustainability is imperative for the wheel to keep surging.

Orthodontists believe that if they are the best in their area, they will automatically achieve financial success. A lot of us land up very disappointed with this thought process, have high stress levels and are then disillusioned with the profession.

Despite the glitzy outlook for the orthodontic profession, we are, quite often, in the midst of a crisis that greatly affects all practicing orthodontists. We have no clue as to where we are going wrong since we have sparse research-based, well-organized practice data available to us, especially in the Asian Pacific region. Is it the low case starts, decline in total income and profitability, a fear of increasing fee structure or lack of marketing to the general public and colleagues in other disciplines of dentistry? Or, is it just complacency? If we can just spare a little time and think, we will probably agree that it's all. It's time that we take a closer look at these serious issues and realize the significance of having a great control on certain business fundamentals.

To reach the highest levels of orthodontic success, doctors need excellent clinical skills. This is non-negotiable, but a strong business know how is imperative as well. Many entrepreneurs never figure out the key drivers of their businesses and eventually go bankrupt. Though orthodontic practices never file for bankruptcy, they do face challenges that they have little clues about; especially in uncertain economies such as we are facing today.

Failure to understand key drivers, leads to stagnant professional growth. This has serious repercussions not only on the financial comfort of the orthodontist, but also on the quality of service delivered. We are, in developing economies, noticing constant erosion of the Orthodontic Care Delivery, which to a large extent is due to the unsustainable treatment price model (which incidentally is the orthodontist's business solution to fledging practices) and a total lack of understanding of business aspects such as management, corporate governance, human resources management and ethical marketing.

A very important key driver for a region where on an average despite huge population groups and growing economies, orthodontists still have low gross incomes and low case starts compared with the rest of the world is marketing. To keep it as simple as it gets, "marketing creates customers."

For orthodontic practice purpose there are essentially three kinds of marketing strategies: External, internal and referral.

External marketing campaign involving print advertising or local mass-media advertising should have variability and sustainability. It is advisable not to engage in this activity if you can't sustain for up to 6 months at a time. External promotional activities focus on your target audience to visit your practice and opt for your services.

Internal promotional activities are focused on targets in your practice to make them aware of your services and eventually to stimulate them to begin treatment or to refer others to your practice.

The campaign should make new patients and parents feel as if they are actively involved in the treatment process. The entire activity involving brochures, counter displays, posters, follow-up calls, patient surveys (registered patients, those who declined treatment and outgoing), patient newsletters, etc., should translate to higher conversion rates, loyal patients and increased referrals.

Referral marketing is a newer term that has two focus areas: The existing patient database and referring dentists. Conventional marketing, with logos, stationary designs, business cards etc., cannot be the sole determinants of patients choosing orthodontic clinics. Patients will see these aspects of internal marketing only once they step in, but what gets them in?

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Referral marketing is an intense and strategic focus on both patients and referring doctors using multiple strategies to encourage them to refer other people. The truth is that most patients have a limited number of people that they can or will send to your practice. However, when hundreds of patients refer low numbers of other individuals, the results are excellent as cited by a number of professional orthodontic practice surveys. Creating strategic "deliberate relationships" for referral pays great dividends. Unfortunately, referral marketing is also a very esoteric part of marketing not taught in most conventional business schools. A substantial part of practice development strategies should ideally focus on developing professional relations or training office staff to look at this aspect in a dedicated manner.

To guarantee successful practices, a strong referral based marketing program is a must, not an option. In any given locality, practices that consistently and effectively engage in a referral based marketing have proven to be and will continue to be profitability leaders.

The key to choosing a particular marketing activity is to measure its success by tracking each one in terms of responses. Marketing is a highly sophisticated science that will always deliver predictable results, if implemented professionally using the appropriate systems.

We owe it to our teams, our families, to help our practices perform efficiently and effectively in every manner. Every passing day that we refrain from taking steps to strategize referrals, grow and increase profitability, opportunities for growth are lost.

Orthodontic practitioners, educators and administrators (of professional organizations) will probably in the next millennium have to focus on management and marketing education and strategies as the biggest driving force for the progression of both the science and the profession.

If all of us integrate sourcing professional guidance on management matters, sourcing PR information and material to colleagues through professional organizations and include management protocols as a part of Doctoral Orthodontic Education, we would probably be serving our profession in the best possible manner. And together, by influencing thoughts toward the cause, "we can" makes a huge difference!

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Application of evidence in teaching and clinical protocols: Do we still nurture the "ostrich mindset"?

When an ostrich is afraid or perceives an impending danger, it buries its head in the ground assuming that because it cannot see, it cannot be seen. A rather interesting way to avoid problems! Some of us as professionals too, behave like the ostrich. We run away, change the topic or avoid certain people. The "ostrich mentality" is when a person refuses to confront or deal with issues that are facing him/her, whatever they may be.

As orthodontists, we carry information transmitted to us by a process of formal education and reading literature. We are taught to imbibe, but very often, not to analyze. We carry opinions, mindsets, protocols and clinical techniques that have very often never been validated by a scientific process and spend a lifetime assuming they are the "gospel truth." There are large sections of the orthodontic populace, clinicians and academicians who are skeptical of their beliefs and procedures being questioned. This stems from a unique combination of misplaced confidence and diffidence and most importantly, a resistance to change.

During a discussion with a professional colleague, as to what the direction of future research should be, specifically, literature search for a post graduate orthodontic student project, I thought a search on "Clinical trials in Orthodontics" would be a meaningful exercise which would help the student corroborate research with day-to-day clinical questions. Initiating a student into reading about research designs and an in-depth analysis of Evidence Based Protocols (EBPs) is the best way to create the "thinking and analyzing orthodontist of tomorrow," was my point of view. My colleague's answer to this suggestion left me dumbfounded and actually inspired this editorial. The answer was "Evidence and Trials' stuff is good for reading, not writing about. It doesn't give the student any information that they can apply clinically." Though the colleague did agree EBO was good and the need of the hour, integrating it into a teaching programme where a well rounded basic orthodontic overview is taught, is indeed a challenge for Educators.

In the year 2014, should the orthodontic clinician and the academician still be a doubting Thomas to the reality of EBPs? Are we not at the risk of providing our patients care and our students information that cannot be substantiated by a scientific process? From a health care delivery perspective, is a patient safe in the hands of such a clinician? Is a teacher who doesn't stimulate orthodontic analysis beyond clinical steps really doing justice to the tomorrow of orthodontics? The answers to these questions may well have a bearing on the future of our speciality!

The medical profession has designated Evidence Based Practice as a key feature of high quality medicine. The Dental profession is also making strides in the field. The goal ultimately is to improve "patient care based on new research developments." In orthodontics, evidence based care is still in its infancy.

Studies in Medicine comprehensively indicate that most doctors welcome Evidence Based Practices and actually believe it improves patient care. Barriers to the same are cited as lack of time, overwhelming amount of literature and difficulties incorporating evidence into practice. In dentistry, when Swedish[1] and Malaysian[2] dentists were asked to express barriers, the additional reasons mentioned were lack of knowledge about evidence based practices and financial constraints. In a survey of orthodontists,[3] it was found that awareness of the Cochrane database was low and understanding of evidence based terminology was also poor. Most of the orthodontists, even today, rely on eloquence based experts or a colleague's advice, when faced with a clinical uncertainty, rather than follow an EBP to change their practice philosophy. Orthodontic

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literature being conflicting and ambiguous is another barrier, often cited by the ones who want to, but don't use EBP. This can be addressed by initiating programs and continuing education that will help with skill sets to have an in-depth understanding of the knowledge base available to us.

Less than a third of orthodontists today understand or can explain the meaning of a systemic review, a meta-analysis, prospective trials, cohorts, odds ratio, sample power, confidence intervals, specificity, null hypothesis, to name a few. Probably less than 10% can explain what PICO means. In light of this reality, when we can't analyze what we are reading or teaching, would not reading, analyzing and writing about EBP, Research Protocols or Clinical Trials augment a better future for a well-trained and molded orthodontist of the 21st century? To a question that often surfaces when asked about whether a research or a literature search project should even be a part of a Masters' program that is training students for being clinicians and practitioners, my answer is simple. Research Methodology, Basic Biostatistics and EBPs are to a clinical science what "grammar is to a language." You might not surface it every day, but you still unknowingly need to understand and apply it well, if you need to use the language! For the academician who is training orthodontists, incorporating Evidence and Research Protocols is non-negotiable if we are to train young minds that never need to hide themselves in the sand or face conceptual ignorance, but soar and conquer horizons that are still unseen by our science!

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Orthodontics in the "Conceptual Age" from left to the right: A future that promises to be bright!

Orthodontics is interestingly juxtaposed globally! Practices are yearning for growth and orthodontic education is looking at reinventing itself to face the times. Professional bodies are also desirous of their leadership to address issues facing the specialty. We've been doing things the way they ought to be done, incorporating technological advancements in our protocols, but what is that "thing" that we need to understand, to provide a new direction to 21st century orthodontics? Are we as professionals immune to global concepts that govern success in the work sphere? Does our education and continuing education really imbibe from global trends in arenas other than orthodontics? This editorial attempts to look at one such phenomenon.

In 2005 Daniel Pink wrote his book "A Whole New Mind," where he introduces the term "The Conceptual Age" to readers. The conceptual age is the new era of work where current economic demand calls for workers who are skilled in areas guided by the right hemisphere of the brain. The 18th century has been described as the agricultural age; the 19th century, the industrial age; the 20th century, the information age and the 21st century, "The Conceptual Age". The knowledge worker has given way to this age. The conceptual age has high concepts and high touch as their primary elements. High concept includes the capability to detect patterns and opportunities, create artistic and emotional beauty, craft a satisfying narrative and combine seemingly unrelated ideas into something new.

High touch involves the ability to empathize with others, understand the subtleties of human interaction and find joy in oneself and to elicit it in others and stretch beyond the quotidian in pursuit of purpose and meaning.

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There are six fundamental human abilities that everyone can master to assist them with professional success and personal fulfillment and are described as design, story, symphony, empathy, play and meaning.

Those who have studied brain functions know that the left side of the brain is in control of the sequential, logical/rational and analytical. The right side of the brain is in control of the nonlinear, intuitive and holistic. These and other right-brain activities (inventiveness, empathy, joyfulness and meaning) are needed in the conceptual age. Though the right side of the brain is in prominence in the conceptual age, the left side of the brain is not forgotten. They work together (whole brain concept) with the left side of the brain providing the details while the right side of the brain synthesizes the details into a big picture. Putting both the left and right side of the brain together with the six fundamental abilities listed above gets you the following:

- Function (left)/design (right) — beautiful, whimsical and emotionally engaging.
- Argument (left)/story (right) — fashion a compelling narrative to get your point, argument, idea, across; stories amuse while facts illuminate stories divert while facts reveal, stories exist where high concept and high touch intersects.
- Focus (left)/symphony (right) — synthesis, seeing the big picture, crossing boundaries to uncover hidden connections, combining disparate details into a new whole; recognizing patterns and making bold leaps of imagination.
- Logic (left)/empathy (right) — to forge relationships and care for others; it has been proven impossible for computers to reproduce empathy.
- Seriousness (left)/play (right) — we all need to play; people rarely succeed at anything unless they are having fun doing it.
- Accumulation (left)/meaning (right) — purpose, transcendence and spiritual fulfillment; the search for meaning exits in all of us.

Hence, those who say "I am right-brain" or "I am left-brain," should stop and begin thinking of oneself as a

whole-brain individual with a tendency toward one side of the brain. Realigning thought processes is critical for success in the conceptual age.

When we train specialists for success as educators, to administer practices, or lead professional organizations, are we really looking at "The Whole Brain Concept"? The orthodontic world is at a critical inflection point and to compete in tomorrow's global arena, today's orthodontists must demonstrate more than knowledge or technical expertise: They must cultivate new skill sets. This is partly because the amount of new information about any given subject is constantly increasing. Tomorrow's professionals will need to take a creative thinking approach to the sea of knowledge, bridging the gap between analytical left-brain functions and creative right-brain capabilities. Simple ways to integrate these are described below:

1. Strategic imagination refers to "dreaming with purpose." We're so mired in busywork, i.e., finishing bends, bracket positions or submission of dissertation projects on time that our ability to think long-term has waned. The successful orthodontist of tomorrow will have to imagine "Orthodontics in 2025" and then work toward attaining skill sets for the scenario then!
2. The ability to ask smart and often unsettling questions is known as "provocative inquiry." Transformative power lies in asking questions that make us rethink the obvious. In the healthcare industry, for example, it can be seen in the shift from curing illness to preventing it through wellness services. All evidence based practices that question timing and initiation of treatment and its long-term effects in orthodontics are a step in that direction.
3. The quick and obvious strategy will not survive the fierce competition of the conceptual age. Employees will need to continually exercise their creative problem solving skills, the application of best practices from unexpected sources to create fresh solutions. For orthodontics specifically, all research that is looking at "out of the box" solutions to day-to-day clinical issues. i.e., robotic wire bending, computer-aided design computer-aided manufacturing appliances or genetic and molecular research are reflective of this mindset.
4. Keeping pace with change is a challenge, yet meeting unexpected situations with quick thinking and resourcefulness is the very definition of agility. In a world where change is the only constant, a plan B — and C, D and E — is truly critical. Cultivating the mindset of preparedness by creating "Wild Card" scenarios is critical. Planning for success under constraint helps you learn agility and prepare for change before it is forced upon you unexpectedly. The best orthodontic example is the current accent and efforts toward "accelerated orthodontics" or a "demographic analysis" of new practice locations.
5. Building on agility, orthodontists will also need to demonstrate resilience, which translates to the tenacity and courage in the face of obstacles. People who are undaunted will give their professional endeavors a competitive edge in the conceptual age.

The valued leaders and successful professionals of the conceptual age will be firing on all cylinders — and many will involve right-brain functions. To avoid extinction, orthodontists must embody the kind of daily future thinking that will enable their teams and efforts to conceptualize — and handle — the blessings and burdens of a new era!

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Is all well with orthodontic care in the private sector?

While speaking with many colleagues in the Asian Pacific region, reflections often focus on how the profession has changed and how many of those changes have made orthodontic practice more challenging.

Ever-increasing operating costs, increased, and sometimes unreasonable patient expectations and the fear of litigations against orthodontists are some of the common concerns. Many conclude that the "golden age" of orthodontics has passed.[1] I, personally, view these concerns with skepticism; for there is reason to be optimistic about our future and excited about what contemporary practice has to offer our patients in improving their oral health, as well as enhancing our lifestyles.

Armed with modern technologies, orthodontists are better able to respond to patient needs. Cone beam computed tomography radiography, modern self-ligating appliances, advanced diagnostic and treatment concepts, TADs, and soft-tissue lasers have contributed to contemporary orthodontic practice and improved the lives of our patients. Each of these advances brought with it demands for further training, revisions of existing office systems and a reality, that should inspire the 21st century orthodontic patient. From a "quality-of-life perception" standpoint, we are better prepared to understand factors that contribute to patient satisfaction and dissatisfaction today.

We now enter this new era in orthodontics, with greater competition, higher patient expectations, and increased legislative involvement. Fortunately, improved technology (product), ease of stakeholder involvement (people), and adoption of Total Quality Management principles (process), has never been easier. However, it's important to understand challenges that have caused this process to not percolate down to every orthodontic patient who receives care today. Most patients do not receive the choices we'd like them to receive. The two tiers of orthodontic patients in the private sector are defined by demographics, economics, and an orthodontic bias.[2]

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The most popular form of orthodontic care delivery is the "fee for service" or the "free enterprise model" that operates out of an orthodontic office. The other is the "corporate care" model which has defined parameters, is low cost at times; or is sometimes orthodontic care at a dentist's office, and involves a split in the orthodontist-dentist fee. In our regions, this is probably the best example of "managed care." Ask an experienced orthodontist and he or she will vouch vehemently that the traditional or former "fee for service" method is right for the patient and creates the highest quality of care, but of what use is this care, if we can't get the patients through the front door of our practices, a trend that is sadly becoming a reality today?

Orthodontics has stabilized fees, improved efficiency, marketed itself, and controlled overheads. All of this would be fruitless unless we have patients who are not bound by corporate plans or would prefer treatment in their dentist's office, by an orthodontist that the dentist recommends. Trends in orthodontics are not isolated. This phenomenon is occurring in medicine, but we are different. Managed care will ensure us employment opportunities, but surely stunt our growth and innovation!

One thing is certain. And that is that we can't turn a blind eye to this phenomenon. Choices made today will affect the face of orthodontic care in the future. Until "specialty acts" that make specialty dentistry by specialists only, allowing a patient the right to choose their orthodontist and orthodontic care delivery from an orthodontist's office, the concept of the "fee for service" free enterprise orthodontic practitioner could face serious challenges!

Many orthodontists will stay fee-for-service because their economic environment and ability might allow them to do so. My belief in the fact that a lot of orthodontists will probably create such a "value" in orthodontic therapy, coupled with efforts from Professional Bodies will keep this model afloat! However, a lot of our brethren will succumb to "managed care" because that's what their

competitive, social and economic environment will permit. The unfortunate part is that each side will try and impugn the other for damaging orthodontics as a profession. In the midst of change, self-righteousness often raises its ugly head. It probably stems from insecurity.

The only secure way to practice is to improve our relationships with patients; improve total quality care; and focus on techniques that work in contemporary orthodontics to increase the potential patient pool. This, by the way is the greatest "under-utilized asset" of orthodontics.[2]

In the developing economies, even by conservative surveys, we are reaching out to <10% of the population in the private sector, who could benefit from orthodontic care. Most orthodontists who like to flaunt their orthodontic credentials by the number of decades they have put into the profession, think that "fee for service" is their inalienable right and should be made a part of their national constitutions or even be incorporated into the testaments! Of course, all of us would agree that we can deliver the best quality care to our patients in this environment, but that doesn't mean the patient is getting the best value for his/her currency spent!

We live in an environment of free enterprise, and that is the business model that drives economies globally! In this scenario, market forces will fill the void of need.[2] We can censure managed care and its warts all we want; if there were not a need, it wouldn't be around, and most critically, it wouldn't flourish!

"Managed care" is a problem for the future of orthodontics. But the way to confront this phenomenon is to learn from the misfortunes of others, without succumbing to this phenomenon. Industry reports are replete with examples of how "good ideas and quality" wane in the face of "poor management." If we shed our arrogance and critically analyze forces that are changing the orthodontic terrain, and apply ourselves to changes needed, we'll augment the survival of "fee for service model;" if we don't, well Sayonara is probably nearer than we think!

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Excited about the next conference? Five reasons you should be!

In our busy, social media crazy world we often forget the importance of being in a live face-to-face setting with others from the profession. Being active in our profession can bring with it many benefits. There is power in being connected to colleagues, but it can also be easy to talk yourself out of committing to that annual meeting year after year.

Many people think that joining an organization is enough, but to capitalize on the return of your investment, you need to be engaged and participate in professional meetings. Some quarters do think that being around colleagues for what essentially is a self-employed person's profession can be a waste of time, or worse, a chance for others to steal your ideas. However, not everyone in your profession is actually a competitor, as many can be allies and friends. The mindset one chooses about participating in events will eventually impact our results and professional success.

The primary goal of conferences is continuing education. It should be underscored however that traditional scientific conferences set a wide array of goals and that their key strength lies in the widespread interaction and social networking they provide. Technology has yet to overcome the power of eye contact in generating new ideas, thoughts and collaborations.[1]

HERE ARE FIVE REASONS TO ATTEND YOUR NEXT ORTHODONTIC CONFERENCE

Educational opportunities

No matter how experienced you are at orthodontics, everyone can learn. The world knowledge bank is doubling every 3 years, and updating as well as contributing to it is a professional obligation! Working in a practice by oneself, can often be isolating, and without exposure to a variety of points of view, we can miss new ideas and trends that can impact future results. The educational aspect of a conference can expose one to new ways of conducting your practice, and help you discover how to be more productive.

Networking with peers

Conferences provide a great opportunity to network. Often colleagues from other regions of the country/world can become valuable resources for referrals and best practices. Avoiding peers for fear of others discovering your competitive advantage can actually limit your own success. Collaboration is the way to approach networking. While there are those whose intentions can be suspect, most people can help each other uncover ideas and spark inspiration when they get to know each other on a personal level. I for one, have learnt a lot of my orthodontics by peer interaction and continuing education lectures, and vouch for a fact, that just reading the same information would not have been as insightful. A casual statement to this effect by Dr. House, MD from the popular television (TV) series says it all, "Watch more TV, read less"!!! Holistic education has to be beyond published literature!

Encounter new products and suppliers

Too often, people shy away from the trade show exhibit halls at conferences. They fear that they will have to bear the shameless selling by salespeople, but these industry suppliers are some of the best people for you to get to know, if you want to learn more about the current professional climate. Discovering innovative products and services for your practice is necessary to stay competitive in today's fast-paced world. Plus, these vendors who sell to your profession, fully grasp what is happening inside your competition. Invest time with the sponsors at the event and turn them into your friends and allies.

Position yourself as an expert

When you are active in your profession, you can develop a reputation as an expert to your peers, students and patients. Those who are engaged over the long term are often asked to speak at events and to write articles for their professional publications. Like it or not, others like to associate with the experts in any industry. Patients feel

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good about being with those that are celebrated by their peers. If your strategy is to be "the best-kept secret in your professional community," you will be missing a lot of valuable opportunities!

Have fun

Being a successful professional should be rewarding and fun. All work and no play can get you old fast. Conferences can add a layer of enjoyment to managing your career growth by mixing a social aspect into your learning and professional branding efforts. Many events have fun activities such as parties, golf, and tours of the local area where the event is hosted. Taking an extra day at the beginning or end of the trip to explore or visit friends in the region is also a great way to maximize the investment in travel. Never underestimate the power of a little fun mixed with some interesting people!

Many falsely believe that since they can now access industry information via the Internet that the days of the live meeting are gone. The truth is, meetings are more important than ever.

The value in meetings comes from the human-to-human connections that occur. Often people cite the serendipitous "hallway conversations" that they have with other attendees as the most valuable parts of attending an event. While these are not on the agenda, or mentioned in the plenary sessions learning objectives, when two or more people begin to discuss topics on a deeper and personal level, the success of the event to those involved becomes irreplaceable. It is the people that actually bring the "Return on Investment" to your time at a conference!

So friends from the APOS, tighten your seat belts, and brace yourselves for the many one-on-one's that await all of us, later this year in Kuching! See you all there …

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We're going to that next conference! How do we go about networking there?

The last editorial contemplated the benefits of attending professional meetings and the "return on investments" of the time we spend at these meetings.[1] Despite technology and the web that engulfs all of us, human to human connections for the progression of Orthodontics and Orthodontic professionals is a nonnegotiable, even in this era!

That human connection in the world of business and management is referred to as networking. *Networking* is a socioeconomic activity by which groups of like-minded people recognize, create, or act upon professional opportunities, and is critical for growth in any professional endeavor. The benefits from networking in a conference environment include meeting new people who can give you new research or information leads that will open up new possibilities for you, so it pays to keep your mind focused. " Networking is not something you turn off and on. It is the gathering of acquaintances or contacts — the building up or maintaining of informal relationships, especially with people whose friendship could bring advantages such as jobs or professional opportunities. Networking is something every professional must do week in and week out. Successful networking takes "perspective, preparation and practice. Networking at a conference is easier than you think–even if you are shy or don't enjoy participating in networking.

If the big names floor you, and you're feeling intimidated by the experts around, take a deep breath and prepare to realize the opportunity this event presents.[2] This editorial reviews some tried and tested protocols for helping you to make the most of the big thinkers and agenda-setters at a conference while you've got them close.

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START NETWORKING BEFORE YOU EVEN GET TO THE CONFERENCE

It's important to know who your fellow attendees will be and what their specializations, topics of interest, or expertise is. In particular, look up the people who will be presenting at the conference. They are the influencers who can help you get better networked into your area of focus, or who may even be able to share ideas with you or give you a little time to talk through things that you're doing.

Take the time to visit the presenters' websites, if relevant. They should also have E-mail addresses on their websites. If they don't, try to find them on sites like LinkedIn, Facebook or ask common acquaintances.

If you're aiming to network with someone working for a company that sells orthodontic products, also research the company's background and relevant information.

E-mail these influencers to let them know that you look forward to hearing their talks. You're growing a relationship when you recognize someone for the valuable expertise they'll be sharing at the conference. These presenters will appreciate you taking the time, and you'll gain relationship equity with them. They will, most likely, E-mail you back and thank you. Now you can re-email them and let them know you will make sure you introduce yourself, in person, when you see them at the event.

INTRODUCE YOURSELF AT THE EVENT

Attend the talks of those presenters you have E-mailed. Go early and sit in the front row so that you're in a good position to reach them after the talk. Turn off your cell phone if you haven't already done so. Be attentive so that you can raise any particular points with them afterward if the opportunity presents itself. After their presentation, take up a business card with a personalized note you've already written on the back, and start telling them how much you appreciated their insights. This will build even more relationship equity. Introduce yourself, compliment the presenter on their presentation, saying briefly why you liked it, and ask any relevant questions that you have.

Be sure that your business card is up-to-date with the latest details to contact you. If what you do is not clear from the card, be sure to fix that because the presenters will be receiving many cards, and you don't want to be lost in the pile because of ambiguity. Furthermore, be sure to use clean, unbent cards for a professional look.

You can also ask to follow up with a quick phone call later with a question you may have about their presentation. Now you're at the point where you have really created a connection and more likely than not, laid the groundwork for a long-term connection with whom you can develop all kinds of new professional, creative, scientific, or career opportunities.

BE READY TO GET TO THE POINT QUICKLY

Presenters, Opinion Leaders, Traders, and others associated with the conference will generally be time-limited and won't get much of a chance to stand around chatting with you. This is an aspect that often scares novice networkers because they're worried about being tongue-tied. As with giving the business card, it's a really good idea to role-play the kind of conversation openers and content that you'd like to convey with the particular person. Coupled with your prior research into their expertise, you should be able to hone down the precise things that you'd like to get across in a very short period of time.

Make a list of questions you'd like to ask the presenter. Consider picking the most important two questions in case you really are time pressured, so that you get the optimal connection without feeling too flustered.

One-way of getting assurance that your questions are welcome is to preface the conversation with something like: "Have I caught you at a bad time? I had two quick questions I wanted to ask you."

Bear in mind that you might be able to arrange to see them later at a dinner event or similar event during the conference if they're not free straight after their talk. Still aim to give them your business card, but be sure to make time or reason to catch up again during the period of the conference.

If you have promotional material, paper, or any other documentation or software that you'd like the presenter to have, be sure to have it ready and packaged up to give to the presenter. This is a good way of having a reason for more follow-ups too, as you can ask the presenter what they thought of the things you gave them.

LISTEN

Whatever opportunity you get to network directly with the presenter, be sure to listen well. A good networker is a good listener and while you're talking to the presenter, focus on them and their answers to your questions and not on anybody else in the room. Limit your own talking and encourage the presenter to talk. Whatever you do, no matter how excited or enamored of this person's expertise/fame/importance you are, don't jump to conclusions about what they're going to say next and try to fill it in for them. Remain calm and let them do the talking. Stay positive and don't fear pauses. Be considerate of the fact that the conference is probably abuzz with atmosphere and more overwhelming for the presenter than it is for you even.

MAINTAIN EYE CONTACT, NOD, AND UNFOLD YOUR ARMS

Don't be afraid to make notes on your business cards or in your smart phone if there is anything you promise to follow-up. This shows your enthusiasm and willingness to do what you've promised. It also ensures that you won't forget!

LEARN HOW TO EXCUSE YOURSELF GRACEFULLY

There will be times when the presenter doesn't turn out to be the right contact you were hoping to connect with, or you start being clearly aware yourself that the presenter does not appear that interested to talk with you. In this case, excuse yourself politely, thank them for their time, and continue your networking with other members of the conference.

SEE, WHICH OTHER CONFERENCE ATTENDEES SEEM TO BE WITH THE PRESENTER

If the presenter came alone, then this step won't be of help. But if the presenter came with a team and some of them are part of the audience, try to network with them and exchange business cards. Let them know what your research, or study is, and see whether it is possible for them to connect you to the presenter in some way, or even better, find out which other people within the presenter's team are worth connecting with more deeply in terms of exchanging information and ideas.

Remember that those who act as "spheres of influence," while often lower in an institution, or organization, have

just as much importance. They are the people who have time to listen to others and are proud of what they do and are happy to share information to others. These people will network with integrity and can share good information with you and be important contacts too. For example, you might have wanted to discuss something with the professor who just gave the presentation but he's had to rush back to his baby's birth. If his PhD student is attending the conference too, find her and ask her the questions and share your ideas. If she's convinced that you're genuine and someone definitely worth staying in touch with, she'll help remind the professor about you. Just be sure to keep in touch with both her and the professor after the conference.

FOLLOW-UP

If you can, send a relevant article to the topic they shared. This will show that you have an avid interest in the topic and that you're willing to share information with them. Even a similar treated case with records, might help. And if possible, connect the presenter with other relevant people you know personally and share information as generously as you can.

Follow-up with promptness anything that you promised you'd do. If you find for some reason that cannot meet the promise, let the presenter know that there has been a problem and what you intend to do next. Keep the channels of communication flowing; not everyone follow-up after networking and they miss enormous opportunities.

You can stay in touch with the presenter by E-mail and phone. Anything can happen here. It's all about sharing who you are and what skills you offer to the world of work that should start a great conversation around connections and opportunities for all those great influences you meet at conferences.

This editorial and the previous one were intended to reignite the spark that drives professionals like us to meetings, and keep the humaneness of professional interactions alive, something that most successful orthodontists treasure most about their careers when they hang in their boots!

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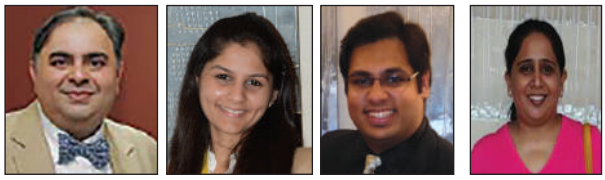
Spot on orthodontics! Pun intended: The impact of white spot lesions on 21st century orthodontics



Enamel decalcification or white spot lesion (WSL) development of the enamel surface is the most important iatrogenic effect of fixed orthodontic appliance therapy.[1] Individuals with malocclusions often have many plaque retention sites due to tooth malpositions. A cause-effect relationship and incidence statistics of WSLs in such individuals sometimes question the very logic of multibanded/bonded fixed appliance therapy. Orthodontic treatment with multibanded appliance imposes a significant risk for development of WSL. Bands and brackets increase the retention of plaque and food on smooth tooth surfaces that encourage the formation of WSLs. Despite intensive efforts to educate patients about effective oral hygiene procedures, enamel demineralization associated with fixed orthodontic appliances remains a significant clinical problem.[2,3] Formation of these spots after the completion of orthodontic treatment can lead to patient dissatisfaction and legal complications.[4] From a holistic care perspective, formation of WSLs is discouraging to a specialty whose goal is to improve aesthetics. The need of the hour is to be proactive and take active responsibility toward prevention of WSLs by educating patients about the importance of maintaining an excellent dietary compliance and oral hygiene regime.

DEFINITION

The term WSL was defined as "the first sign of a caries lesion on enamel that can be detected with the naked eye."[5]

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The WSL has also been defined as a "subsurface enamel porosity from carious demineralization' that presents itself as "a milky white opacity when located on smooth surfaces."[6]

PREVALENCE

Literature reports in this regard irrespective of differences in methodology of data collection are alarming! Orthodontic patients have significantly more WSLs than nonorthodontic patients, and these WSLs may present esthetic problems years after treatment.[3,7] A recent review of literature[8] showed variations ranging from 2% to 97%, for WSL prevalence associated with orthodontic treatment.[3,7,9-13] This high prevalence is attributed to the difficulties in performing oral hygiene procedures on bonded dental arches along with a long-time accumulation and easier retention of bacterial plaque on tooth surfaces around fixed orthodontic appliances.

Depending on the examination technique used, the prevalence of WSLs varies. Gorelick *et al.*,[10] in their study using the visual examination technique, reported that 50% of patients had one or more WSLs at the end of treatment. Boersma *et al.*,[8] using quantitative light fluoroscopy, investigated the prevalence of WSLs at the end of orthodontic treatment and reported that 97% of subjects had one or more lesions.

In the literature, conflicting reports have described the distribution of WSLs. Gorelick *et al.*[10] reported that the tooth most commonly affected was the maxillary lateral incisor. On the other hand, Mizrahi[14] concluded that the maxillary and mandibular first molars were the teeth most commonly affected. In a later study, Ogaard[7] agreed with Mizrahi's conclusions. In contrast, Geiger *et al.*[11] reported that lesions occurred most frequently on maxillary lateral incisors and canines. Tufekci *et al.*,[15] however, found no significant differences among teeth in the distribution of WSLs at 6-month, at 12-month, or on the day of bonding (control).

A more recent study by Boersma[8] found that 40% of the buccal surfaces in males had demineralization compared with 22% in females. One possible explanation for these

results is that females are generally more compliant orthodontic patients.

CLINICAL DETECTION IN ACTIVE TREATMENT

Fixed appliances serve as plaque retention sites and in the absence of good oral hygiene, plaque accumulates and acidogenic bacteria cause marked demineralization. Detecting WSLs during active treatment can be challenging for the clinician. The clinical crown must be free from plaque and debris, and the presence of excess gingival tissue can make visualization of WSLs difficult. A thorough examination of each patient should be done at each appointment, and each patient should receive a customized oral hygiene treatment regimen to halt the progression of any demineralization.

The high prevalence of WSLs at 6-month into active orthodontic treatment suggests that demineralization can quickly become a concern in the presence of fixed appliances when oral hygiene is poor. According to Ogaard *et al*.,[2] these lesions can become noticeable around the brackets within 1-month of bonding. So even patients who otherwise practice good oral hygiene, cannot afford to slacken up between any consecutive appointments. It's critical that orthodontists reiterate this fact to their patients regularly. It's also important for the clinician to recognize inadequate oral hygiene early, so that preventive measures can be implemented before the development of WSLs. Length of treatment is also directly proportional to the causation of the Lesions. The prevalence of WSLs was 38% in a 6-month group, whereas it was 46% in a12-month group as reported by Tüfekçi *et al*.[15]

PREVENTION

White spot lesions are generally considered to be the precursors of frank enamel carious lesions. It is, therefore, necessary to universally promote the need to maintain a high standard of oral hygiene and to reduce daily exposure to refined carbohydrates throughout the treatment period. In addition, the continuous presence of fluoride in both saliva and plaque, even in low concentrations, is necessary for maximum caries inhibition. This would, at first, involve daily exposure to fluoridated water[16,17] (where available) and the use of a fluoride-containing toothpaste.[18] The need to prescribe an additional topical fluoride will be dependent upon the needs of the individual patient and clinical judgment. The performance of currently available fluoride releasing bonding cements[19-22] and elastomeric modules and chains[23,24] makes their use both difficult and impractical. Studies of the effects of casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) have so far shown promising dose-related increases in enamel remineralization within already demineralized enamel lesions.[25-27] The ability of CPP-ACP to prevent WSL formation has not, as yet, been proven. A Recent introduction of a novel technology based on Arginine and an insoluble calcium compound with fluoride in toothpaste does show promise for prevention and early intervention of WSLs.[28,29]

AFTER DEBONDING

If WSLs occur during treatment, it is advisable first to allow the teeth to remineralize naturally. Nearly half of the original lesions would have remineralized after 6-month with no specific additional treatment. Fluoride must not be used in high concentrations because it can arrest remineralization and lead to staining. Low concentrations of fluoride might assist remineralization

If the lesions persist, professional bleaching of the teeth to diminish the contrast between the WSL and the rest of the enamel surface should be considered. Bleaching therapy can camouflage WSLs after removal of orthodontic brackets.[30] If bleaching therapy is used to mask decalcified areas, it must be considered that the microhardness of sound enamel surfaces and demineralized enamel surfaces after bleaching might be reduced.

For severe cases, acid micro abrasion is recommended when the esthetic results after external bleaching therapy are not satisfactory.[31] Finally, aggressive restorative treatment such as a direct or an indirect veneer can be considered if the patient still sees the need for further esthetic improvement when WSLs cannot be totally removed.

WE OUGHT TO CARE!

Debonds are the most exciting time for Orthodontic Patients, Parents, Orthodontists, and Staff. White Spots do detract from the quality of results and bring about disappointments for all of the above and the referring dental professional. Patients are increasingly getting aware of this menace associated with orthodontic therapy and Definitive protocols for their prevention and management are the need of the hour.[32] Appliances that do not affect the labial surfaces, accelerated orthodontics, targeted mechanics are all possible preventive modalities; but none can replace motivational techniques and due diligence during therapy. From a professional excellence standpoint, to motivate orthodontists to pay attention toward the prevention of WSLs, the degree and occurrence of WSLs need to be quantified and evaluated in pre and postorthodontic records, with their absence, also being

a criterion for scoring during evaluation of cases for Examinations and Peer Review Boards.

A concerted effort to focus on the Evaluation, Quantification, Prevention, Identification of Risk Groups and Protocols for treating WSLs is imperative for preventing this "spot on" Orthodontic Care, and also for Orthodontics to be "Spot on"!

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Leadership: A virtue that orthodontic professionals need to posses

Leadership can be defined as a "process of social influence in which one person can enlist the aid and support of others in the accomplishment of a common task."[1]

For example, some understand a leader simply as somebody whom people follow or as somebody who guides or directs others, while others define leadership as "organizing a group of people to achieve a common goal."

Studies of leadership have produced theories involving traits, situational interaction, function, behavior, power, vision and values, charisma, and intelligence, among others. The best corporate entities or governments are driven by a leader's vision. Why would orthodontic departments and practices be any different?

A "vision" implies a clear understanding of what you want to accomplish and where you want your professional endeavors to result in, in a specified period. Orthodontists must have a vision for the future of their practices if they are to grow successfully and prosper. Effective leaders share the practice vision with the team. Explaining the vision helps the staff become active participants in building a practice and achieving all goals.[2]

Running a successful orthodontic practice is about more than just practicing orthodontics. It is about leading a group of people on a journey focused on achieving measurable goals. It is about maximizing talents and teamwork to accomplish something that could not be done individually. Numerous studies in the orthodontic literature have proven this fact explicitly.[3-5] Successful practices are about providing exemplary patient care while attaining increased levels of production and profitability.

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IS LEADERSHIP ABOUT A FORMULA?

When it comes to leadership, there is no one size fits all. Every leader has his/her own personality, style, and approach to leading teams. Having stated that there are leadership truths and myths that seem to be consistent. This editorial will discuss these traits and aim to inspire orthodontic professionals to reassess their thought processes on these principles of leadership.

IS LEADERSHIP ABOUT ALWAYS WORKING "SMART" AND NOT HARD?

The "work smarter" principle is something that all of us will agree with, but the "not harder" part does raise eyebrows. There are definitely ways to be smarter about prioritizing your tasks effectively, planning your day wisely to increase your productivity, and as a leader, to know when and what tasks to delegate.

But every single successful practitioner or academician I have met has always worked very hard on realizing his/her dreams. Great leaders empower their teams to do more; they are very protective of their time. They are shrewd in applying their knowledge and experience in order to move forward and avoid mistakes either they themselves or others made in the past. One could call that "working smart."

But nothing great has ever been achieved without working hard. True leaders lead by example, they are first in and last ones out, they are fully invested in the vision of their ventures and, through showing their dedication, they inspire people around them to show the same kind of commitment and display the same behaviors.

We are living through a period right now where we have a lot of very smart people looking at math, and analytics, and efficiencies, these are all great things to take pride in, but you need to put in the work … Gary Vaynerchuck, an entrepreneur, states it aptly "you can call out all the best business opportunities you want, but the bottom line is that nobody ever got paid to make snow angels." This reminds me of something my dad would tell me as a little boy "don't waste time learning the tricks of the trade, learn the trade!"

"There are no secrets to success. It is the result of preparation, hard work, and learning from failure."

—Colin Powell

IS A LEADER A "KNOW IT ALL?"

A common myth among people is that leaders have all the answers. On the contrary, the best leaders have a clear understanding of their own limitations. They know that success is a team sport, and there is no such thing as a "self-made" man. They realize that it takes a diverse team to innovate truly.

They search for passionate people in diverse areas of expertise and bring them together. Great leaders listen more than they speak. They listen with the goal to understand, not a goal to answer. They hire amazing teams and solicit regular input from team members. They admit their mistakes and empower their people to execute on the office's vision through their own knowledge and initiative versus a dictate from above.

Truly amazing leaders empower others to become leaders. Their higher goal is to work themselves out of the job so that if they are not around, the organization functions just as successfully as when they were in it.

"A leader is best when people barely know he exists, when his work is done, his aim fulfilled, they will say: We did it ourselves."

–Lao Tzu

DO ALL GREAT LEADERS LOVE THE "SPOTLIGHT?"

It is true that if you are a leader of a practice or a department, there is an expectation that you will also be the spokesperson for the enterprise. But the leadership comes in many forms. You do not have to be on the organization's executive team to be a leader. True leaders (whether they are at the helm or not) are humble. They do not much care about the spotlight. They care about the results. And that comes from focus.

Some of the greatest leaders of our time were simple men who shied away from the limelight and yet have transformed professions and taken it to new heights.

In his book Good to Great, Jim Collins says that exceptional leaders channel their ego needs away from themselves and into the larger goal of building a great organization. "It's not that they have no ego or self-interest," says Collins. "Indeed, they are incredibly ambitious – but their ambition is the first and foremost for the institution, not themselves." These amazing leaders, Collins found, "are a study in duality: Modest and willful, humble and fearless." Actually, orthodontic literature is resounding with many such names. The APOS as an organization has had many such OBs in the past.

An Orthodontic Department chair on retirement said, "I never stopped trying to become qualified for the job." This was the humility of a person who has had a distinguished career as a researcher and an academician.

Society often tries to mistake "modesty for weakness." Being out of the spotlight, sometimes helps retain focus and deliver more for leaders.

"It's alright to be Goliath but always act like David."

–Philip Knight

ARE LEADERS ALWAYS "ON THE JOB?"

Even though great leaders work hard, they realize that they need the space to be able to strategize, to think, to create.

"Restore connection is not just for devices," cautions Arianna Huffington. "It is for people too. If we cannot disconnect, we cannot lead." Leaders like Steve Jobs and Bill Gates were known to go away for extended periods of time to reconnect with themselves, their vision, and their ideas.

Leaders need to find that place of wisdom, strength, and real connection (with themselves and others) and they need to lead from that place. Smart leaders also build a culture of creativity through encouraging their employees to take time to reflect. It's imperative to incorporate this trait early enough in our careers.

"Creating a culture of burnout is opposite to creating a culture of sustainable creativity."

–Arianna Huffington

ARE LEADERS "BORN" OR "MADE?"

"The most dangerous leadership myth is that leaders are born – that there is a genetic factor to leadership. This myth asserts that people simply either have certain charismatic qualities or not. That's nonsense; in fact, the opposite is true. Leaders are made rather than born."

–Warren G. Bennis

Leaders are created just like anything else, through hard work. And hard work and training are the price we will have to pay to achieve any goal. Anyone can excel at anything if they truly put their mind to it.

Leadership is a skill, not a genetic disposition. Despite strong predilections, sensitizing ourselves to the need of incorporating "leadership training" to augment our existing domain skills, will go a long way in the way we impact our lives in particular and the profession at large!

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Products, Procedures… or a Pipe Dream? A Reality Check on the Game called "Accelerated Orthodontics"!

A patient of mine who was in treatment with me for close to 17 months had to move to the USA as he was going to go to university there. I did the usual formalities; prepared transfers forms and help him seek an orthodontist in the town he was to study. The transfer went along well. He was very happy with the new orthodontist, and the treatment was cruising along. He did come by to the office, and say the usual hellos while he visited Mumbai on winter and summer breaks. He came last, a couple of weeks ago with a dilemma. There was a 3 mm retraction space in one of the quadrants remaining, and the sophomore now was in a hurry to get rid of his appliances. When he asked his treating therapist about his desire to get this space closed fast, and thus have his braces debonded quicker; he was given two alternatives (each costing a few hundred dollars!).

Option 1 was a device to cause micro (injuries) perforations in the region that would not require patient co-operation, and option 2 was a vibratory device that the patient had to use for a given number of minutes a day. No injections, perforations, pain but compliance. The difference in cost was not something that would influence this patient's choice of modality. He came to me for an opinion on this choice. As a researcher, who has been a part of trials on acceleration; and this topic was a formidable part of what I've been reading upon, in the last few years, I was faced with helping somebody make a clinical choice, where a cost benefit ratio was involved! Phew! I shouldn't have been in office that day. What should have I told him? A versus B or a few other C's, D's and E's?

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It's one thing to collate literature or research findings and make a conclusion. It's quite another to tell a paying patient, "If you agree to spend X no of dollars for a product or a procedure, your treatment time will reduce from 5 to 2 months? Are we there yet on this "acceleration of tooth movement" terrain to make such decisions confidently?

The "acceleration of tooth movement" protocols fall basically under two groups for a clinician:

a. Products: Acceledent, Propel, Low Level Lasers, Electrical Currents etc.
b. Procedures: Corticotomies, Osteotomies, Interseptal Procedures, Piezzo Surgeries, Local Injections, Distraction of Periodontal Ligament (PDL), Surgery First etc.

The 21st century has seen rapid developments in the science of orthodontics where achieving desired results clinically and technically, both effectively and efficiently, matter. This is especially so by using new technologies, like stimulation soft wares that can assist in treatment planning and translational products. In addition, continuous modification of wires and brackets as a result of the biomechanical efficiencies in orthodontics has greatly improved. However, these biomechanical systems may have reached their limit, and there is a need to develop new methods to accelerate teeth movement, today.

Increased treatment times are the most common deterrents that face the profession of orthodontics and cause a reluctance among adults to embrace treatment plus increasing risks of caries, gingival recession, and root resorption.[1]

A number of attempts have been made to create different approaches both preclinically and clinically in order to achieve quicker results, but still there are a lot of uncertainties and unanswered questions toward most of these techniques. Nimeri *et al.*[2] categorize these attempts broadly into biological, physical, biomechanical, and surgical approaches. These attempts though variant in nature, are dependent on the biological variables and factors that initiate inhibition and delayed tooth movement.

Orthodontic tooth movement occurs in the presence of mechanical stimuli sequenced by modeling of the alveolar

bone and PDL. Bone modeling is a process of both bone resorption on the pressure site and bone formation on the tension site.[3] Orthodontic tooth movement can be controlled by the size of the applied force and the biological responses from the PDL.[4] The force applied on the teeth causes changes in the microenvironment around the PDL due to alterations of blood flow, leading to the secretion of different inflammatory mediators such as cytokines, growth factors, neurotransmitters, colony-stimulating factors, and arachidonic acid metabolites. As a result of these secretions, modeling of the bone occurs.[5,6]

THE ACCELERATION TERRAIN

There are three phases of tooth movement: The initial phase, which are characterized by rapid movement after the application of force; followed by a lag period, where little or no movement and the last phase, where gradual or sudden increase of movement occurs.[7]

The early phase of tooth movement involves acute inflammatory responses characterized by leucocytes migrating out of blood capillaries and producing cytokines, which stimulates the excretion of prostaglandins and growth factors.[8] The acute phase is followed by the chronic phase that involves the proliferation of fibroblast, endothelial cells, osteoblasts, and alveolar bone marrow cells remodeling processes.

Biologically, experiments have been done using these molecules exogenously to enhance tooth movement both in animal experiments and humans. Examples of these molecules are prostaglandin E, cytokines that include lymphocytes and monocyte-derived factors, receptor activator of nuclear factor kappa B ligand, and macrophage colony-stimulating factor.[9-11] The effects of cytokines, osteocalcins, prostaglandins, Vitamin D_3, and parathyroid hormone and relaxin have also been evaluated.

Another approach in accelerating tooth movement, that has been evaluated, is by using device-assisted therapy. This technique includes direct electric currents, pulsed electromagnetic field, static magnetic field, resonance vibration, and low-level laser, which was mostly investigated and gave the most promising results.[12]

The concept of using physical approaches came from the idea that applying orthodontic forces causes bone bending (bone bending theory) and bioelectrical potential develops. The concave site will be negatively charged attracting osteoblasts and the convex site will be positively charged attracting osteoclasts as detected by Zengo *et al.*[13] in his measurements on dog alveolar bone.

The bioelectrical potential is created when there is an application of discontinuous forces, which leads to the idea of trying cyclic forces and vibrations. It has been found that applying vibrations for different duration per day accelerated tooth movements between 15% and 30% in animal experiments.

THE CLINICAL TRUTHS

Is there enough information for the clinician out there in the literature to decisively make a call on the method to induce acceleration? Corticotomies are proven beyond doubt to enhance the acceleratory phenomenon but, does the RAP phenomenon induced last the length of treatment. Is it really desirable to perform this procedure routinely? I dare not say "yes" based on the current evidence we have![14]

The challenge for a research design to prove the therapeutic efficacy of a particular method of "acceleration" lies in probably addressing the following areas:

1. A uniform design that studies most of the modalities showing promise in similar circumstances, and over the entire treatment (most studies only study alignment or retraction or distalization etc., which gives us a part of the picture but not the entire one!). Split mouth designs are really not the best replication of a total treatment scenario and need to be assessed with caution.
2. Multi-centric evaluation of a uniform design will be the best method to test the validity.
3. Patient experience and comfort scores and scales will have to be employed for a holistic assessment. For example, if let's say, a class 1 bimax case is treated with conventional mechanics in 20 months, with corticotomy in 15 months, with micro osteo perforations in 16 months and with lasers and vibrations in 17 months in the proposed trial; was the patient experience same and level of discomfort, the same in the all the groups? The amount of costs and discomfort a patient is willing to undergo for faster treatment should also be subject of evaluation.
4. One meaningful goal is to explore and identify new means for enhancing the orthodontist's ability to provide personalized treatment. The leading specialists in this drive are the oncologists, who utilize genetic and genomic investigations of individual patients, in order to be able to choose the right medication for the specific type of cancer of each person. In orthodontics, it would be helpful to identify the genes responsible for bone growth and remodeling, and to expose biomarkers that accurately reflect the degree of involvement of systems such as the nervous, vascular,

immune, and skeletal, in the individual response to orthodontic therapy.

The goal is to include in the diagnosis, details about the molecular genetic background behind processes such as bone metabolism, wound healing, inflammation, and the cellular response to selected stimuli, physical and chemical. Additional tests can be used to examine tissues and cells in the laboratory, to better understand the outcome of the clinical operations, and to be able to predict it with confidence, with each of the proposed modality of acceleration.[15]

5. Studies often use quantitative data to reflect upon evaluations and findings. Qualitatively how the patient finished is very often not evaluated in studies accessing acceleration. "The best way to finish a case fast," something any experienced clinician will tell you, is to "not finish at all." Quicker treatment can be compromised treatment at times! The PAR indices of all treated cases in a given trial should also be the subject of evaluation, as well as the ABO deductions to evaluate the finish.
6. The "icing on any orthodontic cake" is the stability of finished results! Stability of treatment results, treated with any of the "acceleration methods" should be comparable and also be a parameter of evaluation as time goes by, in a prospective manner.

PRODUCTS, PROCEDURES OR...

We get back to the patient we started this editorial with! Do we as a profession have answers to give him?

Confidently, that we can put on a contract, "based on scientific data," that suggesting the use of a particular kind of a procedure or a product will help us finish his treatment in X number of months/days for sure? Product manufacturers will jump on a terrain where demand beckons, and the demand for faster tooth movement is definitely there; but is "science there yet," is a bigger question?

Can current literature give us information we can use in new patient consults tomorrow morning, where by advising an additional procedure or a product, treatment time that is considerably shorter can be promised?

If the answer to any of these questions is "no" then the game has not yet panned out the way it ought to be, yet. There is information to be sought, and truths to be still known, to make shorter but meaningful orthodontics, not just another FAD or a pipe dream!

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Undergraduate orthodontic education: Is there a slip between the cup and the lip?

Orthodontics is the first specialty of dentistry, and it requires no Newtonian hypothesis to understand that, in the 21st century for all specialties of dentistry, interdisciplinary protocols are the mantra for Quality Oral Health Care. The law of dependent origination is one of the most important teachings of the Buddha, and it is also a very profound fundamental principle at work in dependent originations. The sequelae of the principle is that of "cause and effect". This is a realistic way of understanding the universe and is the Buddhist equivalent of Einstein's theory of relativity.[1]

To illustrate the nature of dependent origination of the things around us, let us consider an oil lamp. The flame in an oil lamp burns dependent upon the oil and the wick. When the oil and the wick are present, the flame in an oil lamp burns. If either of these is absent, the flame will cease to burn. This example illustrates the principle of dependent origination with respect to a flame in an oil lamp.

We are witness to flickering lamps in the profession at various levels. Ask a young orthodontic specialist the biggest threat to his/her professional success or what is that one thing that is a roadblock to the growth of the profession, the answer you get more often than not in the Asia Pacific region is "general dentists" practicing orthodontics! Our colleagues imparting weekend courses to them are also the subject for great ire. It's also disappointing that the orthodontic manufacturers whose products have made it easier for general dentists to promote and deliver orthodontic care, are driving the market perception of orthodontic care! The key issue for deliberation here is, are really the products stimulating dentists to provide orthodontic services? Or is the knowledge that these dentists innately have about orthodontics, due to archaic Undergraduate Orthodontic Education protocols, which make them gullible to advertising?

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THE GOALS OF UNDERGRADUATE ORTHODONTIC EDUCATION

Let's answer a question honestly. What do students learn in undergraduate orthodontic education? Practically very little, almost nothing! and theoretically, Concepts that are most often, not contemporary. The real information on the conceptual realities of tooth movement and its possibilities is considered the classified information to be discussed only with residents and specialists. There is no denying that fact that, orthodontics as a specialty, its vastness and time related treatment changes, do pose a challenge for didactic dissemination in an undergraduate setting; but do we really have the intent to teach it? Did we ever, as a specialty have it? The goals of most UG syllabi have been to teach dental students about diagnosing developing malocclusions in growing patients and the appropriate age of referral to an orthodontist. This helps the patient partially and is ideally aimed at helping the orthodontist. Prof. Kokich refers to this phenomenon as "self-serving"![2]

All dependent organizations can never ignore the What's in it for me? (WIIFM) principle for interdependent fellows. Any intelligent and curious professional who has received such an exposure to orthodontics is obviously going to flirt with weekend courses and try a few cases themselves! What should we actually focus on, when we plan a syllabus for undergraduate students? The role orthodontics can play, in helping general dentists, toward achieving ideal results for comprehensive dental restorative cases.

This will probably get them into the WIIFM Zone and benefit the orthodontist, the general dentist and the patient population, at large!

THE PROBLEM COMPOUNDED!

When residents of mine(the co-authors), said they wanted to carry out a small survey for presenting at a general dental interdisciplinary convention at the school, I suggested we

track referrals of patients checking into the institutions Out Patient Department.[3] The aim of the exercise was to assess and evaluate orthodontic treatment needs in adult patients visiting general dental clinics for concerns other than orthodontics, and the general dentist referral pattern to the Department of Orthodontics.

This prospective clinical study was conducted on 200 randomly selected adult patients (age >18 years). All the patients were subjected to an intra-oral examination by a panel of experienced orthodontists.

After intra-oral examination, these patients were categorized into three groups:

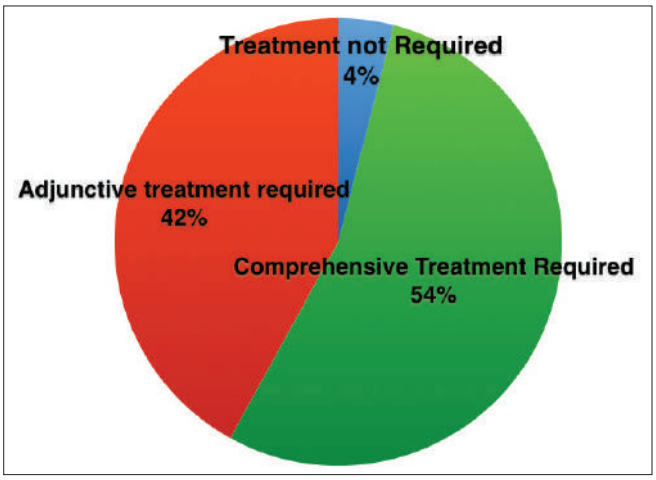

Figure 1: Orthodontic treatment needs of the screened patients as assessed by the orthodontic panel. (4% patients didn't need any treatment, 54% would actually benefit from full bonded comprehensive orthodontics, and 42% patients would benefit from adjunctive orthodontic therapy)

1. Patients not requiring orthodontic treatment
2. Patients requiring comprehensive orthodontic treatment
3. Patients requiring adjunctive orthodontic treatment.

Then the list of treatment recommendations on these patients case files were assessed to see whether any orthodontic opinion was recommended by the general dentist. The general dentist assessing the patients for their chief complaints, and recommending treatment options was unaware of the survey, thus making it a single blinded study attempting to eliminate any biases.

Patients included in the study had to meet the following criteria: They had to be adult patients (age >18 years), have a permanent dentition, their chief complaint did not relate to orthodontics, they approached a general dentist for dental concerns. Patients were excluded if they were: Children and adolescents (age <18 years), were seeking orthodontic treatment, had any history of orthodontic treatment, were totally edentulous, and required emergency dental treatment (presence of swelling, abscess, trauma etc.)

After statistical analysis, we results we got are summarized in Figures 1 and 2.

Orthodontic literature tells us that even when adults are self-motivated to undergo orthodontic therapy, one-half to two-thirds actually rely on their general dentist to provide the necessary referral.[4] Thus, general practitioners do play an integral role in identifying adult patients who might benefit from orthodontic treatment, as well as in arranging orthodontic consultation for patients who have decided on their own to seek treatment. If, as per our survey <20%

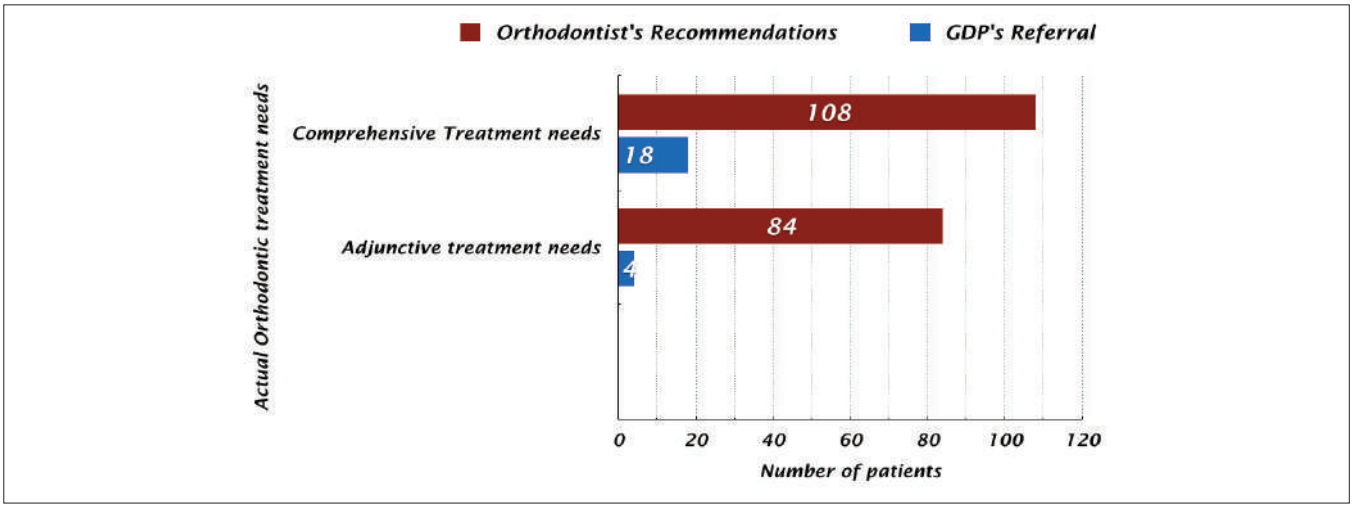

Figure 2: Comparing patient's actually needing orthodontics as per orthodontists recommendation, with treatment recommendations made by general dentists. (Only 16.67% patients [18 patients out of 108] needing comprehensive orthodontics were actually referred for treatment by the general dentists. Only 4.76% patients [4 patients out of 84] needing adjunctive orthodontics were actually referred for treatment by the general dentists)

dentists refer adults needing comprehensive therapy, for it; and <5% for adjunctive therapy to adults who need it, we're looking at a serious problem here!

These are figures from a teaching institution in Asia, where nobody benefits out of not referring a patient to the appropriate specialist! So the reason for not referring on the GDPs part, primarily can be attributed to a *failure to identify the need for treatment*, in the first place itself. Undergraduate orthodontic education is staring at a major revamp in the specialty of orthodontics, if it is to provide its services to the fullest potential!

CLINICAL POSSIBILITIES

I happened to attend a symposium on "full mouth rehabilitation" for dentists, where a leading global specialist on TMDs and was discussing treatment protocols for various cases, after deprogramming them. In a specific case, where an upper molar had extruded due to extraction of the lower tooth in the same arch, opinions on treatment plans were sought. We've intruded such teeth with micro-implants a plenty, to facilitate vertical space for implants in the opposing arch. However, none of the non orthodontic audience, even suggested this as a treatment alternative. When I explained it, none had even heard about it, and were surprised that they never read about such simple mechanics, that would prevent intentional root canals and crowns for patients. Neither had their orthodontists ever mentioned about it to them. That moment was the stimulus for this editorial!

Whether its attrited teeth, that can be intruded to provide space to the dentist to restore them, or incisal inclinations causing trauma, or space redistributions and uprighting teeth to aid restorations and prosthesis ;or even forced eruptions to develop implant sites, undergraduate orthodontic education, doesn't even address these extremely critical areas.

This poses a huge problem for the future of orthodontics! The undergraduate orthodontic program needs to look beyond technique and theory bombardment, and focus on a restoratively centered and an interdisciplinary treatment planning driven program.[2] The supposed risk of exposing undergraduates to "fixed appliance orthodontics" is much smaller than losing referrals for cases, that can benefit from orthodontics, and thus increase the scope of the specialty, manifold!

ADDRESSING THE SLIP!

"It is the long history of humankind (and animal kind, too) those who learned to collaborate and improvise most effectively have prevailed."

- Charles Darwin

Collaboration is the only way forward for the 21st century professional. Restructuring goals and allowing the spirit of creating a "value and a stake" in orthodontic care, to the undergraduate dental student is nonnegotiable for the tomorrow of orthodontics! If we do not "wake up and smell the coffee" on this pivotal aspect of orthodontic care, the "slips from cups to the lip," I'm afraid, will be an exponential reality in holistic oral health care!

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Power corrupts: PowerPoint corrupts absolutely!: Part 1

As one boards the flight back from a conference, you take back knowledge and experience. And experiences come in all forms: The good, the tolerable and the unmentionable! Imbibing good lectures are memories that linger a lifetime while the unmentionables sometimes inspire editorials, especially this one!

"Death by PowerPoint "is a phenomenon caused by the poor use of what is essentially great presentation software. Key contributors to death by PowerPoint include confusing graphics, slides with too much text and presenters whose idea of a good presentation is to read 90 slides out loud.

Death by PowerPoint can be easily characterized by a few of these…

- Observing the audience members' glazed eyes
- Snoring audiences
- Murmurs and buzzing
- Furtive use of smartphones and trips to the bathroom.

When an audience remains emotionally disconnected from the content that is being presented, there is a good chance that the speaker has either not spent enough time and effort thinking about which key points he wants the audience to take away, or has spent entirely too much time and effort setting up the presentation in PowerPoint, incorporating every feature and display option the software provides. Every Orthodontic resident, clinician or an academic is either a presenter or a potential presenter, and this skill today is almost as important as our domain skills.

The rule of the game is simple! Technology is a visual aid to enhance what is being said, "not" the focal point of the presentation!

This editorial is a two part series. Part 1 focuses on common errors that kill audience interest during a lecture. Part 2 will dwell on tips tricks, and experience mantras that enable presenters to make presentations that leave a lasting impression.

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The "PowerPoint" software is a generic name that I'm using for presentation software. I'm a passionate "Key Note" fan, and the "Prezis" are also gaining popularity recently. We don't mean to compare the three at all! The point is, as an application, they all allow you to do everything you need to do in creating an effective presentation. Unfortunately, they also come with enough bells and whistles to lead you down the path to presentation hell.

To be known as someone who does presentations right, here are six pointers of things that are on a *"**Must Not Do**"* list:

1. **Use your slide as a storybook page**
   Too much matter on a slide, which dissuades readers from reading it, is frustrating, and the best way to lose an audience. Spreadsheets, charts, and complex formulae should never be crammed into a single slide. The rule is to use a font not <30 number in size and *convey only one important message* per slide. Section your information into multiple slides for effective communication.
2. **Use the jazziest fonts in town**
   Every font communicates in a manner different from another. Fonts that make the audience search for letters or convey a casual approach often obscure a message. Bold should be used sparingly, and italics preferably never. Using too many fonts on a single slide also is a distraction. My recommendation would be fonts like *Gill Sans, Tahoma, Futura or Calibri.*
3. **Talking to/reading your slides**
   The best and surest way to create a rebellion in your audience is to reproduce your whole talk on slides. Within minutes, everyone will zone out. I recollect as a graduate student, going to a dental congress, and have a chairperson ask a presenter to stop his presentation mid-way and remark "If we have to read on your slides, what you are saying verbatim, then we can see it for ourselves, we don't need you to speak!" I was shocked at the chairperson for being so direct, but the audience applauded him!
   Aside from making oneself superfluous as a presenter, one also tends to have way too many slides, if one follows this approach! In the age of social media, where everybody wants slides of lectures to be put up on such

forums, for the benefit of people who couldn't attend a congress or a symposium; my simple question to these requests is, "If a handout can replace the experience of listening to a speaker, then the speaker is either too bad, or the audience is really too uninterested!" Lecture slides augment the lecture. They can never replace it!

4. **Create a discotheque on your slides or their background**
   Colors add value and cheer to everything in life! But there is a place for everything and yet, everything has to be in place. While there may be situations when neon green, electric orange and psychedelic pink probably convey a message in a presentation, at most places they don't. Choosing colors that don't leave a retinal after-image or make content difficult to read, is imperative. Sometimes colors appear different on the screen and the computer. It's better to test you're your combinations on the screen beforehand. Background templates that change with each slide, include complicated images or patterns, or display themes that have no connection to the content of your presentation are definitely not helpful.
5. **Over or underutilizing animations/transitions**
   Conveying the entire message at once in a slide is not an effective use of the presentation tool. A well-crafted presentation has to have a distinct flow and contain a few deliberate surprises or structured revelations. Within each slide, you can do this by using various masking, slide-building, or animation techniques. The gradual revelation of information has greater impact and keeps your audience with you, not ahead of you! While using animations to one's advantage is a huge asset, sometimes overuse can create "unwarranted sci-flicks." Different animations from one slide to the next will make your audience cringe. This is especially true for animations that involve a lot of movement; for example, one slide has each bullet point spiral in and the next slide has each bullet point fly in from a different side of the screen. You're probably only two slides into your presentation, and half of your audience would already be suffering motion sickness! Use animation sparingly and stick with only a few moderate ones in any one presentation.
6. **Not realizing man-made technology, and not vice versa!**
   Videos and Sounds on transitions are great tools. One quotation that types itself onto the screen, accompanied by the clicking of a keyboard, might be entertaining. When every bullet point is ushered in by the same sound effect, teeth will start to grind. The same applies to bells, swooshes, and camera shutter sounds. Even music can become an irritant if used inappropriately. Using sound effects sparingly and only to enhance the meaning of the content are the way to go about it.

Videos again are a great way to enhance presentations. They engage an audience, provide entertainment value and help make a difficult point. However, if your video starts playing automatically before you've had a chance to set the stage, it may lose the intended impact. Also, autoplay doesn't always kick in right away. When a video stalls, most presenters try to click play, and that advances the slide. Your best bet is to set up the video to be started on a click. The key is to be in control of audios and videos embedded into the lecture.

Communicating through presentations should ideally serve to *Inspire, Influence and Inform* an audience, and exactly in that order of importance. Technology today forms an excellent resource to enhance, what essentially is a "human to human connect". By using it inappropriately, we are contributing to the dying art of "Lecturing"! Preparing slides are a small but important part of getting a lecture ready, but not the only part. Understanding this phenomenon is critical to disseminating knowledge through this medium.

It's interesting here, to recall an anecdote that is attributed to President Woodrow Wilson. "How long does it take you to prepare one of your speeches?" asked a friend of President Wilson?

"That depends on the length of the speech," answered the President. "If it is a 10-min speech it takes me all of 2 weeks to prepare it; if it is a ½ hour speech it takes me a week; if I can talk as long as I want to it requires no preparation at all. I am ready now." Irrespective of slide software, it's the "preparation and planning," that are the core values that go into building "great lectures" and "wow presentations" that convey specific messages in a given time frame.

The Orthodontic Professional of today has "PowerPoint" to empower his message to be conveyed. And power of any kind, if used inappropriately, corrupts!

The Part 2 of this series in the next issue will discuss the making of meaningful presentations that capture audience imagination.

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Power corrupts: Power point corrupts absolutely — Part 2

Part 1 of this Editorial, in the previous issue focused on "What not to do" while communicating through the formal presentation medium in professional interactions. In this part, we focus on the attributes of powerful communications through effective presentations. To put it simply, these are those lectures at conferences, the "memories of which linger a lifetime!"[1]

As I flash down memory lane, a statement that I heard during a sightseeing excursion to the Sears Towers in Chicago, IL, USA, is something that has stayed with me. It's a philosophy proposed by the German Architect to inspire the architectural design of the tower. The Philosophy was "Less is More!". This is a phrase from the Robert Browning poem "Andrea del Sarto, also called 'The Faultless Painter'" published in 1855.[2]

It might sound shocking to many, and a cliché to the rest: The biggest secret to an awesome presentation is simplicity! The most complex concepts should be packaged in a manner that they are simple for audiences to comprehend, and yet take home! You can still challenge your audience. You can also deliver presentations that have the depth of meaning and feature complex designs.

The challenging material, depth of meaning, and sophisticated designs are all vital to the success of a presentation. Clement Mok nails it when he says, "very often, people confuse simple with simplistic. The nuance is lost on most."[3]

Successful presentations are simple and utilize simplicity, without being simplistic.[4]

THE ONE-SENTENCE THEORY

Conversation science talks about "a governing thought," behind every successful communication. The supporting elements/statements can augment the thought, but the clarity of this governing thought is paramount. As a planner for professional meetings, I sometimes cringe at the comment made by colleagues lobbying for greater time slots, "How can I present years of research in 20 min or 30 min?" This question clearly indicates that the potential presenter has still not understood the "governing thought principle" or simply what the 'soul' of his/her own research/clinical material is.

Simplifying a presentation topic to a one-sentence summary before beginning designing your presentation, is extremely important. If one cannot explain a presentation in one-sentence, one is not ready to create a presentation. Many presenters lose their overall message because they were too focused on weaving together the supporting elements, and forget to just get to the "governing thought" of the presentation. They could not land the plane. Instead they were in the clouds, circling the governing idea. Luckily, this problem has a simple solution: The one-sentence theory. The one-sentence description serves as a compass, making it easy to explore ideas without getting lost in the land of possibilities.

If you think your research is too big for a one-sentence summary, reading the works of Daniel Pink, an author of three New York Times bestsellers, who suggests writing a "one-sentence description" of the purpose of your life, is a revelation.[5]

SIMPLE IS STYLISH

Once we've decided to build a presentation around that one-sentence, and the "less is more" on the slide, the next question is how big should that sentence be, and what are the "words" you will use in them? Pretend your presentation will be delivered to an audience of children.

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Albert Einstein, a genius who gave us complex theories of physics, puts it brilliantly "If you can't explain it to a 6-year-old, you don't understand it yourself!"

Steve Jobs' success as a presenter can be attributed to his ability to use simple words and short sentences to describe big ideas. A study revealed that during one presentation in 2007, Jobs spoke at approximately a 5th grade level. In 2007, when Steve Jobs spoke at the Mac Conference and Expo, he used an average of 10.5 words per sentence. The percentage of difficult words was 2.9%, and the school grade level that could comprehend him was 5.5. Bill Gates in the same year spoke at the International Consumer Electronics Show, using 21.6 words per sentence, with 5.11% difficult words that could be comprehended at a mean grade level of 10.7. At the same show, Michael Dell used an average of 16.5 words per sentence, with a 6.4% of difficult words that could be comprehended at a mean grade level of 9.1.

Coming home to orthodontics, I recollect the 2009 AAO Congress at Boston, where the Late Vince Kokich, probably the best teacher, orthodontics has ever been witness to, was to deliver, what was announced as his last lecture at the AAO Annual Session. For an 8 am lecture, the auditorium at 7:30 am had no seats left, and there was a queue for even standing positions in the room, outside in the prefunction area. I was in the queue, patiently waiting for my turn to possibly get in. One of the gate marshals, actually equipped "What's so special about this guy, that we're witnessing a crowd like this. Is he giving out free gifts?" I smiled, as I barely made it to the packed room. The lecture was phenomenal, and it was an emotional moment for the orthodontic fraternity to hear the legend for the last time on this podium. On my way out, I saw the Marshall at the gate again. I asked him jokingly, "So did you get the free gift?" He said, "This guy is really special. I don't know any orthodontics, but he still connected with me." This statement has stayed with me since. Champions and experts have one ability: To make their craft look simple and easy!

Simple language never diminishes the quality of your content. Your audience will appreciate the ease of listening to your talk. By eliminating unnecessary technical jargon and opting for ordinary language, you are simplifying the listening experience for your audience.

THE THREE POINT SOMETHING

With the purpose of your presentation simply stated in one-sentence, you can start to develop your presentation content by creating an outline. When constructing your outline, edit your material until you have no more than three main ideas supporting your overall message.[4]

Remember, great presentations are simple to understand and enjoy. By building the message of your presentation on a foundation of three key points, you are simplifying the experience for your audience. In addition, you are making it easy for your audience to recall the flow of your presentation.

Consider the Latin Phrase "Omne Trium Perfectum."[6] What this implies is that everything that "comes in sets of three is perfect" or that "every set of three is complete." Steve Jobs in 2011 described the new iPad as "thinner, lighter, and faster." The rule of three is all around us, as it works! The human brain remembers with ease one, two, and three.

The 4th, 10th, or 47th point is rarely remembered. To get started, the classic three act story telling structure is the best way to begin. Build every story around (1) a set up: The clinical issue or the research question, (2) a struggle: The process in research or the clinical case progress, and (3) a resolution.

The resolution aspect in a clinical presentation is extremely critical. The audience wants to know what's in it for them, and how can they take the contents of the talk back home, to the floors of their clinical departments or chair side to patient care.

FAILING TO PLAN IS PLANNING TO FAIL

A classic piece of literature on "planning an orthodontic lecture is a two-part series by Kokich and Kokich."[7,8] Selecting a "theme" appropriate to an audience is extremely critical. Imagine lecturing to a group of referring dentists about, "torque efficacy of various prescriptions." It would be such a waste of an opportunity! The audience and forum should dictate the topic and content, and never vice versa.

The second important decision is deciding the amount of material to be showcased and whether the "breadth or depth" of a topic needs to be covered.[7] I answer this dilemma often by referring to the "three-point" protocol. It's bizarre that novice presenters want to use presentations as a mode to disseminate all that information they have on a particular topic. A colleague once said and I agree, "a good presentation is the one that keeps you hungry for more!"

Good records, a smooth flow of the clinical or research story with well-defined sign-posts and transitions are inseparable parts of a good orthodontic lecture. All these can enhance the "take home" of a presentation, but never replace the "soul" or that "one defined message" that needs to be thoroughly planned before any execution is deliberated!

This two-part editorial has looked at common errors that occur in presentations, incorrect, and correct use of presentation software, and the values that go into a "wow" presentation. In an era where effective communication forms the essence of a successful professional's life, imbibing these skills into our fold is what will define the "tomorrow" of the specialty and its teaching protocols!

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One APOS, one voice!

The flight back from the International Orthodontic Congress in London this September, was a memorable one. Reminiscing moments of fraternal interactions, scientific learnings, immaculate organization and watching the orthodontic world literally converge on a single platform to "smile" was quite an experience!

The weather was the best September could offer: summer's best of weather, and autumn's best of cheer! It was as if the world of Orthodontics had carried its own sunshine to London to celebrate the greatest festival of Orthodontics!

For the Asian Pacific Orthodontic Society, the event had two major highlights: The APOS Scientific World Village Day (WVD) and the APOS cocktail reception both hosted on the 29th of September at ExCel, London. The theme for the day was "one APOS, one voice!"

Why this theme? To get started, it's imperative we discuss the Asian Pacific Region first.

THE ASIA-PACIFIC

The Asia-Pacific region is of vast proportions, stretching northward to Mongolia, southward to New Zealand, eastward to the island states of Oceania, and westward to Pakistan. It also encompasses an enormous variation of climate and topography, from tropical to arctic, and from the Himalayas to coral reefs.

In addition to its immense physical expanse, the region also presents a great historical, cultural, and ethnic diversity as well as a variety of stages of political evolution and economic development. The characteristics of the region are most diverse in terms of natural, environmental, economic, and cultural.

The region can be subdivided biogeographically into the continental, archipelagic, and small island ecosystems. In totality, related to the biogeographic characteristics, the region has a dominant marine environment. There are at least three tectonic belts and unique and diversified natural environment. The marine life spreads out from the Pacific Basin, to the South China Sea, Indian Ocean down to the Antarctic in the south. The climatic patterns therefore range from the tropical to temperate climate zones. Topographically, the Asia-Pacific region is characteristically represented by the highest mountain peaks of the Himalayas ("the roof of the world") and the deepest ocean floor in the Sulu Sea. Due to the great diversity of Asia-Pacific terrestrial and marine ecosystems, the whole area contains probably the greatest biological diversity on earth.

HUMAN CHARACTERISTICS OF THE ASIA-PACIFIC

There is not one single society, political system, economic system, culture, or religion that defines the Asia-Pacific region and this aspect also differentiates it from other regions of the world. The populations of each country located within the Asia-Pacific region have each been moulded very differently by their individual histories and geographies.

The region is home to many racial, cultural, ethnic, linguistic, and religious groups which have over time converged and diverged from one another. Factors such as colonization, war, political instability, economic instability, the availability and use of natural resources, and natural disasters have had an impact in very differential patterns on the countries which form the region.

There is no single Asian language. Most regions speak

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different languages and dialects. Sometimes even within a region, linguistics can be a barrier.

When we talk of the quality of life, the Human Development Index (HDI) for this region is also diverse. The HDI is a comparative measure of life expectancy, literacy, education, standards of living, and quality of life for countries worldwide. It is a standard means of measuring well-being, especially child welfare. It is used to distinguish whether the country is a developed, a developing, or an underdeveloped country, and also to measure the impact of economic policies on quality of life. The index was developed in 1990 by Indian economist Amartya Sen and Pakistani economist Mahbub ul Haq. The HDI is included in a United Nations Development Programme's Human Development Report. The latest report was released on July 24, 2014 and compiled on the basis of estimates for 2013.[1]

When we peruse the 2014 HDI ratings,[2] Australia from the Asia-Pacific is No. 2 in Global rankings and New Zealand no. 7, Hong Kong and South Korea are ranked no. 15, Japan no. 17 (Very High Human Development): Malaysia is ranked no. 62, Sri Lanka 73, Thailand 89, and China 91 also having High Human Development. The Asian Pacific Countries in the Medium Human Development category are Indonesia ranked 108, Philippines 117, India 135, and Bangladesh 142. The Low HDI countries in the region include Nepal (rank 145), Pakistan (rank 146).

This diversity in Human Development also affects the needs, delivery, and modalities of health care and health care education. For Orthodontists from such diverse backgrounds to converge on a single forum for fraternal bonding and scientific deliberations, and speak in "one voice" is indeed noteworthy.

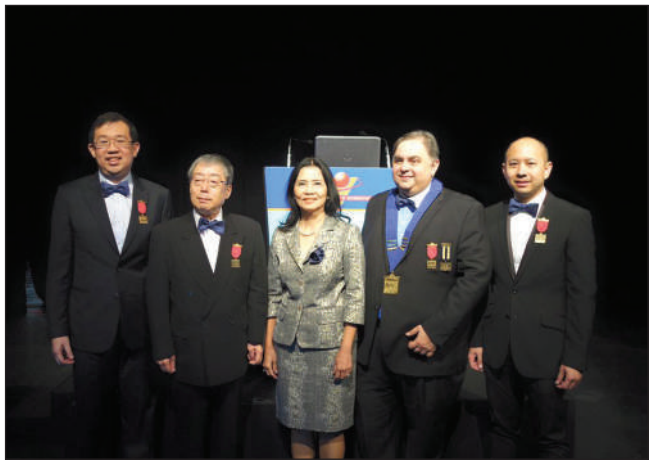

Figure 1: APOS World Village Day speakers with the Chairs: L-R Dr. Bryce Lee, Dr. Kazuo Tanne, Dr. Somchai Satravaha, Dr. Nikhilesh Vaid and Dr. Tanan Jaruprakorn

THE APOS WORLD VILLAGE DAY

The one voice that the Asian Pacific Orthodontic Society speaks in, despite the diverse cultural and geographical origins of its constituents, is the language of "Orthodontics!" If we browse trends in global orthodontic literature as well-podium lectures at major international conferences, there is no doubt in anybody's mind that the sun of contemporary orthodontic excellence and disruptive technology, undoubtedly rises in the east. Rapid strides have been made in the region, in every aspect of Orthodontic care and research. It was not surprising then, to see one of the largest attendees at the APOS WVD scientific program, among the host of village day programs at the IOC, London on September 29, 2015. The program was chaired by Dr. Tanan Jaruprakorn; Vice President APOS, Dr. Bryce Lee; Secretary General APOS and yours truly [Figures 1 and 2].

The speakers who enthralled the audience on a variety of topics were Dr. Kazuo Tanne (Japanese Orthodontic Society), Dr. Nikhilesh R. Vaid (Indian Orthodontic Society), Dr. Eric Liou (Taiwan Association of Orthodontists), Dr. Somchai Satravaha (Thai Association of Orthodontists), Dr. Mike Razza (Australian Society Singapore Orthodontists) and Dr. Tianmin Xu (Chinese Orthodontic Society).

Dr. Tanne started the proceedings with an overview and statistical data on the status of orthodontics and orthodontic education in the Asian Pacific region with detailed and tabulated research on ground realities in every area that has a constituent association in the APOS. This talk was appreciated and will appear as an article in the APOS Trends soon. I spoke on a research validation and clinical application of Camara's 6 Horizontal Smile Lines as an Esthetic Check list for finishing, while Dr.

Figure 2: APOS World Village Day speaker Dr. Mike Razza receives his certificate from the Chairs

Figure 3: Dr. Nikhilesh Vaid, President APOS welcomes guests to the Cocktail reception. In the pic: Dr. Joseph Bouserhal, Dr. Eric Liou and Dr. Tom Ahman

Figure 4: The Cocktail reception: L-R, Dr. Micheal Mah, Dr. Benny S, Dr. Andi Gatot, Dr. Bryce Lee, Dr. Prashant Zaveri, Dr. Eric Liou and Dr. Tanan J

Figure 5: The Cocktail reception: L-R, the friendship and fun times!

Figure 6: The camaraderie get together!

Figure 7: The esteemed guests at the reception

Liou literally regenerated the science with a new path breaking concept of Injecting platelet-rich plasma to improve bone volume and quality, in subjects undergoing orthodontics. Both lectures evoked keen audience interest. Dr. Somchai heralded an interesting lecture on limits of compromise in adult patients, and posed interesting questions on whether treatment objectives for adults and growing patients should be the same by showcasing excellent clinical results. Dr. Razza's insight into autotransplantation, and data backed by excellent outcomes was very encouraging. Dr. Mah's presentation on impacted second molars was literally a clinical guide on what works, and what does not! Dr. Tainmin Xus' Physiologic Anchorage control strategy was very innovative and yet simplistic. This concept features in this issue as a special article.

APOS COCKTAIL RECEPTION AT THE INTERNATIONAL ORTHODONTIC CONFERENCE, LONDON

The biggest names in the Global Orthodontic firmament descended at the Fox's bar at 3:30 pm on September

29, 2015 to celebrate the success of the APOS WVD at the conference. This reception was an initiative by the APOS office bearers to provide a forum to forge new friendships amongst APOS associations (and their leaders), and renew old ones. Attendees smiled, hugged, posed for "selfies," promised to meet each other soon, thanked the WFO for putting up the conference in the manner that they did, and bonded… yes, very much in "one voice"… the voice of "orthodontics!" [Figures 3-7].

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What's "Trend"ing in Orthodontic literature?



2016 marks the commencement of the 6th volume of "APOS Trends in Orthodontics". Its been a momentous journey, that we have deeply cherished. This editorial focuses on the bigger picture: The orthodontic publishing arena,as it exists today! What are we reading, and what is getting published in journals worldwide? The number of orthodontic residency programs are increasing globally;and so are the numbers of orthodontic journals. "More", definitely denotes greater material to peruse; however, does it also imply meaningful and relevant information? This question does open up a Pandora's box. Analyses of a lot published data points to a large proportion of published research lacking methodological rigor, to be reliable enough for answering clinical questions.[1]

Hence, it is important to understand the intrinsic characteristics of a publication, i.e., topic, origin, basic or applied research, authorship demographics, constituent components of affiliation, and other variables.[2] In light of increasing interest in evidence-based orthodontics, the availability of high-quality evidence is another important factor.[3,4]

There have been a few studies investigating orthodontic journals from 1993 onward that have aimed to analyze the types of articles and their authorship characteristics in three orthodontic journals – American Journal of Orthodontics and Dentofacial Orthopedics (AJODO), the Angle Orthodontist (AO), and European Journal of Orthodontics (EJO). However none of these studies have focused on the topics that these articles have addressed.[5,6]

To understand the "trends" that are influencing editorial decisions and the publications that are being accepted currently, we evaluated four orthodontic journals: AJODO, AO, Journal of Clinical Orthodontics (JCO), and the EJO.

To establish a set of comparable data, the method adopted by Kanavakis *et al.*[4] was followed, and the journals with highest impact factors in Orthodontics, for the last 3 years were selected, i.e., AJODO, EJO, and AO. The fourth journal selected was JCO due to its popularity and high readership numbers. The impact factors for the first three journals are given in Table 1. The impact factor of a journal for a particular year is defined as the number of citations from that journal from the previous 2 years divided by the total number of articles published in those 2 years. Journals are assigned an impact factor in Journal Citation Reports, published by Thompson Reuters.[7]

The online web edition of the journals was assessed. The examination of the association of the parameters: "type of article," "main affiliation," "origin," and "keywords" across journals was performed. There were in all five reviewers who decided on the specific "topic" category to which the article should belong. Each article was categorized in only 1 topic group and not more. In the case of a difference of opinion on the topic category, the article was to be categorized by a vote amongst the panel of reviewers.

In all, there were 1962 articles evaluated, (combined in all the four journals) with 692 articles published in AJODO, 543 in AO, 256 in JCO, and 435 in EJO, from August 2012 to August 2015.These articles were divided under 45 different topics. The complete data is presented in Tables 2 and 3.

We considered each journal individually and the top 10 topics which each of these journals published in the 3 year span, was also evaluated. The complete data for AJODO is presented in Table 4, for AO in Table 5, for EJO in Table 6, and JCO in Table 7. At this point, we would like to clarify that this evaluation is a collation of information, and has not been subjected to statistical evaluation for effects and correlations.

Table 1: Orthodontic journals with their impact factor from 2012 to 2014 according to Journal Citation Reports, Thomson Reuters

Title	2014	2013	2012
American Journal of Orthodontics and Dentofacial Orthopedics	1.382	1.437	1.458
European Journal of Orthodontics	1.483	1.390	1.078
Angle Orthodontist	1.225	1.277	1.184

Table 2: Number of articles published between August 2012 and August 2015

Journal	AJODO	Angle Orthodontist	EJO	JCO	Total
Number of articles between August 2012 and August 2015	692	543	435	256	1962

AJODO – American Journal of Orthodontics and Dentofacial Orthopedics; EJO – European Journal of Orthodontics; JCO – Journal of Clinical Orthodontics

Table 3: Topic wise assessment of articles published between August 2012 and August 2015 in the given journals

Topic	AJODO	Angle Orthodontist	JCO	EJO
CBCT	56	32	1	11
Research + training	9	3	0	13
Social media	2	4	2	3
Retention	11	6	5	11
3D diagnosis/digital model	23	13	12	19
TAD'S/plates	52	43	27	26
Bonding	16	24	10	14
Molecular research	26	20	0	16
Root resorption	13	6	2	6
Surgical	35	25	8	10
Statistics/indices	11	3	0	5
Practice management	2	0	13	0
Growth modification	13	23	8	15
Malocclusion	22	22	3	16
Bracket	13	21	8	23
Expansion	21	17	6	8
FEM	11	4	0	8
Force vector	9	6	0	5
Adjunct appliances	10	13	36	8
Anomalies	24	12	5	13
Acceleration	15	3	4	2
Anchorage	14	9	14	4
Mechanics	13	4	9	4
Patient perception	18	18	1	18
Interdisciplinary	15	2	6	1
TMJ/TMD	12	8	3	5
Airway	19	20	0	12
Lasers	4	6	1	1
Bone	21	12	1	8
Esthetics/soft tissue	16	26	3	17
Archwire	7	18	4	11
Impactions	24	8	15	7
CLCP	18	8	0	12
Autotransplant	12	2	3	2
Enamel/pulp	7	4	2	6
Craniofacial growth	15	5	0	16
Lateral cephalograms/ OPG	13	21	0	14
Arch width	13	5	0	6
Rx outcome	17	12	15	22
Invisible	6	8	26	7
Oral hygiene	8	8	1	5
White spot	5	6	0	3
Periods	13	12	2	10
Debilitating disease	5	2	0	1
Mastication/muscles	3	7	0	11

AJODO – American Journal of Orthodontics and Dentofacial Orthopedics; EJO – European Journal of Orthodontics; JCO – Journal of Clinical Orthodontics; TAD – Temporary anchorage devices; CBCT – Cone beam computed tomography; 3D – Three-dimensional; TMD – Temporomandibular disorders; TMJ – Temporomandibular joint; OPG – Orthopantomogram; CLCP – Cleft lip and palate; FEM – Finite element method

The top 10 article topics combined, after collating all 4 journals were also evaluated. This did throw up some interesting results. We do admit that the focus areas of all the four journals are different; hence collating this information is only for an indication of "trends."

Table 4: Top 10 topic wise assessment of articles published between August 2012 and August 2015 in American Journal of Orthodontics and Dentofacial Orthopedics

Topic	Number of articles
CBCT	56
TAD'S/miniplates	52
Surgical	35
Molecular	26
Impactions	24
Anomalies	24
3D diagnosis	23
Bone	21
Expansion	21
Airway	19

TAD – Temporary anchorage devices; CBCT – Cone beam computed tomography; 3D – Three-dimensional

Table 5: Top 10 topic wise assessment of articles published between August 2012 and August 2015 in Angle Orthodontist

Topic	Number of articles
TAD'S/miniplates	43
CBCT	32
Brackets	31
Esthetics	26
Surgical	25
Bonding	24
Growth modification	23
Malocclusion	22
Lateral cephalograms	21
Molecular	20

TAD – Temporary anchorage devices; CBCT – Cone beam computed tomography

Table 6: Top 10 topic wise assessment of articles published between August 2012 and August 2015 in European Journal of Orthodontics

Topic	Number of articles
TAD'S/miniplates	26
Brackets	23
Rx outcome	22
3D diagnosis	19
Patient perception	18
Esthetics	17
Malocclusion	16
Craniofacial growth	16
Growth modification	15
Lateral cephalograms	14

TAD – Temporary anchorage devices; CBCT – Cone beam computed tomography; 3D – Three-dimensional

Table 7: Top 10 topic wise assessment of articles published between August 2012 and August 2015 in Journal of Clinical Orthodontics

Topic	Number of articles
Adjuncts	36
TAD'S/miniplates	27
Invisible	26
Rx outcome	15
Impactions	15
Anchorage	14
Practice management	13
3D diagnosis	12
Bonding	10
Mechanics	9

TAD – Temporary anchorage devices; CBCT – Cone beam computed tomography; 3D – Three-dimensional

Table 8: Top 10 topic wise assessment of articles published between August 2012 and August 2015 in all four journals combined

Topic	Number of articles
TAD'S/miniplates	148
CBCT	100
Surgical	78
Brackets	75
Adjuncts	67
3D diagnosis	67
Rx outcome	66
Bonding	64
Malocclusion	63
Molecular	62

TAD – Temporary anchorage devices; CBCT – Cone beam computed tomography; 3D – Three-dimensional

Articles on TAD's and miniplates were on the top spot with approximately 150 articles published across the four journals (AJODO published around 52 followed by AO with around 43 articles and EJO and JCO with around 26 articles).

The second most published topic was Cone Beam Computed Tomography. (CBCT), with approximately 100 articles out of which more than half of them were published in the AJODO. The interesting information here was that only one article related to CBCT was published in the JCO.

The next two topics with almost the same number of articles published were "Surgical orthodontics" and "Type of brackets and their treatment effects." As far as surgical orthodontics is concerned, two-third of the total published articles were in AJODO and AO, with very few in JCO and EJO. For articles published on the "Type of Brackets and their treatment effects", almost two-third were in EJO and AO with very few in AJODO and JCO.

The complete data for the top topics published are presented in Table 8.

It is important to understand that topics such as temporary anchorage devices, CBCT, surgical orthodontics were more accepted in AJODO, AO, and EJO. AJODO also gave a lot of importance to topics like molecular research and studies on expansion, airway, and anomalies, which were not a part of top ten topics published in other journals. AO still accepted articles on lateral cephalograms, bonding, bonding materials, and brackets systems. EJO and AO both accepted a lot of articles on esthetic and soft tissue considerations as well as growth modification which was not the case with AJODO. EJO accepted articles on three-dimensional diagnosis and digital models, craniofacial growth, and patient perceptions as well.

JCO accepted more articles on adjuncts, innovative appliances and also on Invisble Orthodontic appliances. We also came across some interesting facts, such as in the last 3 years approximately 25 articles were published on how to conduct orthodontic research and training in AJODO, EJO, and AO. There were publications related to social media in all the four journals in the recent years. JCO alone had 15 articles published on practice management in this time span.

This study could ascertain notable differences between all the four journals with respect to the type and topics they publish. Our collation is aimed to give us a broad insight on what are the current "trends" in orthodontic publication, and these are of course,subject to critical appraisal and detailed analysis. The Editorial Team thanks the readers of APOS Trends for their unstinted support to the journal, over the years. We, reiterate our commitment to be a true reflection of "trends" in Orthodontics across the globe, in the coming years too!

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Waiting for that BIG IDEA!

We are inundated with information on that "one big idea" in media, scientific discourse, and clinical corridors! Orthodontics and its allied specialties have had many such ideas that have changed the course of our professional existence. The Advent of the Edgewise Bracket, Cephalometrics, Growth Modulation Concepts, Prescription-based appliances, Wires of differential modulus, TADs, Surgery First, CBCTs, CAD/CAM, customized appliances, robotic wire bending, Aligners … the list of these "big ideas" goes on! Every aspiring resident, inspired by many of these is searching for that one "big" idea to make his/her mark in the annals of orthodontic literature. The perception generally is that we do need big "ideas" to get started!

Most often, however, it is the smaller ideas that lead to big things. Scott Berkun, a renowned author, points out, "little ideas can be useful enough if you present them in the right place. Making your office run 10% more efficiently, cooking your food in a slightly easier way, or heck, even inventing a device that allows you to take selfies in a somewhat easier yet more visually obnoxious manner. All these ideas have one thing in common: They solve small problems, instead of trying to change the world."[1]

What holds most innovators from greatness is often a small thing that happened to be consistently overlooked. The lack of progress is not because there is a grand idea missing. Instead, the cause is a simple idea prevented by bureaucracy, killed out of ignorance, or buried under incompetence. If those simpler, smaller ideas were set free, the effect would be as potent as any grand theory. Somehow, we discount simple ideas for being playthings, for being too small to be worthy, not recognizing the surprising power hidden in what seem to be our littlest decisions.

The McDonalds brothers had a very simple idea. They made hamburgers at a few stands in California. Like any reasonable owner would do, they wanted to run those stands efficiently. How did they do that? They tried to make the process for making food repeatable, an assembly line for food construction. Any homemaker or line cook of the 1950s made the same discovery as making school lunches, or eggs over easy again and again motivates this kind of thinking. Had you shown the McDonalds' business plan to any of the great business minds of the day, they would ha thought you were insane: They would have said that the idea was not big enough to warrant interest of any kind. Fifty years later, McDonalds has 30,000 locations and $22 billion in revenue. Certainly not all of that value can be attributed to the simple notion of creative efficiency, but dedication to the notion did enable their early domination of competitors. The point is simple: A small idea, applied consistently well, can have disproportionately large effects. The insight was not to find a big idea, but in seeing how a little idea, done right, could become big.

In the Orthodontic parlance, the little ideas are the published Technique Updates, Clinical Pearls/Innovations, and sometimes even Case Reports. These might be lowest on the evidence hierarchy but have great value in terms of clinical application and being a resource pool for future developments in the specialty. Never worry about the size of an idea, it is more productive to think about the possible leverage an idea has. An idea can have a different amount of leverage depending on where, when, and how carefully it is applied. One old idea from one profession, reused in the right way in another profession unfamiliar with it, might just have transformative effects. The use of NiTinol in orthodontics is a classic case in point. In Atul Gawande's book The Checklist Manifesto, he explains how the simple idea of a task list, something used by aircraft pilots for decades, has improved patient safety in surgery by 30% or more. Hospitals did not need a breakthrough technology. There was not a new theory or grand vision. A simple act, with a simple, old tool, had incredible, and surprising, leverage.[2]

There are many dubious stories in the history of innovation, and some, despite their improbability, make valid points about the significance of ideas. Charles Steinmetz (or Edison or Tesla, depending on the version of the legend you hear), holder of over 200 patents, retired from general electric (GE). A complex system had broken, and no one could fix it so they hired him back to consult. Steinmetz found the malfunctioning part and marked it with a piece of chalk. He submitted a bill for $10,000. The GE managers were stunned and asked for an itemized invoice. He sent back the following: Making the chalk mark $1, knowing where to place the chalk mark $9,999.

Ideas are like chalk marks: As simple as they seem, knowing where, when, and why to use even the smallest ones, can change the world.

A surprising number of the conveniences of modern life were invented when someone stumbled upon a discovery or capitalized on accident: Microwave oven, safety glass, smoke detectors, artificial sweeteners, X-ray imaging.[3]

Let us know some of these ideas:

- Microwave Oven: In 1945, Percy Spencer, an engineer at Raytheon, discovered a candy bar that melted in his pocket near radar equipment. He chose to do a series of experiments to isolate why this happened and discovered microwaves. It would take ~20 years before the technology developed sufficiently to reach consumers
- Safety Glass: In 1903, Scientist Edouard Benedictus, while in his laboratory, did drop a flask by accident and to his surprise, it did not break. He discovered the flask held residual cellulose nitrate, creating a protective coating. It would be more than a decade before it was used commercially in gas masks
- Artificial Sweeteners: Constantine Fahlberg, a German scientist, discovered Saccharin, the first artificial sweetener, in 1879. After working in his laboratory, he did not wash his hands and at dinner discovered an exceptionally sweet taste. He returned to his laboratory, tasting his various experiments, until rediscovering the right one (literally risking his life in an attempt to understand his accident)
- Smoke Detector: Walter Jaeger was trying to build a sensor to detect poison gas. It did not work, and as the story goes, he lit a cigarette and the sensor went off. It could detect smoke particles but not gas. It took the work of other inventors to build on his discovery to make commercial smoke detectors
- X-rays: Wilhelm Roentgen was already working on the effects of cathode rays during 1895 before he actually discovered X-rays. He was a scientist working on cathode rays. On November 8, 1895, during an experiment, he noticed crystals glowing unexpectedly. On investigation, he isolated a new type of light ray.

To be more helpful, work is the essential element in all finished creative projects and inventions. No matter how brilliant an idea, or miraculous discovery, work will be required to develop it to the point of consumption by the rest of the world. And its effort, even if in pursuit of pleasure, provides the opportunity for serendipity to happen. The unknown cannot be predictable and if creativity is an act of discovery, then uncertainty must come with the territory. Curiosity is a far simpler concept than serendipity and far more useful. People who are curious are more likely to expend effort to answer a question on their mind.

The Myths of Innovation will always be popular, which means for any inspiring story of a breakthrough, we must ask some pertinent questions:

1. How much work did the creator do before the accident/breakthrough happened?
2. How much work did they do after the accident/breakthrough to understand it?
3. What did they sacrifice (time/money/reputation) to convince others of the value of the discovery?

It is answering these three questions about any creativity story, however accidental or deliberate, that reveals habits to emulate if we want to follow in their footsteps.[3]

The last editorial discussed "trends in orthodontic literature."[4] Trends are a culmination of innovation, creativity, and a regimented search for evidence. These trends educate and inspire orthodontists to yearn for the next "big" wave in our specialty. To the "select geniuses" who have made these waves, we doff our hats! To the zillion hard working colleagues, who take the trouble to document the smallest of their ideas, and contribute to orthodontic literature, our gratitude and deepest appreciation too! For an orthodontic clinician busy in rendering patient care, an idea emanating from the clinical trenches has infinite potential to inspire if not transform into that "Big Orthodontic Idea." I attended a Medical Editors Conclave last week that emphasized on citable literature be given priority in publishing, to stay relevant in the impact factor game. The general consensus was that Pearls/Innovations/Techniques or Case Reports rarely get cited; hence, original research is what Editors should focus on. If editors 20 or 30 years ago thought that way, a lot of brilliant orthodontic ideas would have probably never seen the light of the day!

The APOS Trends since its inception has encouraged "Clinical Pearls and Innovations." For recognizing the best articles in this section, we have even introduced the "Loh Soo Ann APOS Trends award for Best Clinical Pearl/Innovation article." This jury for APOS Trends awards did not award this category for the year 2013–2014. I sincerely hope there will be worthy claimants for it in the years 2015–2016. While the creative orthodontic minds aspire for that "next BIG idea," it is equally important to pen down every small one that comes by. We appreciate our contributors for taking the trouble to pen down these little ideas and innovations for the journal in particular, and the profession at large. For often, it is these small ideas that complete the "BIG" picture, it in life or orthodontics!

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Commoditizing orthodontics: "Being as good as your dumbest competitor?"

The media coverage of the "DIY Braces" in the past few months has had our profession startled! Did we really not see this coming? The trends over the past decade or so have been signaling something that we should have been listening to?

A 23-year-old college student studying digital design at the New Jersey Institute of Technology hated his crooked teeth and needed braces but was a "broke" college student. Hence, he turned to technology and three-dimensional printed his own aligners for <60$. This student said his motive was not completely financial because he knew that he could probably afford braces a few years from now after he graduated college. He said that it was the mixture of saving money and trying a cool experiment that intrigued him.

"When I realized that I could do something that was a little bit culturally disruptive, while demonstrating my skills as a designer and a maker and fixing something that was making me self-conscious for virtually free, I felt it was more than worth the risk," is what he said to the media. He researched processes and created 12 aligners for himself with a step by step process that is documented on his blog, and these were a part of a portfolio project for school! Professional Orthodontic Organizations have condemned this phenomenon and warned the populace at large about the health comprises and dangers this phenomenon could attract! In fact, a couple of years ago, a consumer alert on "gap bands" was issued in an editorial comment in the AJODO, with some images that were indeed horrifying.

In the UK, Your Smile Direct offers services that involve impression making at home with a DIY kit that arrives on request. This is followed by shipping these impressions to the company that then fabricates aligners and monitors treatment over the internet. The British Orthodontic Society issued a statement, "We urge patients to think twice before deciding to go ahead with any treatment which is carried out remotely, without a consultation, or chosen via the internet. The best starting point for orthodontics should always be to see a clinician who has the appropriate training and experience."

In Asia, fashion braces or fake braces (these only have a flaunt value, they do not facilitate orthodontic tooth movement) have been a symbol of status, wealth, and style! Adolescents in Thailand, Indonesia, and Malaysia have been buying these faux oral accessories – which do not need to be bonded by an orthodontist, not even by a dentist – in a multitude of colors and designs, including Hello Kitty and Mickey Mouse, from open air stores in malls and night markets. Beauty salons offer to attach them! Health concerns by orthodontic organizations have been expressed, and even a few deaths have been reported from toxicity of their ingredients. In 2016, selling or importing them has legal implications that include a fine and even imprisonment.

Is this the last we are hearing about this phenomenon, or is this just the beginning? DIY antibiotics and self-medications are things that health sciences have been grappling with, for some time now! What is next - "DIY Surgery?" The "best deal" mindset is something that the internet has tapped into and the click of a mouse offers solutions galore to immature markets and potential clients hungry for that "too good to believe" deal. Health services, such as airline and hotel deals, are being "commoditized" in this environment. However, you approach commoditization, any profession will have to try to innovate at all costs to beat it back because as Peter Drucker said, "In a commodity market, you can only be as good as your dumbest competitor!"

As orthodontists, we do struggle to comprehend terms used in business or management sciences. Hence, I will elaborate a bit on what the "commodity phenomenon" entails. Pine and Gilmore published a book in 1999 titled, "The Experience Economy." They analyzed developments in society and argued for the fact that commodities and services are no longer enough to satisfy consumers, realize revenue growth, and increase businesses; it is the experiential elements that matter. Thus, staging of experiences must be pressed as a distinct form of economic output to stand out in a cluttered marketplace of competition based on "price" and not "value."

The four distinct forms of economic outputs described in this book are "commodities," "goods," "services," and

"experiences." It is not surprising that economists who have tracked the health (based on three parameters: Consumer price index, growth, and job creations) of all four forms of economic functions have actually found the "experience" sector performing better on all three parameters in most parts of the world.The commodity sector has actually had negative growth and diminishing returns on all parameters. What lessons can we as specialists of a "wellness science" take home from this vital piece of information?

Before we deliberate economic functions or factors in orthodontics, understanding consumerism from a health-care perspective is important. Consumerism in health care is a movement that advocates patient participation in health-care decisions. It is a paradigm shift from the "doctor says–patient does" model to a partnership model. Assessing healthcare is far different from making a purchase at the local mall, and it should always be. The sum of health-care purchases does not equal the parts! An implicit assumption in many prevailing views of health-care consumerism is that care can be objectively characterized as good or bad. While quality measurement standards from groups can help identify key aspects of clinical quality–there is wide agreement that those measures alone are not enough. Much of healthcare still remains about a patient's human connection with their treating therapist. There is an art and style to clinical sciences and real variability in what style patients respond to and prefer.

This is not to say that the embrace of consumerism is unfounded or misplaced. The process has already brought much-needed transparency to healthcare markets that could help improve quality and reduce costs. At the same, it is far from the panacea that many suggest. In thinking about the healthcare consumer, we must not forget that people desirous of health-care services (even in the wellness sector) prefer being considered and cared for as "patients" instead of as "consumers."

Orthodontic offices that have advertised or postured themselves as being a "deal" or offering "economic sops/discounts" have actually contributed to the "commodity" trend for our specialty. Managed care, corporate chains/providers, or appliance manufacturers marketing orthodontic therapy directly to consumers (not patients!) for "special economic offers" have then followed suit. While these trends affected only the regions where they were being promoted in, the "information age" that we live in today (has been true to its name), and the web presence of this phenomenon ensures it is now having a classical "Domino effect!"

Cigarette advertisements in most parts of the world are mandated to carry a statutory warning or a health advisory on their packets. No professional advocacy group has yet lobbied for one on orthodontic appliances and techniques that are advertised to the consumer directly, claiming to be "alternatives to braces" or "the most efficient systems"! An advisory could simply state, "Diagnosis, Clinical Examination, and Evaluation of feasibility of use of this appliance by a specialist orthodontist/qualified orthodontist are important for treatment success with the same" or something on similar lines. The "one size fits all" phenomenon in orthodontics has never been and will never be the magic potion of therapy!

Just advisories or statements condemning the DIY trend on social media are probably not enough. Regulations will need to be lobbied for in all parts of the world. Creative thinking and proactive solutions are imperative to understanding the critical basis of this phenomenon if we are to prevent a tomorrow where the "brightest professionals in dentistry" will have to succeed by being "as good as their dumbest competitors." A scenario I assume, both professionals and patients, shudder to think about!

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Lets talk ALIGNers!

The 21st century has an appliance that has firmly established itself as a definitive orthodontic solution. Although its extent and application of use have been the subject of deliberations across platforms, research of orthodontic tooth movement (OTM) using clear aligners is limited. Most of the literature consists of case reports, editorials, or articles written by authors with biases.[1] Conventional thinking suggests that the movement is mostly uncontrolled tipping, with the center of rotation located between the center of resistance and the apex of the tooth. However, the repertoire of cases being treated with aligners has expanded the envelope of what aligners can achieve realistically on the clinical terrain, and conventional thinking is bracing itself for a rethink!

There have been few evidence-based attempts to describe the type of OTM resulting from treatment with clear aligner therapy (CAT). Rossini *et al.* in a systematic review published last year in the Angle Orthodontist, discussed efficacy of clear aligners in controlling OTM.[2] Only 11 relevant articles were found from a search across databases from January 2000 to July 2014 (two randomized controlled trials, five prospective nonrandomized, and four retrospective nonrandomized). The risk of bias was moderate for six studies and unclear for the rest. The amount of mean intrusion reported was 0.72 mm. Meanwhile, extrusion was the most difficult molar tooth movement to control (30% of accuracy), followed by rotation. Upper molar distalization revealed the highest predictability (88%) when a bodily movement of 1.5 mm was prescribed. A decrease of the Little's index (mandibular arch: 5 mm and maxillary arch: 4 mm) was observed in aligning arches. The authors concluded that CAT aligns and levels the arches; it is effective in controlling anterior intrusion but not extrusion; it is effective in controlling posterior buccolingual inclination but not anterior buccolingual inclination; it is effective in controlling upper molar bodily movements of about 1.5 mm; and it is not effective in controlling rotation of rounded teeth in particular. They also state that aligners are not an appliance by themselves. The use of auxiliaries and adjuncts improves predictability of treatment with aligners. The authors did admit that the results of this review should be interpreted with caution due to the number, quality, and heterogeneity of the original studies included. From the first review published in 2005 by Lagravère and Flores-Mir[3] where only two studies met the inclusion criteria and no conclusions could be drawn, this review a decade later has shed some light on the therapy.

Three aspects have had a significant impact on orthodontics during the last decade: The appliances being used, the anchorage being used, and finally the distribution of patients being treated.[4] CAD-CAM appliances are a reality; Temporary Anchorage Devices (TADs) have enhanced the scope of anchorage and adults forming a sizable part of orthodontic patients who are being treated today. Adult patients have also impacted the choice of appliances that we use. Leaving commercial manifestations of this trend aside, the focus on science, and its scope is imperative, if we are to formulate clinical protocols and guidelines that optimize chairside aligner use. The orthodontic terrain in the last decade has changed. From bewilderment at an appliance that was supposed to take over the role of an orthodontist (since it did arrive on the market before the science to use it effectively did) to an attempt to seek evidence-based perspective on its application, we have come a long way!

Colleagues often discuss conditions that can be treated efficiently with aligners and source literature on it. This is analogous to seeking information on indications or contraindications for a specific therapy. However, there is a difference here! The difference is that aligners do not understand malocclusions. They only understand specific tooth anatomy and the movement desired on that tooth. The other elements that then come into play are occlusal forces, aligner material specifications, staging, and the use of adjuncts.

Stefano Negrini, a dear friend and a master technician from Ferrara, Italy, is someone who has worked on aligner fabrication and laboratory services for a considerable time now. It was a pleasure interacting with him on this subject when I visited his office a few months ago. He has devised a diagrammatic representation for the possible scope of what movements can be reasonably achieved with aligners. In light of current information, this representation could be a useful chair-side tool to determine feasibility of aligner use in a given patient. It is not a validated tool yet, but could be a starting point for beginners.

For extrusions and A-P corrections, the possible limits are described in Figures 1a, b and 2.

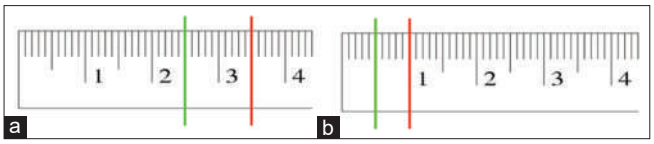

Figure 1: (a) Extrusion of upper and lower incisors. (b) Extrusion of upper and lower premolars and molars. Pic courtesy- Stefano Negrini

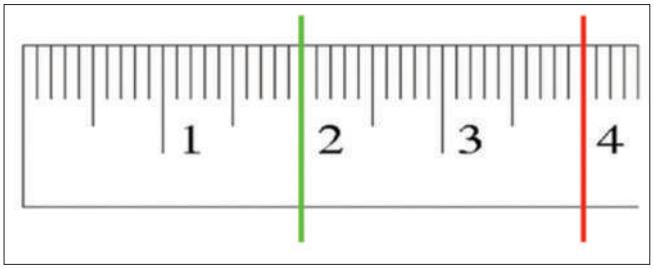

Figure 2: A-P corrections per quadrant. Pic courtesy- Stefano Negrini

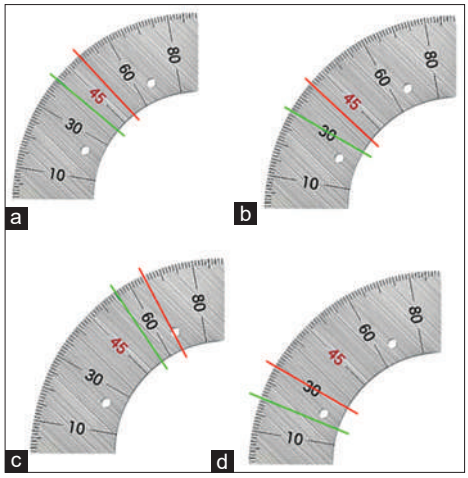

Figure 3: Rotation limits for (a) upper central and lower incisors, (b) upper lateral incisors, (c) upper and lower cuspids and premolars, (d) upper and lower molars. Pic courtesy- Stefano Negrini

For rotations, the possible limits are described in Figure 3a-d. It is interesting that tooth movement for specific teeth vary, indicating that tooth morphology plays an interesting role in aligner therapy. It is recommended that any rotation >5° should use an attachment for better retention of the aligner.

The Editorial team at the APOS Trends is extremely eager to receive manuscripts on this modality of treatment from clinicians and researchers across the globe. From a simplistic perspective, I have always maintained ALIGNers, Align! Expecting them to be a tool that can address all clinical situations, is an Utopian fantasy,at least today. Comparing them to fixed appliances is an Orange and Apple comparison! However, in an era where aligners are an accepted method of delivering orthodontic care, it is only appropriate that validated information and literature of the highest level of evidence forms the basis of clinical choices and decisions! Educators and young residents who looking at pursuing research projects could really find a lot of questions for which answers can be sought by well-drafted protocols on this terrain. It's only when we have these answers that will we be able to "talk ALIGNers" with authority!

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Laser therapy for faster orthodontic tooth movement

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Abstract

One of the major component of patient to reject orthodontic treatment is the long duration of treatment..If Low intensity laser therapy can promote wound healing by increased cell proliferation and improved micro circulation can bring about faster bone remodelling at fracture sites; then why not to use it with orthodontic forces for better results? Soft tissue laser has now become a part of essential equipment of modern dental clinics. To accelerate the physiologic tooth movement during orthodontic treatment a thorough knowledge of laser unit, mode of action and key factors to gain therapeutic effect is a must which this article illustrates .Study carried out by us did show a 30% reduction in the treatment time.

Key words: LILT, OTM, biostimulation

INTRODUCTION

One of the major concerns to the orthodontic patients is treatment time and second is pain or discomfort. Reducing the treatment time requires increasing the rate of physiologic tooth movement. Many methods have been used in the past to accelerate the orthodontic tooth movement as electric and magnetic stimulation,[1] drug injections of parathyroid hormone, misoprostol (prostaglandin E1 analog), prostaglandin E2 (PGE2).[2,3]

Although these substances stimulate the rate of tooth movement, they also have an undesirable side effects of local pain and discomfort during the injections. Recently, electric stimulation and resonance vibration[4] have been tried in animals, but these methods require an apparatus that is not routinely used in dental practice. To reduce pain during treatment often analgesics are advised. But studies have shown that analgesics inhibit prostaglandins, which in turn slows down the tooth movement.[5]

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Low intensity laser therapy

For more than a millennium, dozens of cultures identified light as possessing healing properties. Low intensity laser therapy (LILT), the energy output is low enough so as not to cause a rise in temperature of the treated tissue above 36.5°C or normal body temperature. In initial days, LILT found its application only in medical sciences such as orthopedics, surgery, and medicine.[6]

In the early 1980's, dental lasers were introduced and recognized as a tool for better patient's compliance.

Lasers in dentistry

Medical and dental lasers are found in wavelengths in a relatively narrow range within the electromagnetic spectrum. They include the range of visible radiation (400-750 nm) and invisible thermal radiation, which can be further broken down into the near infrared (750-2000 nm), mild infrared (2000-3000 nm), and far infrared (3000-10,600 nm) wavelengths. The illustration in Figure 1 depicts the short span of the electromagnetic spectrum wherein the wavelengths of popular lasers fall.[7]

Dental lasers can be separated into two broad categories:

1. High-power lasers

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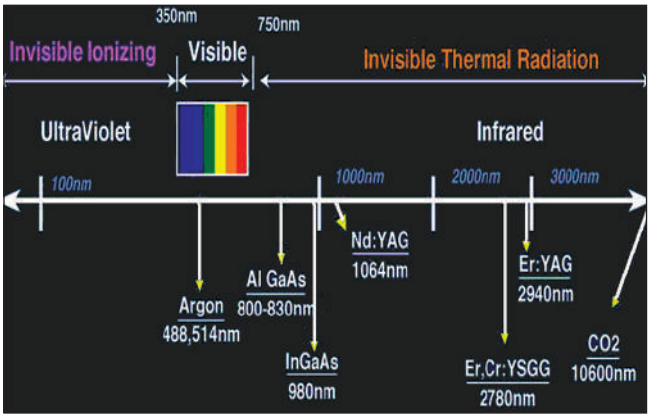

Figure1: Electromagnetic spectrum

High-power lasers typically use above 1.0 watt (W) of power output concentrated in a small, defined area to cut hard and soft tissues.

2. Low-power lasers

Low-power lasers typically use significantly less power than high power lasers, usually ranging from 5 mW up to 400 mW. They are used for caries detection, teeth whitening, light curing of composite resins, oral pain relief for aphthous ulcers, temporomandibular joint disorder, and to increase osseointegration of dental implants.

In the field of orthodontics, LILT has been used to decrease orthodontic pain, and increase bone deposition across the expanded mid-palatal suture.[8] In the last decade, many histological studies have attempted to determine the effect of LILT on the histochemical pathways directly associated with orthodontic tooth movement (OTM).

Low intensity laser therapy's effect on main cellular component involved in OTM.[9,10]

Low intensity laser therapy can influence osteoclast regulation by effecting enzymatic levels of transforming growth factor-β1, cyclooxygenase-2, PGE2, fibronectin, collagen turnover, and tissue vascularity preservation. These enzymes induce the expression or inhibition of members of the osteoprotegerin/receptor activator of nuclear factor kappa B ligand/receptor activator of nuclear factor kappa B system and subsequently manipulate the differentiation, maturation, and maintenance of osteoclasts.

Key factors for therapeutic effects of laser

Laser attenuation and penetration depth

Van Gemert and Welch[11] reported that the maximum penetration of infrared lasers in "bloodless, unpigmented tissue" is close to 1 cm.

In 1993, Kolari and Aicksinen[12] found laser transmittance of 632.8 and 820 nm wavelengths through skin to be between 2 and 3 mm.

Photobiology

The first law of photochemistry, also known as the Grotthuss-Draper law, states that light must be absorbed by a chemical system in order for photochemistry to occur. In 2001, Sommer *et al.*[13] stated that perhaps energy density and light intensity were the most important of the biostimulatory factors. To support their claim, the group points to a number of investigators who found that the stimulatory effect of LILT follows the basic Arndt-Schultz law, which states that "small doses stimulate living systems, medium doses impede, and large doses destroy." Sommer's *et al.* also observed that a threshold of light intensity exists and must be reached in order to produce a biostimulatory effect.

Biostimulatory

Effect of phototherapy increased scientific interest in LILT initially through the early work of Mester *et al.*'s.[6] They concluded that a low powered laser beam would allow for a "biostimulatory" effect that would quicken the therapeutic process.

Timing

Subjects are more readily influenced by LILT in the initial stages of biological response.

Frequency

Multiple applications of LILT produce a greater response than a single dose.[14]

Energy density/dosage

The rule of reciprocity, also known as the Bunsen-Roscoe rule, states that a photochemical reaction is determined by the dose irrespective of the time needed to deliver that dose. Biologic stimulation by LILT follows dose dependency. This was exhibited through bell-shaped curves where every laser wavelength produced a maximum stimulation at a specific dose. Doses greater and less than the optimal resulted in less stimulation. Bell-shaped curves are indicative of dose dependency.

Very few studies in the literature examined the effect of LILT on rate of OTM, and those too are short-term animal studies. In 2004, Cruz *et al.*[15] were the first to carry out a study on human over a period of 60 days. In our study,[16] in 2011 we evaluated the efficacy of LILT in reducing orthodontic treatment duration and pain. Individual canine retraction by a nickel-titanium closed-coil spring was done in 21 patients with extracted premolars. Experimental side received infrared radiation from a semiconductor (gallium aluminum arsenide [GaAlAs]) diode laser with a wavelength

of 810 nm. The laser regimen was applied on days 0, 3, 7, and 14 in the 1st month, and thereafter on every 15th day until complete canine retraction was achieved on the experimental side. Tooth movement was measured on progress models. Each patient's pain response was ranked according to a visual analog scale. An average increase of 30% in the rate of tooth movement was observed with the low-intensity laser therapy. Pain scores on the experimental sides were significantly lower compared with the control sides.

Low intensity laser therapy equipment

LASER unit

The laser type-semiconductor (GaAlAs) diode laser [Figure 2] emitting infrared radiation with 808 ± 10 nm wavelength operating according to the manufacturer's recommendations as in Table 1.

Figure 2: LASER Unit

Handpiece

The handpiece has a cylindrical quartz tip of 4 mm^2 surface area from where laser beam is emitted. Black color coded needle are used for therapeutic purpose which is attached to handpiece.

Protection glasses

Safety precautions are worn by both the operator and patient provided by the manufactures. The principle risks with laser are associated with eye damage [Figure 3].

Figure 3: Protection glass and Disposable LASER tips

PROCEDURE

Low intensity laser therapy for analgesic: Two irradiations are done. One irradiation on middle one-third of the canine root on the buccal side and the second on the palatal side holding the laser tip in direct contact with the tissue.

Low intensity laser therapy for biostimulation during OTM: The total of 10 irradiations are done — five on the buccal side and five on the palatal side in order to cover the entire periodontal fibers and alveolar process [Figure 4]. Manual settings of the laser unit shown in Table 2.

World Association of Laser Therapy has laid down standards to carry out study on laser therapy.

LOW INTENSITY LASER THERAPY-MODE OF ACTION

Laser therapy can best be described through its parameters. The core parameters include:

1. Laser's wavelength: A laser exists at a specific wavelength, determined by the medium through which energy is pumped to create light.

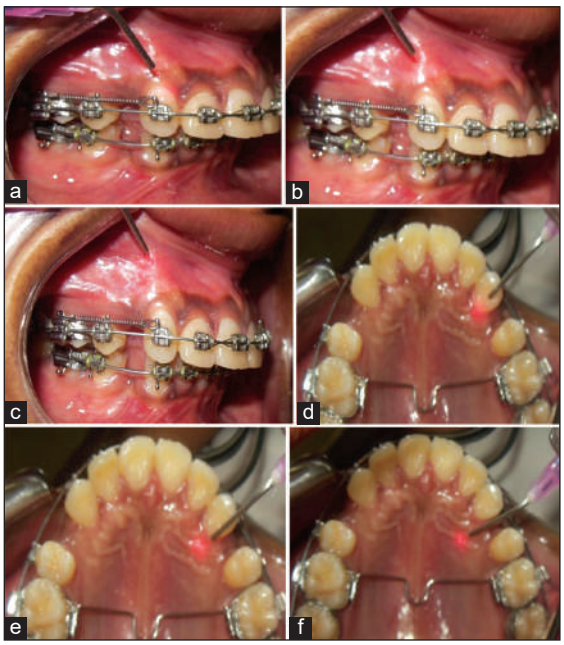

Figure 4: Laser therapy procedure for canine retraction on, BUCCAL. (a) Cervical 1/3rd (b) Middle 1/3rd (c) Apical 1/3rd, PALATAL (d) Cervical 1/3rd (e) Middle 1/3rd (f) Apical 1/3rd

Table 1: Manufacturer's recommendation

Type	Features
Origin	LAMBDA SpA Via dell'impresa 36,040 Brendola (VI) — Italy
Model	LA3D0001.1
Input of power supply	100-240 VAC
Network frequency	47-63 Hz
Maximum current absorbed by the network	0.5 A (@230 V)
Output of power supply	12 VDC-8.33A max
Supply voltage for the system	12 VDC
Max absorption of the system	0.6 A
Power output on the work point	0.1-7 W
Working conditions	Temperature: 10°C to 30°C Humidity: 30% to −75% Atmospheric pressure: 700/1060 hPa
Storage conditions	Temperature: 05°C to −50°C Humidity: 30% to −75% Atmospheric pressure: 700/1060 hPa
External connections	Footswitch (optional)+interlock
Cooling system	Air
Laser class	3
Weight	1 kg

Table 2: Manual settings of equipment

For analgesic purpose, settings adjusted to
Wavelength-800 nm
Wave mode-continuous
Output power-0.7 mw
Exposure time-30 s
For biostimulation, the parameters set at
Wavelength-800 nm
Wave mode-continuous
Output power-0.25 mw
Exposure time-10 s

2. Modality of application: Laser therapy can be delivered in continuous or interrupted emission modes which is further divided into gated pulsed and free-running pulsed mode.
3. Power output: Lasers are most easily characterized by the amount of energy they produce, called power output.
4. Application dose: Application dose measures the amount of energy applied at any one given treatment and is measured in Joules (J).
5. Treatment dose: The treatment dose, or total energy dose, is an additive value combining the energy delivered over the entire length of treatment.
6. Energy density: Energy density is a measure indicating the amount of energy received by a given tissue.
7. Power density: Power density measures the amount of power per unit area leaving the laser applicator or tip.

CONCLUSION

Low-intensity laser therapy increases the rate of OTM in a physiologic manner. It causes no side effects on the vitality or the periodontium of the teeth. Thus, it can safely and routinely be used during orthodontic treatment to shorten the treatment time. Low-intensity laser therapy also is an effective method of analgesia during orthodontic treatment or to relieve from pain immediately after placement of separators.

The Food and Drug Administration does not specify absolute contraindications for the use of LILT. However, individuals have postulated various scenarios in which the therapy should not be used until further research is conducted. One of these is in areas of malignancies or possible malignancies, since most research indicates lasers have a biostimulatory effect.

CLINICAL APPLICATIONS

1. Low-intensity laser therapy can be used for differential movement of teeth.
2. In cases of midline shift, it can be used to stimulate OTM on the opposite side.
3. Application of low-intensity laser therapy only on teeth to be moved conserves the anchorage. Because low-intensity laser therapy stimulates tooth movement by altering the biologic response and not by increasing forces or changing mechanics, it does not tax the anchorage.
4. A few studies have reported a decreased rate of tooth movement in adult patients due to decreased vascularity and cellularity of bone.

With increasing number of adult patients in orthodontic practices, low-intensity laser therapy will be beneficial in adult because it increases the vascularity and cellularity of bone.

FUTURE SCOPE AND RESEARCH

Further studies are required to study the efficacy of LILT during comprehensive orthodontic treatment for reducing the treatment time. and effect of LILT on periodontal tissue remodeling during relapse and retention of orthodontically moved teeth .

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No more monkey business with impacted canines

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Abstract

Various treatment mechanics have been created to direct the eruption of impacted teeth, including the application of intra- and interarch forces to some type of attachment on the affected teeth. The present communication describes the use of two simple auxiliaries, the Monkey Hook* and the Kilroy Spring*, for the directed eruption of impacted and/or the correction of severely rotated teeth.

Key words: Exposure of impacted teeth, impacted canines, impacted cuspids, Kilroy Spring, Monkey Hook

THE MONKEY HOOK AUXILIARY

The Monkey Hook[1] is simply a short section of wire with open loops on opposite ends [Figure 1]. Forces to direct the eruption or rotation of teeth are applied from the Monkey Hook with intraoral elastics, elastic chains, elastic thread, or superelastic coil springs. Closing the loops with pliers permits the secure connection of the Monkey Hook to a bondable "loop button" or the linking of one hook to another to form a "chain" [Figure 2].

EXPOSURE AND ATTACHMENTS FOR IMPACTED TEETH

The advent of direct bonding has allowed for smaller exposure sites for impacted teeth with less associated morbidity when placing attachments. For instance, a loop button or bondable eyelet, consisting of a 1 mm helix of a round wire that is welded or braised to a small diameter bondable base [Figure 1], that may be easily directly bonded to nearly any exposed enamel surface of an impacted tooth. Applying an additional amount of bonding adhesive (e.g., Fuji GI LC), acting as a fillet, around (and even over the edge of the bondable base) appears to improve the retention of this attachment.

A Monkey Hook is connected to the loop button attachment prior to the direct bonding and this combination to the exposed tooth. The vertical loop is positioned parallel to the roots of the teeth adjacent to the impacted one. In this orientation, a continuous arch wire may be placed through the lumen of this loop button later in the treatment when the directed eruption of the tooth is sufficient. If the tooth is deeply impacted, a second Monkey Hook can be easily linked to the first one. Then a stainless steel ligature is used to tie the free-end of the Monkey Hook to the bracket on a tooth adjacent to the exposure site. This will stabilize the hook until forces are later applied. As a result, a portion of the Monkey Hook may extend through gingival tissues after the exposure and is available for the application of a variety of force mechanics [Figure 3].

FORCE APPLICATIONS

For palatally impacted canines, it is important to direct the eruption of the affected tooth away from the roots of any adjacent teeth to reduce the risks of root resorption. In some instances, the tooth must be moved toward the lingual or distal before lateral movements are attempted. In addition, these teeth should first be erupted occlusally, prior to any attempt to direct the tooth laterally toward the dental arch form. As there is obviously no periodontal ligament surrounding the enamel crown of a tooth, it is nearly impossible to move the crown through bone. Consequently, eruption of the tooth vertically to clear

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the crown from the supporting bone will facilitate later lateral movements.

MONKEY HOOK FORCES

Vertical eruption

Common intraarch mechanics that have been previously used to direct the eruption of impacted teeth (e.g., elastic thread applied to a gold chain) may tend to adversely tip or intrude the adjacent teeth. As an alternative, vertical eruptive forces can be created using intermaxillary elastics, stretched from the Monkey Hook to the opposing dental arch [Figure 3]. Although there is no effect on teeth adjacent to the exposure, this arrangement introduces the unpredictable factor of patient compliance with elastic wear.

Slingshot effect

An alternative method is to produce intraarch force using multiple Monkey Hooks connected to the same loop button attachment much like keys on a key ring [Figure 3]. Elastic chains are then connected from each Monkey Hook to teeth adjacent to the exposure, thereby creating a "sling shot" effect [Figure 3]. A closed coil spring is placed on the base arch wire to prevent tipping of the adjacent teeth toward the impacted tooth. A combination of intermaxillary elastics and the "sling shot" may be used to provide simultaneous vertical and lateral eruptive forces [Figure 3].

THE KILROY SPRING AUXILIARY

The Kilroy Spring[2,3] is a pre-formed module that is slid onto a rectangular continuous arch wire in the location of an impacted tooth [Figure 4]. The vertical loop of the Kilroy Spring extends perpendicularly to the occlusal plane in its passive state [Figure 5]. A stainless steel ligature is then threaded through the helix at the apex of this vertical loop. Then the vertical loop is directed toward the impacted tooth. The ligature is tied either directly to the loop button or to a Monkey hook linked to that attachment. As another alternative, either the Monkey Hook or Kilroy Spring may be tied to the links of a typical "gold chain" that has been attached to the impacted tooth.

KILROY SPRING FORCES

The Kilroy Spring is supported by (1) the rectangular base arch wire, (2) reciprocal anchorage derived from the incisal one third of the adjacent teeth (where the lateral extensions or "arms" of the Kilroy Spring contact those teeth on the buccal surface) [Figure 5]. It is critical that a rectangular base wire is used to prevent adverse lingual crown torque of those adjacent teeth. The Kilroy Spring may need to be periodically re-tied or adjusted to maintain a constant force as the tooth erupts.

The Kilroy Spring was designed to produce primarily vertical and some concurrent lateral eruptive forces for palatally impacted canines [Figures 4 and 6-8]. The Kilroy II Spring produces vertical forces and was intended for buccally impacted teeth [Figure 4]. Due to the multiple helices and cantilever design of the Kilroy II, there is a chance of tissue impingement adjacent to the impacted tooth; therefore, more frequent visits to monitor progress are recommended.

The amount of force produced by either Kilroy Spring is increased or decreased by bending the vertical loop toward or away from the impacted tooth prior to its installation [Figure 9]. Due to the flexibility of this device, it can be adjusted to fit the available arch length, even if the space for the impacted tooth is wider or narrower than the impacted tooth. In addition, the vertical loop of the Kilroy Spring

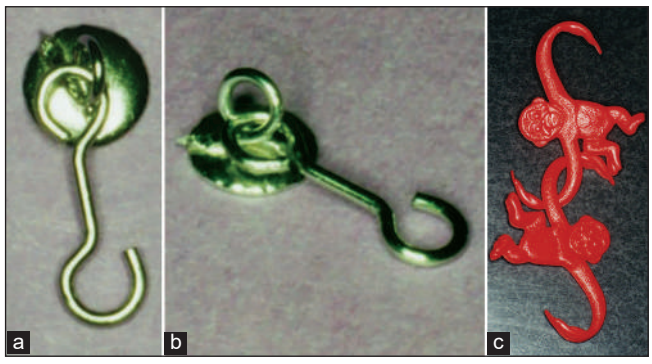

Figure 1: (a and b) The Monkey hook is a section "S-shaped" that is linked to a bondable "loop button." This auxiliary is direct-bonded to an impacted or rotated tooth to permit the addition of directional forces via intermaxillary elastics, superelastic coil springs, or elastic chain or thread. (c) The concept was influenced by the children's game, "Barrel Full of Monkeys"

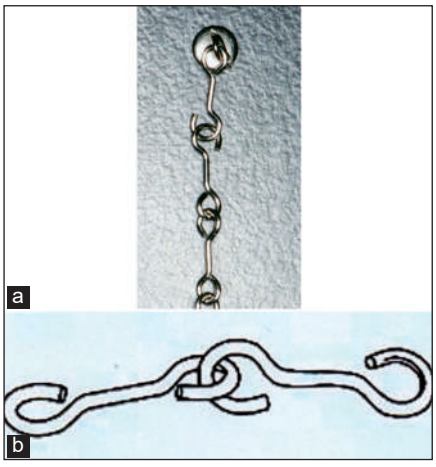

Figure 2: (a and b) Monkey hooks can be linked together to form a chain

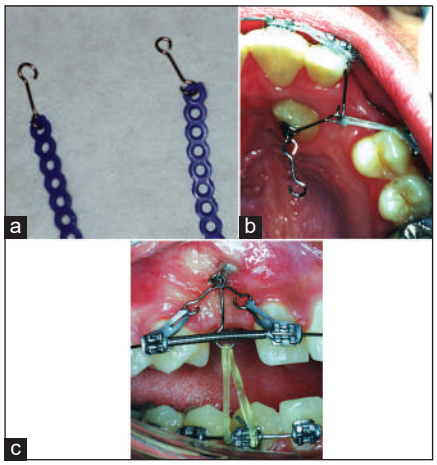

Figure 3: (a) Monkey hooks can be applied to a bonded loop button on a buccally or palatally impacted tooth. (b) Elastic chain, stretched from the Monkey hooks to brackets on the teeth adjacent to an impacted tooth, produce lateral and/or vertical directional forces (i.e., "sling shot" effect). (c) Intermaxillary elastics, supported by the opposite dental arch, can be attached to a third Monkey hook to produce vertical eruptive forces

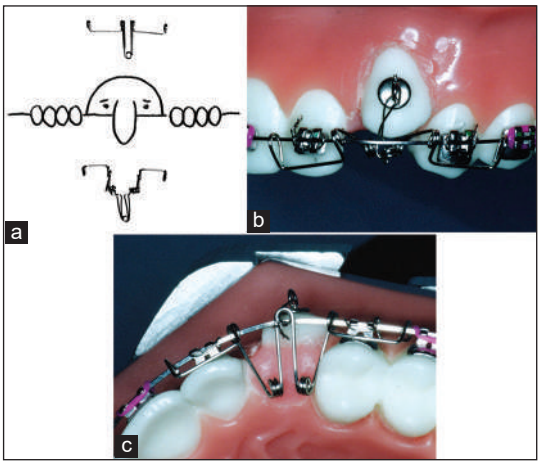

Figure 4: (a) Kilroy Springs, auxiliaries that are slid onto a rectangular continuous arch wire, were designed to produce both vertical and lateral eruptive forces for impacted teeth. The design of the Kilroy I Spring reminded (for palatal canines) the designer of the iconic "Kilroy Was Here" graffiti of the 1940s. (b and c) Kilroy II Spring was designed for use with labially impacted canines. The cantilever nature of the auxiliary requires careful adjustment to balance forces to prevent tissue impingement

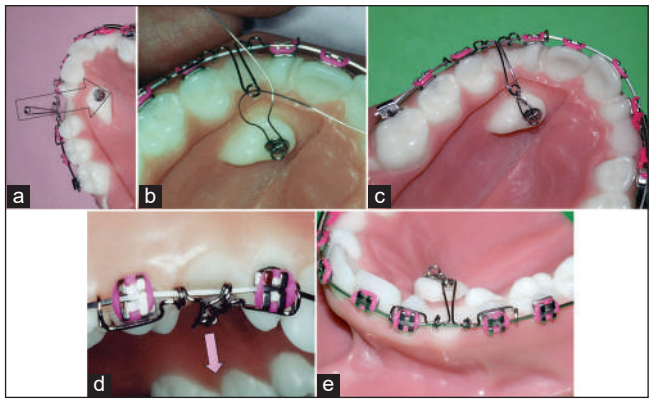

Figure 5: (a) When passive, the vertical loop of the Kilroy Spring is positioned perpendicular to the plane of occlusion. (b) To activate the Kilroy Spring, a stainless steel ligature is passed through the helix, at the end of the vertical loop, and tied to the bonded loop button on the impacted tooth. (c) The vertical loop has been directed to the impacted tooth and secured in place. (d) Vertical and lateral eruptive forces are directed to the impacted tooth by the Kilroy Spring. (e) Support is derived from (1) the continuous rectangular arch wire and (2) the incisal one third of the adjacent teeth as contacted by the extensions of the auxiliary

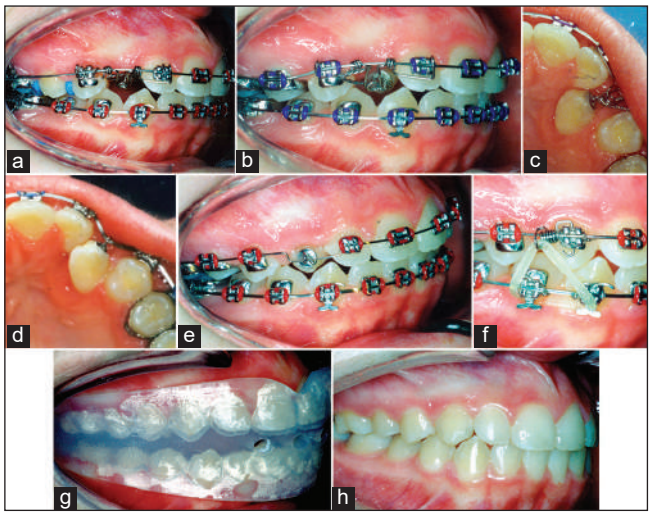

Figure 6: (a) A 13-year-old female with palatally impacted right canine. After surgical exposure and placement of a bonded loop button, a Kilroy Spring auxiliary was ligated to the affected canine as part of typical continuous arch mechanics. (b and c) After 2 months, the tooth has been mildly hyper-erupted. (d) Superelastic wire is inserted through the loop button attachment to direct the tooth labially. (e) A 0.018" stainless steel arch wire was used to "step" the canine into position. (f) Five months after surgical exposure, a bracket is bonded to the canine and a Compliance+ spring® auxiliary is slid onto the round arch wire and secured in the vertical slot of the Butterfly System bracket™[4,5] and an intermaxillary elastic was used to activate the spring to produce labial root torque. (g) Immediately upon removal of the fixed appliances, a positioner was worn 24 hours/day for 1 week to finalize the occlusion and improve the gingival health.[6,7] (h) Final result achieved in 21 months.

can be adjusted to produce some mild force to assist in closing, maintaining, or opening of that space [Figure 9].

ROTATIONAL COUPLES AND RETRACTION WITH THE MONKEY HOOK

Impacted teeth are also frequently rotated and may require directional forces to turn them into appropriate alignment. A second loop button may be bonded to the crown of the affected tooth on the side opposite that of the original attachment. Monkey Hook and elastic chain combinations are connected from each loop button in opposite directions to produce a rotational couple (e.g., forces directed to the lingual cleat of a molar and also directed to the anterior teeth) [Figures 7 and 8]. These Monkey Hook and elastic chain or Niti coil spring combinations can also be used for

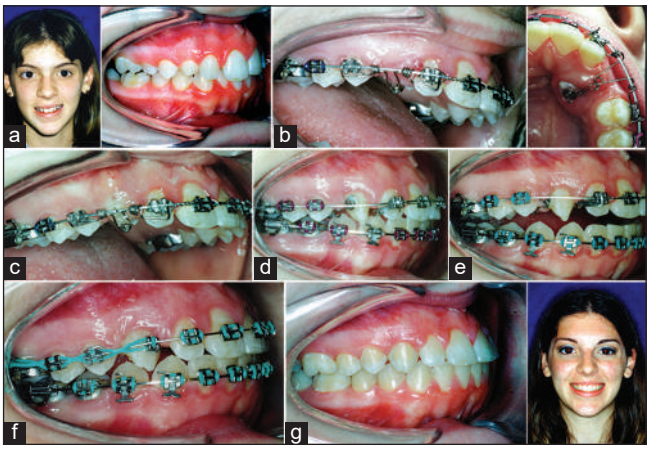

Figure 7: (a) 1,2 Twelve year old female with palatally impacted right canine. (b) 1,2 Kilroy Spring auxiliary was slid onto a rectangular arch wire and the vertical loop was ligated to the bonded attachment on the canine. Reciprocal forces to direct the eruption of the impacted tooth were derived from the adjacent teeth and the arch wire. (c) Vertical and lateral displacement after 4 months. (d) A second bonded attachment is placed on the buccal surface (distal of the canine) and 2 Monkey hooks with elastics chains are connected to the attachments to produce a rotational couple. (e) After 1 month of rotation (f) After 4 months of rotation, a bracket is bonded to the tooth. (g) Final results. Note: Kilroy Spring was in place for 8 months and rotation with the Monkey Hooks required 4 months.

sliding space closure or for retracting individual teeth and can be connected to the heads of mini-screw anchors as well [Figure 10].[8] In these situations, the Monkey Hook is attached to a soldered, crimpable, or vertical slot hook.[4,5] As a "low friction" alternative, a right-angle bend is made at one end of the Monkey hook and then it is "hooked over" the arch wire in the appropriate location to produce retraction [Figure 10].

SUMMARY

Initiating treatment with a bondable loop button (with a linked Monkey hook), attached during the routine surgical exposure of an impacted tooth, provides for a number of mechanical options:

1. Intermaxillary elastics may be employed from the open loop of the Monkey Hook to generate vertical eruptive forces,
2. A pre-formed Kilroy Spring auxiliary may be tied to the Monkey Hook or directly to the loop button for vertical and lateral eruptive forces without dependence upon compliance,
3. Two Monkey hooks (linked to elastic chain) may be added to produce lateral or vertical "sling shot" eruptive forces.

After sufficient eruption of the crown of the tooth, any rotations may be resolved by introducing a rotational couple using two Monkey hooks with elastic chains directing forces in opposing directions from loop buttons applied to opposite sides of the tooth. In addition, the

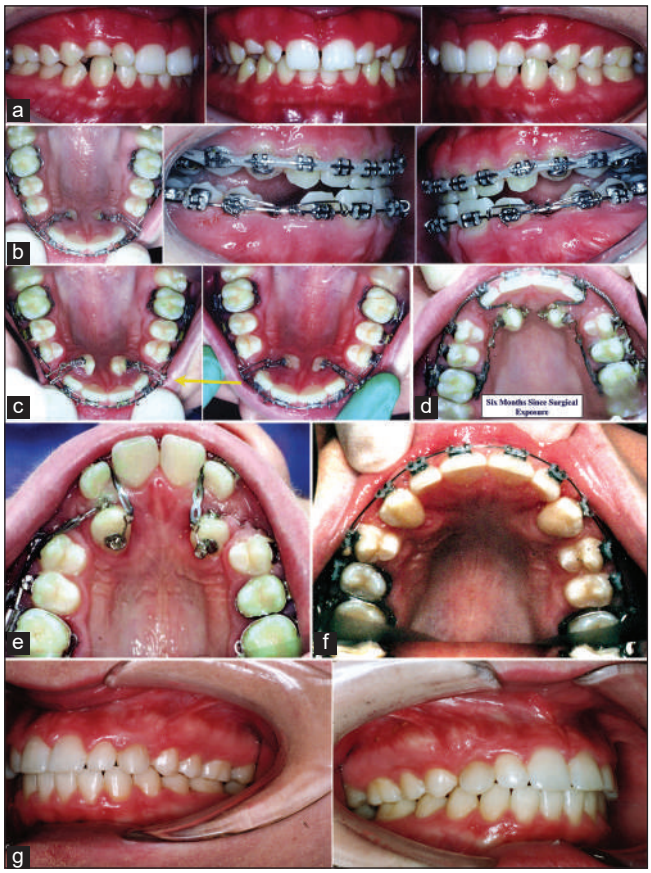

Figure 8: (a-c) A 16-year old female with palatally impacted canines that were surgically exposed and loop buttons were direct-bonded. Kilroy Springs were placed onto a rectangular arch wire and the vertical loops were tied to the bonded attachments with stainless ligatures to direct vertical eruption for 6 months. (d-f) The lingual surface of the crowns were facing labially and required a rotational couple from two Monkey Hooks and elastic chain to rotate them into correct position along with substantial labial root torque and intermaxillary elastics. (g) Treatment completed in 34 months.

base arch wire or a more flexible, auxiliary "overlay" wire may be threaded through the loop on one end of the Monkey Hook or through the lumen of the loop button to complete the directed eruption prior to the placement of a typical bracket on the tooth. The combination of the Monkey Hook, the loop button, and the Kilroy Spring offer simple and predictable solutions for the resolution of impacted and severely rotated teeth.[9-11] Most recently, Yadav and co-workers[12] at Indiana School of Dentistry and University of Connecticut recently reported that the Kilroy Spring "provided the most consistent force direction and minimum changes in other load components. Therefore, unnecessary jiggling of teeth can be minimized."

Another innovative option may be to use an adaptation of the mandibular Traction Arch[13] (a modified lingual arch) using a soldered vertical arm to direct impacted teeth into place. In this scenario, the anchorage to direct the cuspids is derived directly from the anchoring maxillary 1st molars.

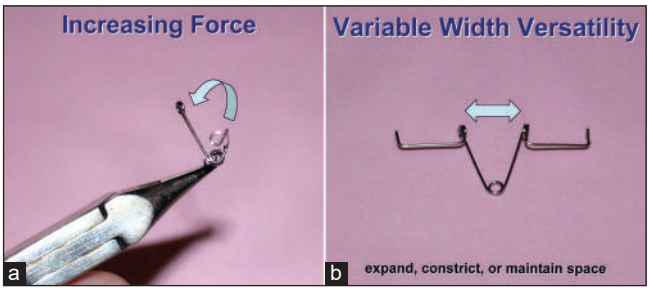

Figure 9: (a) The force produced by the Kilroy Spring can be adjusted by simply bending the vertical loop away from the impacted tooth (more force) or towards the tooth (less force). (b) The Kilroy Spring can be expanded or constricted to fit the available arch length where the impacted tooth is missing or to produce some mild forces for opening or closing that space

POSSIBLE STEPS FOR DIRECTING THE ERUPTION OF AN IMPACTED TOOTH

1. Surgical exposure.
2. Direct bonding a loop button attachment linked with a Monkey Hook.
3. Add a fillet of additional adhesive around, or even over, the bonding base of the attachment to improve retention.
4. Tie a steel ligature from the Monkey Hook to a bracket or the arch wire just stabilize it until forces are applied.
5. Vertical eruptive forces – intermaxillary elastics from the Monkey hook to the opposing arch.
6. Distal directed forces prn – Monkey Hook with elastic chain connected to a cleat or button attachment on the lingual of the first molar.
7. Vertical eruptive forces – Kilroy Spring tied to the Monkey hook or loop button.
8. Sling shot forces – Two Monkey hooks with elastic chain, linked to the loop button, directing the tooth toward the base arch wire. Coil springs on the continuous arch wire are used to open or hold space for the impacted tooth.
9. Rotational couple – loop buttons placed on opposite sides of the tooth with Monkey hooks and elastic oriented in opposite directions to "spin" the tooth.
10. Base arch wire or superelastic "overlay" auxiliary wire threaded through the loop button to center the tooth within the alveolus.
11. Bonding an orthodontic bracket to detail the correction.

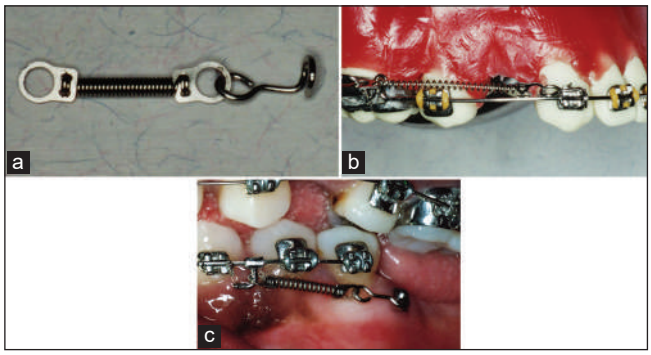

Figure 10: (a and b) Combination of Monkey Hook and superelastic coil spring used to retract individual teeth or dental segments. One end of the Monkey hook is bend 90° and is hooked over the arch wire. (c) Monkey Hooks can also be used to connect from the heads of mini-screws (TADs) to elastic chain or superelastic coil springs[11]

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Current status of temporomandibular joint disorders and the therapeutic system derived from a series of biomechanical, histological, and biochemical studies

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Abstract

This article was designed to report the current status of temporomandibular joint disorders (TMDs) and the therapeutic system on the basis of a series of clinical, biomechanical, histological and biochemical studies in our research groups. In particular, we have focused on the association of degenerative changes of articular cartilage in the mandibular condyle and the resultant progressive condylar resorption with mechanical stimuli acting on the condyle during the stomatognathic function. In a clinical aspect, the nature and prevalence of TMDs, association of malocclusion with TMDs, association of condylar position with TMDs, association of craniofacial morphology with TMDs, and influences of TMDs, TMJ-osteoarthritis (TMJ-OA) in particular, were examined. In a biomechanical aspect, the nature of stress distribution in the TMJ from maximum clenching was analyzed with finite element method. In addition, the pattern of stress distribution was examined in association with varying vertical discrepancies of the craniofacial skeleton and friction between the articular disk and condyle. The results demonstrated an induction of large compressive stresses in the anterior and lateral areas on the condyle by the maximum clenching and the subsequent prominent increases in the same areas of the mandibular condyle as the vertical skeletal discrepancy became more prominent. Increase of friction at the articular surface was also indicated as a cause of larger stresses and the relevant disk displacement, which further induced an increase in stresses in the tissues posterior to the disks, indicating an important role of TMJ disks as a stress absorber. In a histological or biological aspect, increase in TMJ loading simulated by vertical skeletal discrepancy, which has already been revealed by the preceding finite element analysis or represented by excessive mouth opening, produced a decrease in the thickness of cartilage layers, an increase in the numbers of chondroblasts and osteoclasts and the subsequent degenerative changes in the condylar cartilage associated with the expression of bone resorption-related factors. In a biochemical or molecular and cellular aspect, excessive mechanical stimuli, irrespective of compressive or tensile stress, induced HA fragmentation, expression of proinflammatory cytokines, an imbalance between matrix metalloproteinases and the tissue inhibitors, all of which are assumed to induce lower resistance to external stimuli and degenerative changes leading to bone and cartilage resorption. Excessive mechanical stimuli also reduced the synthesis of superficial zone protein in chondrocytes, which exerts an important role in the protection of cartilage and bone layers from the degenerative changes. It is also revealed that various cytoskeletal changes induced by mechanical stimuli are transmitted through a stretch-activated or Ca^{2+} channel. Finally, on the basis of the results from a series of studies, it is demonstrated that optimal intra-articular

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environment can be achieved by splint therapy, if indicated, followed by occlusal reconstruction with orthodontic approach in patients with myalgia of the masticatory muscles, and TMJ internal derangement or anterior disk displacement with or without reduction. It is thus shown that orthodontic treatment is available for the treatment of TMDs and the long-term stability after treatment.

Key words: Articular chondrocyte, condylar resorption, extracellular matrix metalloproteinase, mechanical stimuli, temporomandibular joint-osteoarthritis

INTRODUCTION

Temporomandibular joint (TMJ) consists of hard and soft tissues. Hard tissue is composed of mandibular condyle and glenoid fossa. Meanwhile, soft tissue comprises articular disk, ligament, synovium, and masticatory muscles. It should be noted that synovial joints with articular disks are only temporomandibular, knee and scapuloclavicular joints in humans. Furthermore, the following functional features are found in TMJ.

1. Class III fulcrum: Masticatory muscles act on the dentition, and the residual stress is loaded on the TMJ. Thus, TMJ is accepted as a load-bearing organ.
2. Translatory movement available only in TMJ: Translatory repositioning of the condyle is available only in TMJ in addition to the pure rotation, but not induced in other general joints.
3. Cooperative movement of the condyle and disk: Articular disk located between the articular surface of the condyle and glenoid fossa experiences a cooperative movement with condylar repositioning during mouth opening/closing. Such behavior of the disk exerts a crucial role in stress absorbing.

Temporomandibular joint disorder (TMD) has become an important disease in dentistry and/or orthodontics. Under such background, various studies have been conducted to elucidate the nature and causes of TMD in association with various etiologic factors.[1-4] As a result, TMD is currently accepted as a multi-factorial disease, however, occlusal parameters have also been speculated to have a certain association with TMD.[5,6]

In this article, clinical aspect of TMDs is first discussed with a reference to the relevant clinical parameters key to the onset of TMDs. Then, in order to elucidate the association of various clinical parameters with the nature of stresses acting on the TMJ structures, finite element stress analyses are introduced. Biological and histological changes in the condylar cartilage are then examined when excessive mechanical stimuli are loaded to the mandibular condyle. Finally, in a biochemical aspect, molecular and cellular changes are investigated for cell morphology, amount of extracellular matrices, matrix metalloproteinases (MMPs) and superficial zone protein (SZP) as a protector of the cartilage and subchondral bone when various mechanical stimuli are applied to cultured chondrocytes.

CLINICAL PARAMETERS RELEVANT TO TEMPOROMANDIBULAR JOINT DISORDERS

We would like to first review a series of studies on TMDs and the relevant factors for better understanding the nature of TMDs. These subjects are:

1. The nature and prevalence of TMD,
2. Association of malocclusion with TMD,
3. Association of condylar position with TMD,
4. Association of craniofacial morphology with TMD, and
5. Influences of TMD, TMJ-osteoarthritis (TMJ-OA) in particular, from a clinical viewpoint.

First, prevalence of TMD was examined in an orthodontic patient group. In this survey, the percentage of TMD patients to the total number of patients was approximately 14%.[7] It is surprising to know very high prevalence of TMDs, which are mostly occupied by TMJ internal derangement with various intra-articular pathologic stages, in adolescent patients with malocclusion. It is also of a clinical significance that the adult population has a higher prevalence,[8] and jaw deformity patients exhibit substantially higher prevalence[9] than adolescent patient group and asymptomatic adult volunteers, respectively. Furthermore, it is of a great interest that the prevalence of TMJ-OA is about 18% in all the TMD patients and approximately 2.5% in all the patients.[7]

The second topic is the association of malocclusion with TMDs. The prevalence of TMD was considerably higher in open bite, deep bite, and posterior cross-bite.[10] Thus, some specific types of malocclusion were significantly associated with the occurrence of TMD in patient group. It is also speculated from this finding that condylar displacement in the TMJ space may change disk position relative to the displaced condyle and result in the onset of TMJ internal derangement.[11,12]

The next topic is the association between condylar position in the TMJ space and intra-articular pathologic

status. Condylar position was more posterior in anterior disk displacement with reduction (AWWD), whereas concentric in anterior disk displacement without reduction (ADDWo).[11] It is thus indicated that condylar position is directly relevant to the disk displacement and the nature of TMJ internal derangement or the progress in intra-articular pathologic status from ADDW to ADDWo.[2,4,11]

Then, the association between craniofacial morphology and intra-articular pathologic status was examined by means of the Spearman's rank correlation analysis. The size and position of the mandible presented significantly negative correlations and the mandibular plane and ANB angles exhibited significantly positive correlations with the pathologic stages [Figure 1].[7,13,14] In addition, as a result of correlation analysis for lateral shift of the mandible and intra-articular pathologic stages defined by Wilkes,[14] the amount of mandibular lateral shift presented a significantly positive correlation with the pathologic status of TMDs [Figure 2], indicating that TMDs produce less growth of mandible bilaterally or unilaterally when affected on both sides or one side. It is thus demonstrated from these results that the progress in intra-articular pathologic status is highly related to more severe discrepancy of the craniofacial skeleton in the vertical direction or more prominent lateral shift of the mandible in the transverse direction.

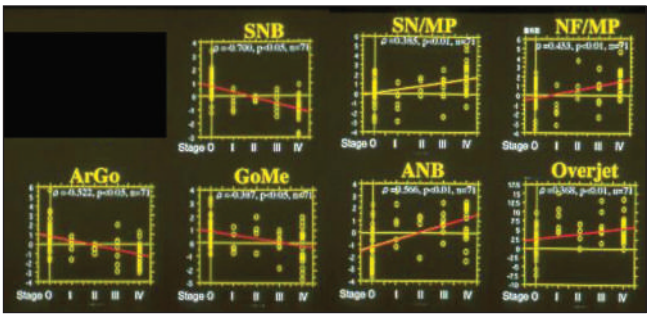

Figure 1: Association between morphology of the craniofacial skeleton and intra-articular pathologic stages, defined by Wilkes, in patients with malocclusion

Figure 3: Jaw deformity patient with distally-located mandible due to progressive condylar resorption after orthodontic treatment

As the influences of TMJ-OA on orthodontic treatment and the outcomes, the morphometric findings mentioned above and the relevant actual TMJ-OA cases provide us with very interesting and useful clinical implications such that condylar resorption in TMJ-OA produces jaw deformity with less developed and distally located mandible and affects the outcomes and stability of occlusal reconstruction.[1,7,9,15,16] Figures 3-6 show a case of TMJ-OA appeared during retention after orthodontic treatment. She exhibited open bite with Class II molar relation [Figure 3]. On the lateral cephalogram and in the analysis, distally-located and more divergent mandible with less developed condyle due to condylar resorption was revealed [Figure 4]. This case was first treated with functional appliance and then followed by edgewise technique under non-extraction [Figure 5]. However, during the retention, open bite was induced by progressive condylar resorption (PCR), indicating that TMJ-OA affects orthodontic treatment and the outcomes substantially [Figure 6].

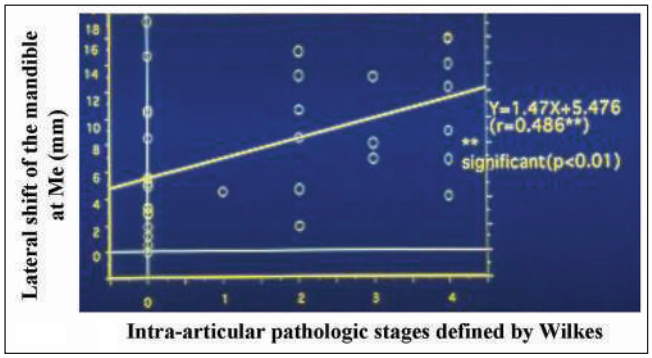

Figure 2: Association between lateral shift of the mandible with intra-articular pathologic stages, defined by Wilkes, in adult patients with jaw deformity

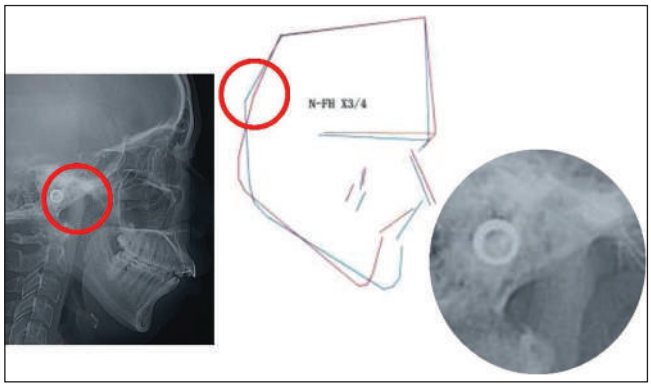

Figure 4: Lateral cephalogram and the analysis a red circle shows the condyle, which is enlarged on the right. It is prominent that the condyles exhibit resorption at the anterior surface, leading to a mesial shift of "Ar" and the resultant characteristic inclination of the mandibular ramus, which is common to patients with condylar resorption from temporomanidular joint-osteoarthritis

On the contrary, it is demonstrated in the treatment cases of TMJ-OA that the sable occlusion achieved by orthodontic occlusal reconstruction has produced biomechanical equilibrium in the TMJ and subsequently provided the condyle with a potential for adaptive or functional remodeling.[17] The details will be shown later in the final part of this article.

These findings are very useful for understanding the nature of TMDs and the mechanisms of degenerative changes in condylar cartilage, which may be hypothesized reasonably that various morphological and functional parameters produces an increase in TMJ loading, which further leads to degenerative changes in the articular cartilage of the mandibular condyle and resorption of bone and cartilage expressed as a TMJ-OA.

To demonstrate the above hypothesis, the association between degenerative changes of articular cartilage and mechanical stimuli was examined by a series of studies with biomechanical, histochemical and biochemical approaches.

BIOMECHANICAL CONSIDERATION FOR THE MECHANISMS OF DEGENERATIVE CHANGES IN CONDYLAR CARTILAGE

Temporomanidular joint loadings from maximum clenching

There have been various studies on TMJ loading by use of finite element stress analysis.[18-24] Among these studies, a report by Tanaka *et al*.[23] can be cited as a representative and frontier study for TMJ loading in the field of biomechanics. In this study, a three-dimensional model of the mandible, including the TMJ was constructed for stress analysis with finite element method [Figure 7]. For loading conditions, the magnitude of muscle forces was determined to exert a resultant force of 500 N, simulating the maximum clenching. Large compressive stresses were induced in the anterior, middle and lateral regions, whereas tensile stresses

Figure 5: Changes in occlusion before and after orthodontic treatment and during retention

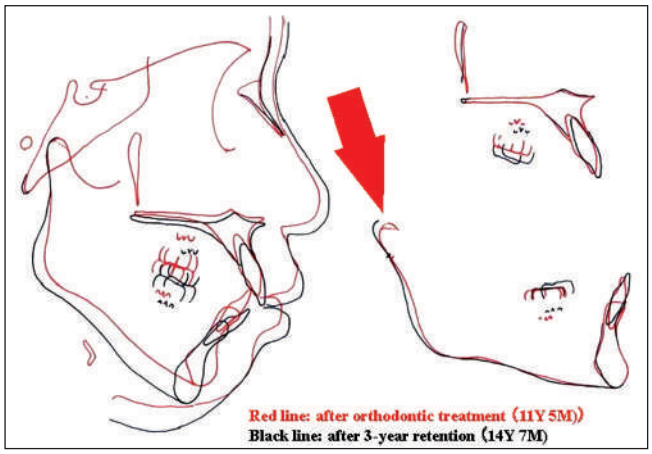

Figure 6: Changes in the position of mandible after orthodontic treatment due to progressive condylar resorption a red arrow indicates an existence of condylar resorption at the anterior surface of condyle during retention. An existence of condylar resorption at the anterior surface of condyle during retention

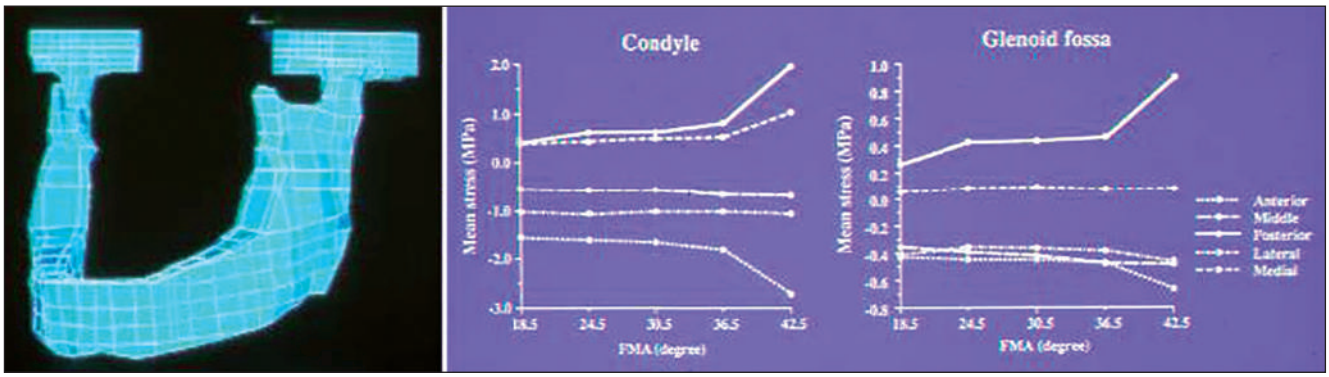

Figure 7: A three-dimensional finite element model of the mandible including the temporomanidular joint (left) and changes in stresses in the condyle and glenoid fossa in association with vertical skeletal discrepancy simulated by varying FMAs (right)

Table 1: Mean stresses in the TMJ structures during maximum clenching

	Anterior	Middle	Posterior	Lateral	Mesial
Condyle	−1.642	−0.543	0.664	−1.017	0.521
Glenoid fossa	−0.440	−0.410	0.445	−0.351	0.103
Articular disk	−0.403	−0.200	0.258	−0.342	0.041

TMJ – Temporomanidular joint

were found in the remaining areas [Table 1]. In particular, the greatest compressive stresses were found in the anterior region of condyle.[23]

The results may be compared with previous anatomic and experimental findings. Oberg *et al*.[25] demonstrated in a study with cadavers that erosion and ruggedness of the bony structures and thinning and/or perforation of the articular disk were more frequently observed in the anterior and lateral areas of the TMJ. Kopp[26] also reported a higher concentration of glycosaminoglycan, which is regarded as a marker of compression, in the anterior and lateral areas of the TMJ. Thus, the greater compressive stresses in the anterior and lateral areas revealed in the above study may account for the various degenerative changes in the articular disk and condyle reported in the anatomic studies[25,26] and clinical cases of TMJ-OA.[1,7,15-17]

Temporomandibular joint loadings varied by vertical skeletal discrepancy

In previous morphometric and radiographic studies,[7,9,13,15] vertical discrepancy was revealed as a key determinant for the intra-articular pathological status of TMD. Thus, the stress distributions were analyzed in association with the discrepancy with an assumption that such morphologic parameter affects the nature of TMJ loading.[24] For stress analysis, the model developed above was modified to represent vertical discrepancies of the craniofacial complex by changing the shape of mandible, maintaining the number of nodes and elements in the standard model. The gonial and mandibular plane angles were changed with a special reference to the means and standard deviations. These stresses were changed in association with varying mandibular plane angles and exhibited more substantial changes than those with varying gonial angles.[24] Changes in the stresses were nonlinear in nature and particularly drastic when the angle became larger than a certain threshold value [Figure 7].

It is thus demonstrated that vertical skeletal discrepancy induces an increase in TMJ loading and lack in biomechanical equilibrium for the TMJ components. These results may help explain the finding that malocclusions with vertical discrepancies have a higher prevalence of TMD than others.[5,10] This may be due to the malposition of condyle in the glenoid fossa in TMD cases with vertical discrepancies.[10-12] Another explanation is that a lack in biomechanical equilibrium in the TMJ induced by the skeletal discrepancies may produce nonlinear and plastic deformation of the articular disk observed in a tensile test of the disk[27] and more extensive degenerative changes in the mandibular condyle with articular cartilage. These speculations are to be examined later in terms of biologic and biochemical responses of articular cartilage by *in vivo* and *in vitro* experiments.

Association of friction at the articular surface with temporomandibular joint loading and disk displacement

During mouth opening, condylar movement essentially requires cooperative disk motion. When the disk slides on the articular surface, shear stress is induced but negligible because of the very low friction.[28] Furthermore, the presence of synovial fluid decreases the frictional coefficient to almost zero.[29] Meanwhile, under various pathological conditions with intra-articular inflammation and degradation of hyaluronan (HA), an increase in friction at the articular interfaces is generated eventually.

Given these considerations, a biomechanical study with finite element analysis was conducted to assess the stress distribution and disk displacement during mouth opening in association with different frictional coefficients. It is demonstrated that an augmentation in the friction at the articular surface produces an increase in stresses and the subsequent disk displacement, leading to the onset of TMJ internal derangement or the more progressed form with degenerative changes.[30] Changes in stress distribution in the TMJ were also reported in previous studies by Foster and Fisher[29] and Williams *et al*.[31] It is also indicated that the amount of friction is increased proportionally to the magnitude and duration of TMJ loading, relating in part to the onset of disk displacement.[32]

Thus, friction at the articular surface is a key determinant for maintaining optimal intra-articular environment which allows smooth movement of the condyle. Therefore, it is of a great significance to eliminate excessive friction at the interfaces between TMJ structures. To this end, various lubricants equivalent to the synovial fluid has been used not to make progress in intra-articular pathology. HA addition, as an application of lubricant, will be introduced in the following section.

Friction at the articular surface and lubrication function

When the TMJ disk slides along the articular surfaces during jaw movement, shear loading of the disk can be considered to be negligible, due to very low friction.[28] Friction in synovial joints, in general, is associated with its

lubrication mechanism,[33] which in turn is dependent on the rheological properties of synovial fluid.

Hyaluronan (HA), which occupies 0.14-0.36% of synovial fluid in normal subjects,[34] is one of the principal components determining its rheological properties. The amount of viscosity, an essential determinant for the lubrication function, is dependent on the molecular weight.[35] In joints affected with OA, meanwhile, the synovial fluid has a reduced viscosity due to a decline in both concentration and molecular weight of HA.[36]

Given these findings, Kawai *et al*.[37] examined the role of HA in the lubrication of the TMJ. They measured the frictional coefficients in the porcine TMJ after the application of HA with different molecular weights and concentrations. Application of HA resulted in a significant decrease in the frictional coefficient by 50-70%. This study thus reached a conclusion that the addition of HA did reduce the coefficient of friction under the experimental conditions, supporting an assumption that the most superficial layer plays a significant role in the adequate lubrication function, which apparently can't be established by the physical action of cartilage alone but by a cooperative function of various TMJ components.[37]

Role of the articular disk in buffering or absorbing stresses on the temporomandibular joint components

It is well understood that TMJ is one of load-bearing organs in the human body, and the disk plays an important role as a stress absorber, resulting in stress reduction and redistribution in the joint.[38-40] For maintaining optimal intra-articular environment, therefore, two major factors can be indicated; that is healthy disk and optimal positional relation between the disk and bony components.

Mechanical behavior of the disk has already been examined extensively. The elastic and viscoelastic features are described by various parameters such as elastic modulus, instantaneous modulus, relaxed modulus and the strain-relaxation time.[27,41-43] In addition, viscoelastic material model was examined for TMJ disk, demonstrating that a four-mode Maxwell model is more suitable for representing mechanical behavior of the disk during stress absorption.[44]

Furthermore, Tanaka and van Eijden[45] published a review about the fundamental concepts of the biomechanical behavior of the TMJ disk. In conclusion of the review, they described that the TMJ disk behaves as a viscoelastic structure and can function as a stress absorber and distributor. This means a biomechanical contribution of the disk to prevent stress concentration and excessive stress in the cartilage and bony components of the joint, all of which protect the joint from degenerative and osteoarthritic changes. They also discussed the disk wear in the anterior[26] and intermediate[46] regions. As mentioned in the preceding sections in this article, these phenomena have already been explained in association with excessive loading validated by finite element stress analyses[18-20,23] and histological or histochemical examination which revealed stress concentration by the presence of chondroitin sulfate.[47,48] In addition, it was demonstrated in a previous study[21] that stresses in the retrodiscal tissues were increased by anterior disk displacement and may lead to the thinning and perforation, indicating an important role of the disk as a stress absorber. It is also of a great significance to keep it in mind that the mechanical properties are varied by various intrinsic and extrinsic factors such as aging, trauma and pathologic disease.[45]

Recently, we have examined if the breakdown of joint lubrication affects mandibular condylar cartilage's frictional property and leads to subsequent degenerative changes in TMJ.[49] The frictional coefficient was measured in porcine TMJ by a pendulum device after digestion with hyaluronidase (HAase) or trypsin. Gene expressions of interleukin-1 β (IL-1 β), cyclooxygenase-2 (COX-2), MMPs, type II collagen and histology were examined after prolonged cyclic loading by an active pendulum system. The results showed that the frictional coefficient increased significantly after HAase (35%) or trypsin (74%) treatment. Gene expression of IL-1 β, COX-2 and MMP-1, 3 and 9 increased significantly in enzyme-treated TMJs after cyclic loading. The increase was greater in trypsin-treated group than in HAase-treated group. Type II collagen expression was also reduced in both enzyme-treated groups. Histology revealed surface fibrillation and increased MMP-1 in trypsin treated group, as well as increased IL-1 β in both enzyme-treated groups after cyclic loading. These findings have demonstrated the compromised lubrication in TMJ is highly associated with altered frictional properties and surface wear of condylar cartilage, accompanied by the release of proinflammatory and matrix degradation mediators under mechanical loading.[49]

BIOLOGICAL AND HISTOLOGICAL CONSIDERATION FOR THE MECHANISMS OF DEGENERATIVE CHANGES IN CONDYLAR CARTILAGE

Histochemical changes in the condylar cartilage in response to excessive temporomandibular joint loading resulted from simulated vertical skeletal discrepancy

In the preceding section, various biomechanical studies have shown the presence of excessive or imbalanced mechanical stresses on the TMJ structures. Furthermore, it should be noted that TMJ internal derangement with

degenerative changes may be relevant to such morphologic characteristics of the mandible as steep mandibular plane, and short ramus expressed as vertical skeletal discrepancies. Therefore, biological responses of condylar cartilage to enhanced TMJ loading, produced by vertical skeletal discrepancy simulated in biomechanical analysis, are discussed herein with a special reference to the remodeling of cartilaginous tissues on the mandibular condyle.

First, an *in vivo* study with histochemical and morphometric approaches is introduced.[50] They simulated vertical skeletal discrepancies in 4-week-old rats by use of a 1 mm - thick metal plate bonded onto the maxillary molars [Figure 8]. In fact, a backward and downward rotation of the mandible was confirmed on serially taken lateral cephalograms, indicating an increase in the TMJ loading on the condyle. The tissue sections were stained with tartrate-resistant acid phosphatase (TRAP) and hematoxylin and eosin for histomorphometric analyses of the thickness of cartilage layers and the number of TRAP-positive cells. During the initial phase of the experiment, the thickness of proliferative and hypertrophic zones in the anterior and superior regions of the condyle was significantly smaller than in the control. The number of TRAP-positive cells was significantly greater in the experimental group than in the controls at the initial phase of the experiment [Figure 9]. Morphometric analyses revealed less-developed mandible, decreased ramus height and large gonial angle in the experimental group [Figure 10]. From these findings, it is shown that biomechanical changes in the intra-articular environment associated with vertical skeletal discrepancy influences or inhibits cartilaginous growth of the condyle and mandible to a considerable extent if induced during growing period.[50]

Various studies have shown that responses of the condylar cartilage may be altered by changes in the biological and biomechanical environments in the TMJ space.[51-53] Similar changes were demonstrated in experimental animals when the incisors were trimmed or removed.[51] McNamara[54] investigated the influences of increases in the vertical dimension on craniofacial adaptation in growing monkeys, demonstrating that the amount of vertical growth at the condylar head was decreased, which is assumed due to reduced cartilaginous remodeling and growth. From these studies, it is emphasized that mechanical stimuli acting on the condyle surely reduce cartilaginous remodeling, if excessive, leading to a decrease in the growth of overall condyle and mandible, which in turn produces vertical skeletal discrepancies with small mandible. Subsequently, such morphologic characteristics would produce enhanced TMJ loading and degenerative changes in the TMJ components.[50]

Changes in the condylar cartilage and masticatory muscles from excessive temporomandibular joint loading due to forced mouth opening

Another *in vivo* experiment is introduced herein to examine pathological changes in the condylar cartilage from excessive mouth opening, which is speculated to generate an increase in TMJ loading on the condyle and glenoid fossa, and the subsequent masticatory muscle disorders. Kawai *et al*.[55] examined the association of mechanical loading with the induction of OA-lesion in the rat TMJ and its influence on jaw muscle activity. Mechanical stress was applied to the rat TMJ by forced mouth opening of 3 h/day for 5 days. As a result, the condylar cartilage exhibited OA-like lesions with a decrease in the number of chondrocytes

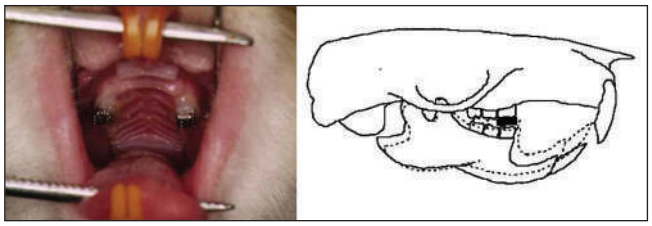

Figure 8: An experimental appliance (left) to induce backward and downward displacement of the mandible (right) and the resultant increase in stresses acting on the condyle, which is demonstrated in the preceding finite element analysis

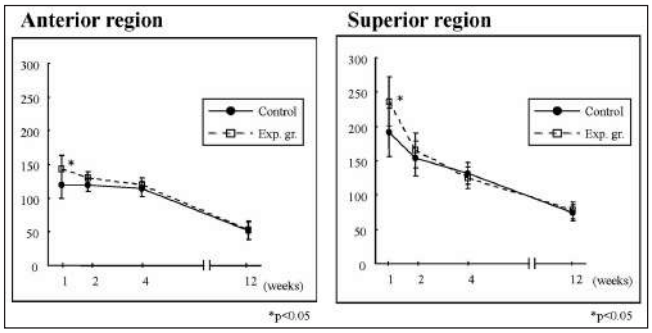

Figure 9: The number of tartrate-resistant acid phosphatase -positive cells, key to condylar resorption, in the anterior (left) and superior (right) cartilage layers on the mandibular condyle

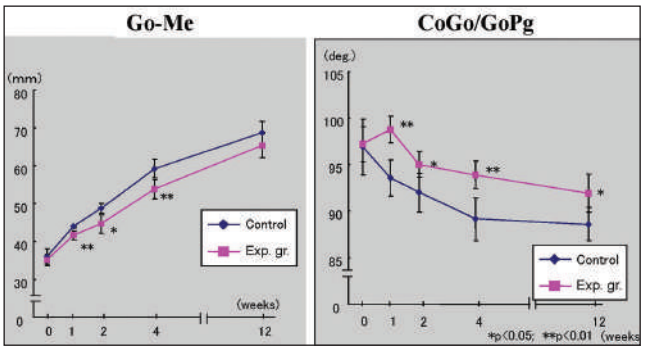

Figure 10: Changes in the size and shape of mandible produced by simulated vertical skeletal discrepancy and the resultant increase in mechanical stresses acting on the condyle

immediately after the experiment. Immediately after the beginning of forced mouth opening, the total duration of muscle activity, defined as a duty time, increased significantly in the masseter muscle, whereas decreased significantly in the digastric muscle at the low activity level. These results suggested that mechanical overloading to the TMJ induced OA-like lesion and the intra-articular pathological status influenced the nature of jaw muscle activity, at a low activity level in particular.

Similar study was conducted in growing rats subjected to forced mouth opening to increase mechanical stress on the mandibular condyle.[56] As a result, marked OA-like lesions were observed in the condyle. In addition, vascular endothelial growth factor (VEGF) was detected in the chondrocytes of the mature and hypertrophic cell layers of the intermediate and posterior regions of the condyle. The percentage of VEGF immune-positive chondrocytes significantly increased with longer application of excessive TMJ loading. Furthermore, TRAP staining of the condylar cartilage showed a significant increase in the number of osteoclasts in the mineralized layer subjacent to the hypertrophic layer where high VEGF expression was detected, suggesting an important role of VEGF in the progression of TMJ-OA.[56]

These findings were also found in previous studies,[57,58] demonstrating the expression of VEGF with an ability to induce osteoclasts in association with excessive mechanical stress. Freemont *et al*.[59] reported that VEGF expression in chondrocytes is induced by high-intensity stress and acts in cartilage as an autocrine inducer of MMPs. Furthermore, Forsythe *et al*.[60] described that VEGF induction in chondrocytes by excessive mechanical stimuli is linked to activation of the hypoxia-induced transcription factor-1 (HIF-1), which is well known to bind to hypoxia response element in the human VEGF gene promoter. It may be a conclusion from these studies that VEGF is probably induced in chondrocytes by excessive mechanical stimuli, facilitating hypoxia to mediate degenerative or destructive processes with the induction of MMPs as an autocrine factor.[56]

BIOCHEMICAL CONSIDERATION FOR THE MECHANISMS OF DEGENERATIVE CHANGES IN CONDYLAR CARTILAGE

Biological and biochemical responses of articular chondrocytes to excessive mechanical stress

Articular cartilage contains a large amount of matrix macromolecules such as proteoglycan and type II collagen. These molecules contribute to the flexibility of cartilage and protection of the joint components from various mechanical stimuli. It is indicated that the mechanical load of appropriate magnitude is essential for the growth and differentiation of chondrocytes. On the other hand, excessive loads influence harmfully the articular cartilage and induce various degenerative joint diseases.[61] It is suggested that excessive or imbalanced mechanical loads induce deformation of the articular cartilage and the subsequent degradation of the cartilage matrices. Jeffrey *et al*.[62] reported a loss of matrix components depending on the degree of mechanical stimuli when articular cartilage biopsy samples were subjected to a single impact load.

In order to elucidate the mechanisms of degradation of the cartilage matrix, various studies have been conducted and demonstrated that proteolytic enzyme, MMP, is a major factor to degrade the macromolecules of connective tissue matrices at neutral PH.[63,64] A lack in balance between MMPs and the tissue inhibitors, TIMPs, was indicated as a cause of matrix degradation.[65] Proinflammatory cytokines such as IL-1beta and TNF-alpha were also demonstrated to have a close relation to the expression of MMPs.[59,66,67] In addition, HA fragmentation or reduced HA synthesis, induced by HAase and inflammatory cytokines respectively, was demonstrated as an important event for pathologic and degenerative changes in chondrocytes and synoviocytes.[68-71]

Furthermore, Honda *et al*.[72] designed a series of studies of biological and biochemical responses of articular chondrocytes to an excessive tensile stress. Chondrocytes, isolated from the knee joint cartilage of 4-week-old rabbits, were subjected to a high magnitude tensile stress of 17 kPa at a frequency of 30 cycles/min for 12 h or 24 h [Figure 11]. They examined the protein levels of cartilage matrices and the gene expressions of MMPs, TIMPs, and proinflammatory cytokines. A change in cell morphology from a polygonal to spindle-like shape was observed. Toludine blue staining, type II collagen immunostaining, and an assay of the incorporation of [^{35}S] sulfate into proteoglycans revealed a decrease in the level of cartilage-specific matrices such as type II collagen and HA in chondrocyte cultures [Figures 12 and 13]. Furthermore, the cyclic tensile stress increased mRNA levels of MMP-1, 3, and 9, IL-1 beta, TNF-alpha and TIMP-1 in the cultured chondrocytes [Figure 14], whereas the levels of MMP-2 and TIMP-2 were unchanged.[72]

Malek and Izumo[73] reported that endothelial cells in loading with fluid flow stress changed to spindle shape and aligned in the flow direction. The mechanism is also assumed to be dependent on tyrosine kinase activity, intracellular calcium, and an intact microtubule network. It is thus suggested that the stretched load may affect the cell morphological change, but not affect the cell alignment.

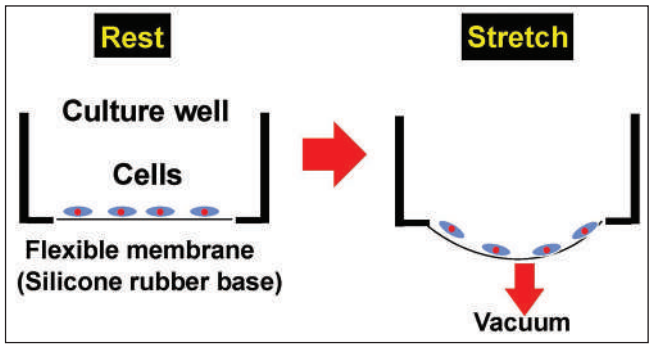

Figure 11: Vacuum-induced tensile stress loading to cultured articular chondrocytes

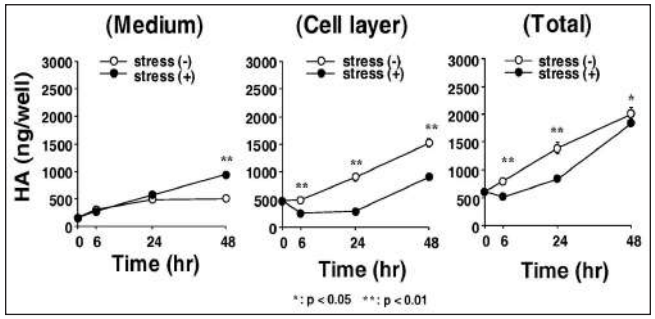

Figure 13: Changes in the level of hyaluronan in cultured articular chondrocytes in loading with excessive tensile stresses

With respect to the expression of MMPs, TIMPs and proinflammatory cytokines, cytoskeletal deformation induced by cellular changes in morphology was indicated.[74] Furthermore, the cytoskeletal deformation was indicated to be associated with regulation of the gene expression for ECM properties.[75] Meanwhile, it is speculated if the expression of MMPs is a direct effect of excessive mechanical stimuli or an indirect effect through the stimulation of various cytokines such as IL-1 beta and TNF-alpha. With respect to this question, Honda *et al*.[72] derived an interesting finding that the gene expression of MMP-1, 3, and 9 was observed in the loaded cultures treated with cycloheximide, indicating that the induction of MMP mRNA is not pertinent to the stimulation of cytokines and other inflammatory products. It is also reported that the gene expression of MMP-1, 3, and 9, but not MMP-2 is regulated by the activation of protein kinase C (PKC) in vascular smooth muscle or chondrocytes[76,77] and that a cyclic tensile load activates PKC in chondrocytes.[77]

Furthermore, Ohno *et al*.[78] detected an existence of superficial zone protein (SZP), a protector for articular cartilage against excessive mechanical stimuli, in the mandibular condyle. In addition, it is shown that the amount of SZP is reduced by excessive mechanical stimuli acting on the cultured chondrocytes,[79] indicating an important role of SZP in the prevention of degenerative changes in the cartilage and the subsequent onset of

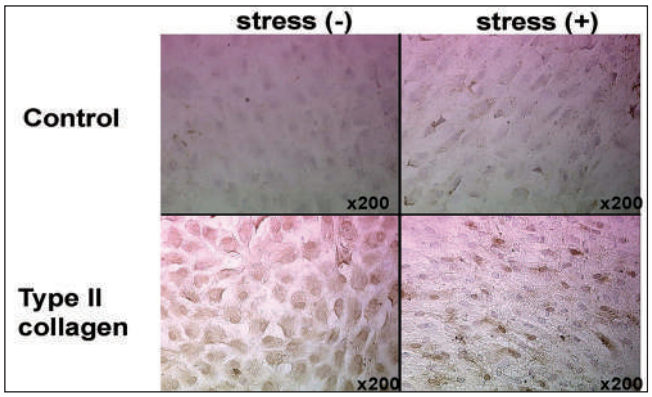

Figure 12: Changes in the synthesis of type II collagen in cultured articular chondrocytes in loading with excessive tensile stresses

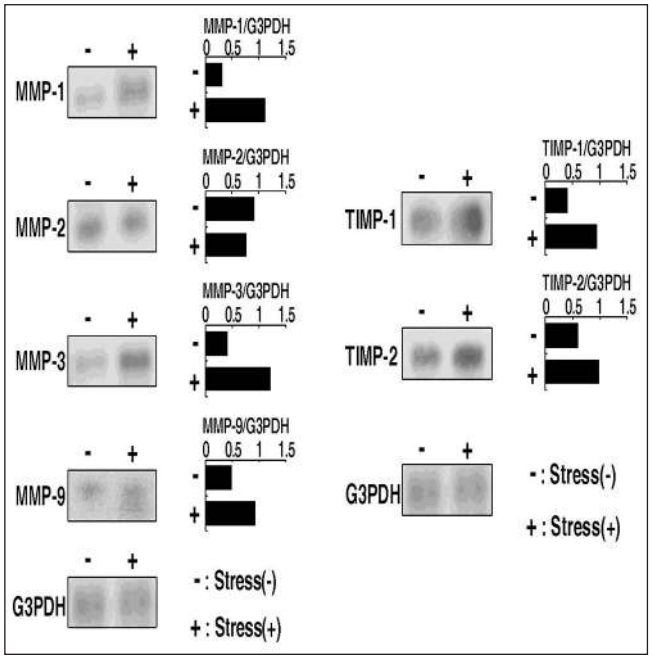

Figure 14: Influences of excessive tensile stresses on mRNA levels of matrix metalloproteinases and TIMPs in cultured articular chondrocytes

progressive condylar resorption (PCR) frequently observed in clinical orthodontics, in female patients in particular.

It is thus shown that excessive stresses induce changes in cartilage cell morphology, reducing a synthesis of SZP and cartilage matrices such as type II collagen and proteoglycan, leading to lower resistance of cartilage tissues to external stimuli. Direct effects of the excessive mechanical stress were observed for the induction of MMPs even in the absence of protein synthesis through the recognition of cytoskeleton and activation of PKC following cellular changes in shape. Finally, it is demonstrated that induction of MMPs and proinflammatory cytokines and quantitative imbalance between MMPs and TIMPs directly produce the destruction of cartilage matrices leading to bone or cartilage resorption in the mandibular condyle.

Effects of mechanical stimuli with different frequencies on the metabolism of chondrocytes

In the preceding discussion, the influences of excessive mechanical stimuli on the metabolism of articular cartilage have been well documented with the speculated mechanisms. The remaining parameters of mechanical stimuli, that is compressive or tensile, static or dynamic, high or low frequency, and so on, have to be taken into considerations with a special reference to biologic and cellular responses.

Mechanical loading is classified into static and dynamic ones by its frequency. Various studies conducted using cartilage tissue explants have demonstrated that sustained loading induced the reduction of cartilage metabolism,[80,81] whereas intermittent mechanical stimulation enhanced cartilage metabolism irrespective of the loading type, tension, and compression.[82-84]

From these considerations, influences of loading frequency on the metabolism of chondrocytes was examined.[85] Intermittent tensile stress upregulated the syntheses of DNA and proteoglycan in chondrocytes at the proliferating stage and matrix-forming stages, respectively. Especially, an intermittent tensile stress with 30 cycles/min or the higher frequencies increased significantly the chondrocyte metabolism. Intermittent compressive stress also significantly enhanced the syntheses of DNA and proteoglycan in chondrocytes, whereas sustained compression significantly decreased these syntheses. These findings suggest that the proliferation and differentiation of growth plate chondrocytes are regulated by the mechanical loading and that the chondrocyte metabolism is enhanced with an increase in the frequency.

One possible mechanism for the cell recognition about mechanical stimuli may be explained by a fact that changes in the level of intracellular calcium ions ($[Ca^{2+}]i$) is caused by the fluid flow,[86] which may be generated by cyclic loading and release of osmotic pressure to the collagen gel. Therefore, intermittent stresses might induce the intra- or extra-cellular Ca^{2+} mobilization, resulting in the promotion of chondrocyte metabolism.

In conclusion of this section, the metabolism of chondrocytes is significantly enhanced by the intermittent mechanical stress even if the magnitude is lower, suggesting that the frequency of mechanical stress may be the most important factor for modulating the metabolism of chondrocytes.

Signal transmission of mechanical stimuli through cell surface ion channels

Association of biologic and cellular changes with mechanical stimuli has been well documented in the preceding sections. Therefore, based on an evidence that mechanical stress regulates chondrocyte proliferation and differentiation via some cell surface ion channels,[87] Tanaka *et al*.[88] examined if a specific ion channel is involved in the cascade during the induction of PTHrP by mechanical strain. Cyclic mechanical strain, applied to rat growth plate chondrocytes at a frequency of 30 cycles/min, significantly increased PTHrP mRNA levels in chondrocytes. The induction of PTHrP was inhibited by nifedipine, a Ca^{2+} channel blocker, but not by the blockers of stretch-activated (S-A) channel.

Yellowley *et al*.[89] showed that the fluid flow caused mobilization of intracellular Ca^{2+} in articular chondrocytes by the activation of G-protein. Furthermore, it was reported that either intra- or extra-cellular Ca^{2+} mobilization was highly associated with regulation of chondrocyte proliferation and maturation. Therefore, when the cyclic mechanical forces are applied to the bottom of the Flexercell dishes, the cells are exposed to fluid flow stress,[88,89] which may consequently up-regulate the expression of PTHrP mRNA through a signal transduction pathway via the mobilization of Ca^{2+}.

Meanwhile, Motokawa *et al*.[90] examined the influences of Gd^{3+} (gadolinium), an S-A channel inhibitor, and nifedipine as an L-type calcium channel blocker for the expression of VEGF and M-CSF in osteoblastic cells with mechanical stimuli. Gadolinium treatment reduced the amount of mRNA and protein concentration, but the nifedipine had no effect. These findings suggest that cyclic tensile forces increase the expression of VEGF and M-CSF in osteoblastic MC3T3-E1 cells via S-A channel. They explained these findings by a hypothesis that the mechanical stress-activated cellular mechanotransducer such as mechanosensitive ion channel, cytoskeleton, and integrins. S-A channel is a membrane stretch-activated ionic channel, which is localized in osteoblast-like cells.[91] Naruse and Sokabe[92] showed that stretching cellular membranes increased intracellular Ca^{2+} concentration in human umbilical endothelial cells, and that the Ca^{2+} response disappeared when extracellular Ca^{2+} was removed or treated with Gd^{3+} which is a potent blocker for the S-A channel. It was also demonstrated that cell orientating and elongating responses of cultured endothelial cells to cyclic stretch were inhibited by the removal of external Ca^{2+} or by adding Gd^{3+}.[93] These findings suggest that cell orientating and elongating are mediated by Ca^{2+} permeable S-A channels that exist on the membrane of endothelial cells. Recently, the eukaryotic gene (Mid1) encoding S-A channel was identified from yeast. It was revealed that Mid1 acts as a calcium-permeable, cation-selective stretch-activated channel.[94] Thus, it may be confirmed that mechanical stretch to osteoblastic MC3T3-E1 cells might cause them

to express VEGF and M-CSF mediated by the S-A channel, indicating that the signal transmission of mechanical stimuli to osteoblasts is different from that to chondrocytes, elucidated previously by Tanaka *et al*.[88]

Recently, Okamoto *et al*.[95] examined a signaling pathway from excessive mechanical stimuli to cellular and molecular changes and clarified that excessive mechanical stress activates integrin αV and affect the signaling pathway through phosphorylation of FAK, ERK and NF-κB in chondrocytes. Moreover, they suggested that the signaling pathway may modulate the cartilage turnover by regulating the expression of COX-2, IL-1 β, TNF-α, MMP3 and MMP13, although these findings may require further investigation in detail in near future.

In conclusion, on the basis of a series of researches, induction mechanisms of degenerative changes in articular cartilage and PCR regarded as TMJ-OA are depicted schematically in Figure 15.[96] An induction of large compressive stresses in the anterior and lateral areas on the condyle was recognized as an initial factor. Increase of friction at the articular surface was indicated as a cause of the larger stress and the relevant disk displacement. Excessive stresses on the condyle induced a decrease in the thickness of cartilage layers and an increase in the numbers of clast cells. Degenerative changes in the condylar cartilage and the expression of bone resorption-related factor were also observed. In a biochemical aspect, excessive mechanical stimuli, irrespective of compressive or tensile one, induced HA fragmentation, expression of proinflammatory cytokines and VEGF, an imbalance between MMPs and TIMPs, all of which are assumed to induce lower resistance to external stimuli and degenerative changes leading to bone and cartilage resorption. Furthermore, condylar resorption affects intra-articular mechanical environment which further induce degenerative

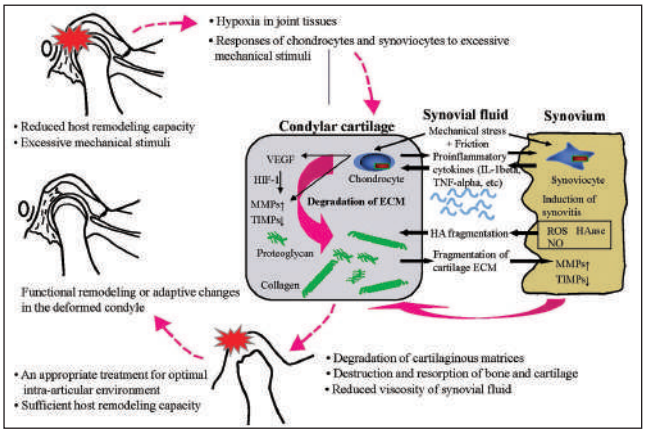

Figure 15: Induction mechanisms of degenerative changes in articular cartilage and progressive condylar resorption regarded as temporomanidular joint-osteoarthritis

changes in a progressive manner. If such a sequence is interrupted by an appropriate therapeutic system with an aid of sufficient host remodeling capacity, a functional and adaptive remodeling may be achieved,[1,17] as noted in Figure 15. Such therapeutic cues for TMJ-OA will be explained later in the actual case with PCR before treatment and adaptive repair of the damaged condyles after treatment.

CLINICAL IMPLICATION FOR THE TREATMENT OF TEMPOROMANDIBULAR JOINT DISORDERS

Temporomandibular joint disorders have been regarded as one of the important diseases in dentistry and orthodontics. Among TMDs, internal derangement of the TMJ is the most prevalent in adolescent subjects.[7] It is emphasized that a certain type of malocclusion with a lack in occlusal stability produces condylar displacement in the TMJ space, and then disk displacement is induced as the condyle occupies concentric position.[11,12] Another explanation for TMJ internal derangement, derived from biomechanical studies on joint friction and synovial lubrication, is that pathologic changes in the TMJ space generate reduced viscosity of synovial fluid and greater friction, which finally induce disk displacement in TMJ internal derangement.[30,32]

For the treatment of TMJ-OA, we firstly have to perform appropriate and precise examinations enough for differential diagnosis.[7,97] In addition to the conventional examinations, a highly advanced biochemical examination of urinary bone resorption markers (pyridinoline and deoxypyridinoline) has recently been used for the detection of bone or cartilage destruction in TMJ-OA.[98,99] During a series of treatment after differential diagnosis, we have to achieve TMJ unloading or the biomechanical equilibrium by means of condylar repositioning, if indicated, and the subsequent occlusal reconstruction without producing adverse influences on TMJ structures and functions.[2,100] Treatment of TMD cases with myalgia of the masticatory muscles, disk displacement with reduction (ADDW) and TMJ-OA is shown below for better understanding the therapeutic system of TMDs with different intra-articular pathologic problems [Figure 16].

The first case is a 25-year-old male with neck and masticatory muscle tenderness and discomfort. He had Angle Class I molar relation with 1.0 mm overjet and 0.5 mm overbite. Maxillo-mandibular relation was Skeletal 3 and lateral shift of the mandible was 2.5 mm to the right. Condylar movement was somewhat irregular and restricted. As a result of functional and imaging examinations, the TMJs on both sides were diagnosed as asymptomatic excluding muscle disorders [Figure 17]. It is thus speculated

that muscle disorders are due to unstable occlusion with right posterior cross-bite.

After the use of stabilization splint, muscle tenderness was almost eliminated, demonstrating that the muscle disorder is an occlusion-related symptom. Occlusal reconstruction was initiated with lateral expansion of the upper dentition followed by orthodontic teeth alignment with multi-bracket appliances [Figure 18].

Stable occlusion was achieved. Then, prosthodontic treatment was carried out for the missing left upper canine area. After the treatment, condylar movement became much smoother and more uniform on both sides than before treatment [Figure 19].

Changes in the masticatory muscle activity are shown in Figure 20. Muscle activity became greater in association with better-balanced occlusal force distribution achieved by orthodontic tooth alignment. Subsequently, the muscle tenderness was eliminated.

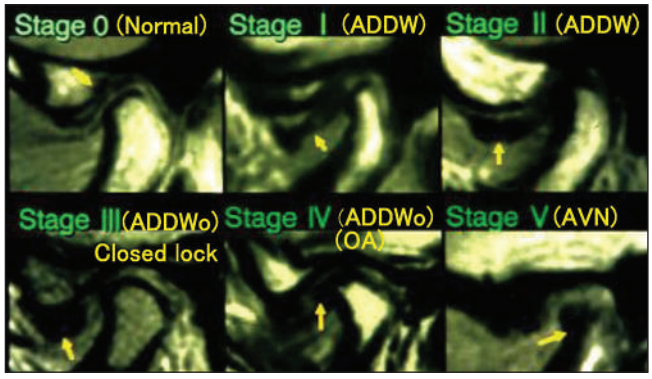

Figure 16: Classification of intra-articular pathologic stages in temporomanidular joint-internal derangement defined by Wilkes

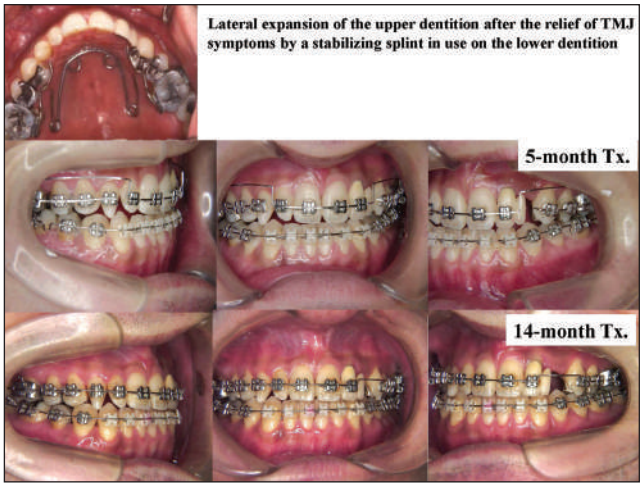

Figure 18: Splint therapy followed by occlusal reconstruction with multi-bracket appliances

It is shown from this case that occlusal discrepancy from malocclusion induces imbalance of muscle activity leading to muscle tenderness and disorders, which in turn can be eliminated by optimal occlusion achieved by orthodontic treatment. Thus, it is demonstrated that orthodontic treatment can become a significant contributing factor to the correction of TMD.

The second case is a 34-year-old female with severe deep bite. Molar relation was angle Class II on the right and Class I on the left. Overjet and overbite were 3.0 and 7.5 mm, respectively [Figure 21]. Anteroposterior relation of the maxilla and mandible was skeletal 2, as denoted by the ANB angle of 8.2°.

Temporomandibular joint pain and reciprocal clicking were observed as the TMD symptoms. The amount

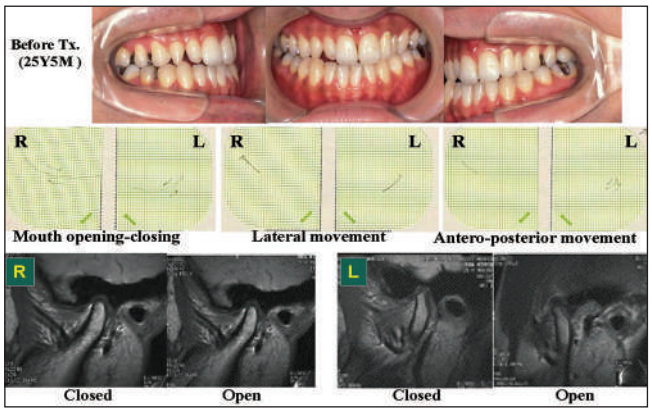

Figure 17: Treatment of a patient with myalgia of the masticatory muscles top: Occlusion before treatment, middle: Condylar movement trajectory to show limited movement of the condyle, Bottom: Magnetic resonance images to show normal status of intra-articular pathology with articular disk on the condyle

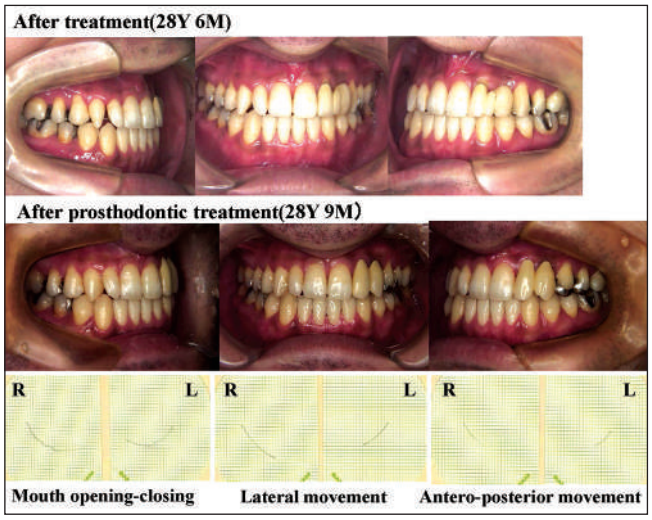

Figure 19: Occlusion after orthodontic (top) and prosthodontic (middle) treatments and smooth condylar movement (bottom) achieved by a series of orthodontic and prosthodontic treatments

of maximum mouth opening was 42 mm. For the sagittal condylar movement, figure eight pattern or crossing of jaw opening and closing trajectories was detected in the right TMJ at the early stage of opening, which is regarded as an early-type figure eight pattern [Figure 21].

On the tomograms, posterior displacement of both condyles was clearly observed. On the magnetic resonance images (MRIs), anterior displacement of the disk with reduction was found in the right TMJ [Figure 22].

From these findings, anterior displacement of the disk with reduction or stage I TMJ internal derangement was diagnosed. Furthermore, the TMD symptoms in this case were speculated due to limited anterior movement of the mandible produced by the extruded maxillary incisors, indicating a possible association between malocclusion and TMD, and an absolute necessity of orthodontic approach for the treatment in this case.

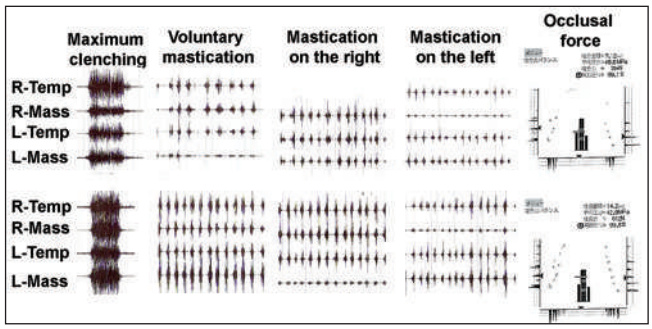

Figure 20: Evaluation of masticatory muscle activity and occlusal contact and force before (a) and after treatment (b) masticatory muscle activity became greater in association with better balanced occlusal force distribution produced by orthodontic occlusal reconstruction in a patient with myalgia of the masticatory muscles

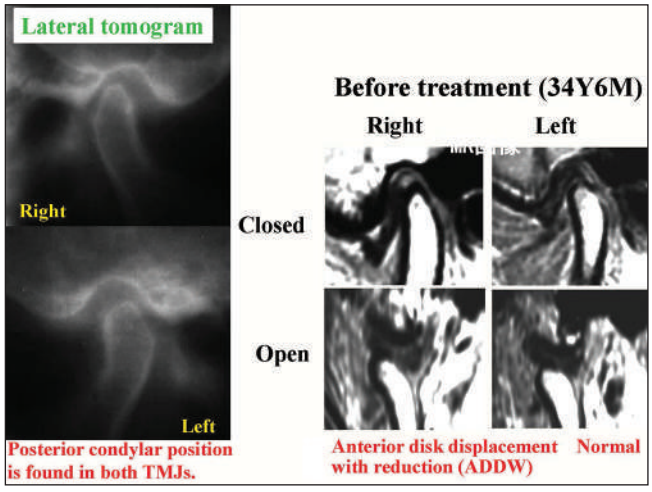

Figure 22: Posterior position of both condyles on lateral tomograms (left) and anterior displacement of right articular disk with reduction on magnetic resonance images (right)

Treatment procedures are shown in Figure 23. Two by two technique with multi-bracket appliance was used with a stabilization type splint placed on the lower dentition. This approach aims to move the upper incisors forward and upward and to allow smooth movement of the distally-located mandible and condyle. Five months later, following the correction of severe deep bite and lingual inclination of the upper incisors, multi-bracket appliances were

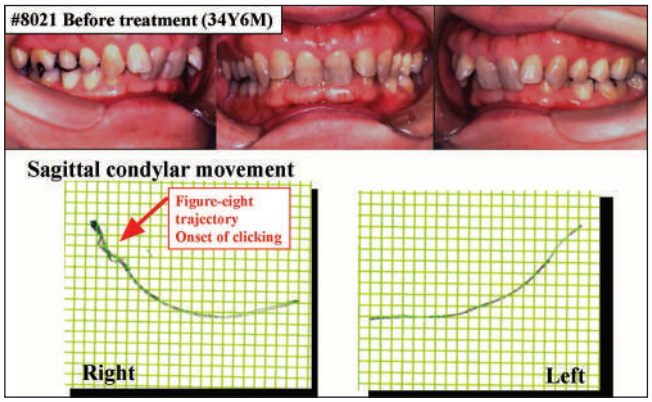

Figure 21: Treatment of a patient with temporomanidular joint-internal derangement or anterior disk displacement with reduction (ADDW)

Figure 23: Occlusal reconstruction with orthodontic treatment and splint in use (to be continued)

used for the leveling. An anterior repositioning splint was placed in use on the upper dentition to allow the flattening of the occlusal plane. Then, the posterior part of the splint was cut gradually to extrude the lower molars and to achieve the posterior bite in the splint-induced position. Finally, the splint was cut into a small one placed on the anterior region.

Seventeen months after initiating the treatment with a splint, the occlusion became stable or invariable even if the splint was not used.

Optimal and excellent occlusion has been achieved by 20-month treatment [Figure 23].

Condylar movement became much smoother for both TMJs than before, indicating the functional correction of mandibular movement and repositioning of the disk and condyle in the TMJ space. MRIs after treatment demonstrated the repositioning of the disks, occupying the normal position between the condyle and glenoid fossa [Figure 24].

The third case is a 21-year-old female with TMJ pain at the left TMJ, muscle tenderness at the left masseter and difficulty of jaw opening.[17] The amount of maximum mouth opening was 33.0 mm. She underwent splint therapy in a private dental clinic.

Molar relation was Angle Class II and overjet and overbite were 6.0 mm and −3.0 mm. Open bite was found at the anterior to the premolar region [Figure 25].

For both TMJs, deformity of the condyle was observed. In particular, severe flattening was observed on the anterior surface of the left condyle. On the MRIs, anterior displacement of the disk without reduction and disk deformity were observed for both TMJs [Figure 26].

From these examinations, this case was diagnosed as ADDWo or stage IV internal derangement with TMJ-OA. According to the diagnosis, posterior bite splint was first used with manipulation to the TMJ to induce counter-clockwise rotation of the condyle and mandible followed by orthodontic occlusal reconstruction [Figure 27]. This approach aims to reduce TMJ loading in the anterior region where condylar resorption was prominent.

After the relief of TMJ pain and limited mouth opening, multi-bracket appliances were placed on the dentitions with a pair of mini splints on the molar regions. Furthermore, multi-loop edgewise archwire (MEAW) was employed to correct an open bite. Stable occlusion was obtained [Figure 28]. It is noted that adaptive changes are generated on the surfaces of condyle on both sides [Figure 29]. However, disk repositioning was not achieved as was expected before treatment.

It is surprising that the left condyle was reformed or exhibited unexpected adaptive responses [Figure 30]. It is demonstrated that the sable occlusion with orthodontic

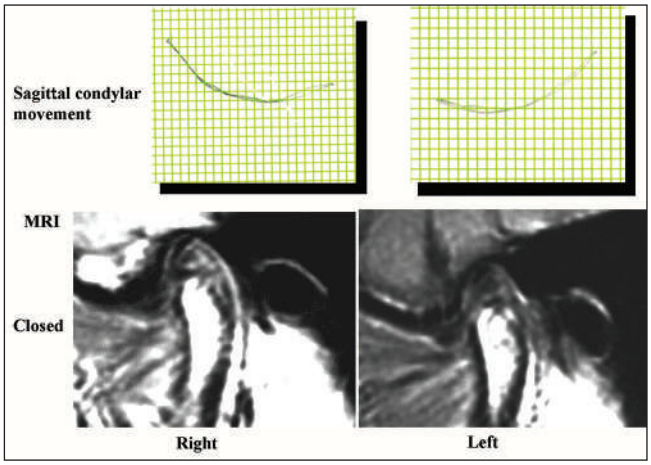

Figure 24: Sagittal condylar movement and magnetic resonance images after treatment (36Y 2M)

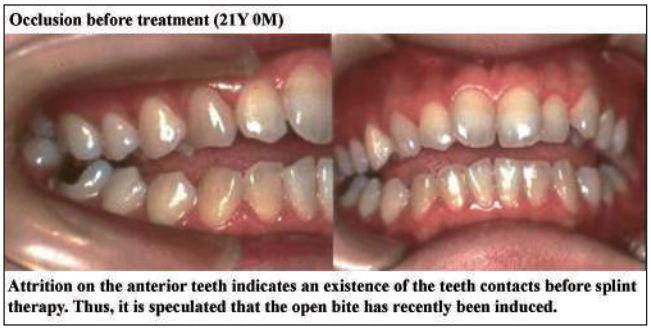

Figure 25: Treatment of a patient with temporomanidular joint-osteoarthritis or anterior displacement of articular disk without reduction

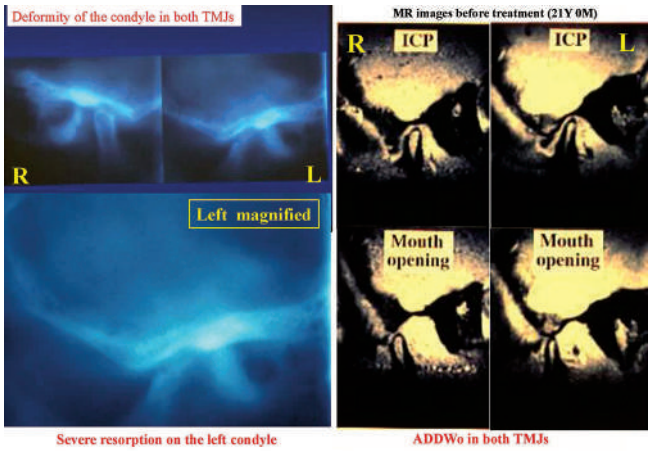

Figure 26: Severe resorption of left condyle on lateral tomograms (left) and anterior displacement of articular disk without reduction on magnetic resonance images (right)

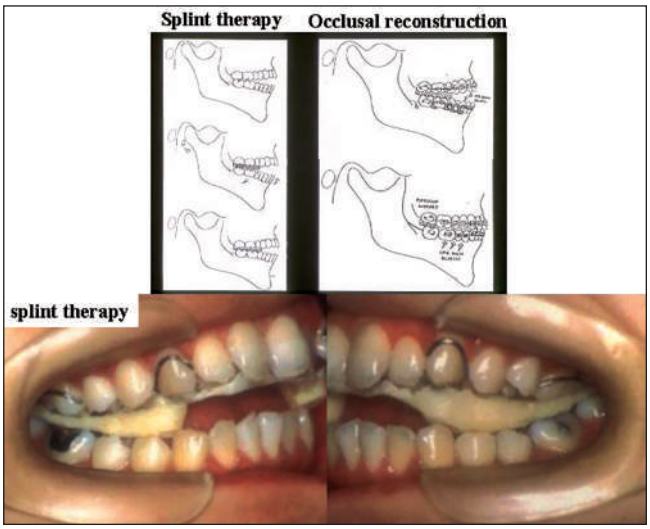

Figure 27: A schematic illustration of splint therapy to eliminate temporomanidular joint pain and limited mouth opening and the following occlusal reconstruction with orthodontic approach

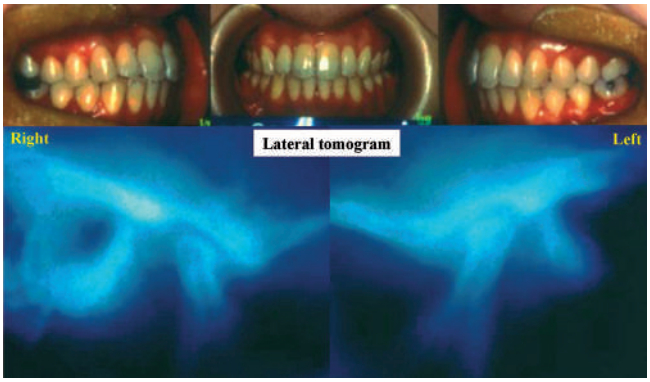

Figure 29: Occlusion after treatment (upper) and adaptive repair of left condyle observed on lateral tomograms (lower)

alignment has produced biomechanical equilibrium in the TMJ and subsequently provided the condyle with a potential for adaptive or functional remodeling. It is also shown that TMDs can be treated by an integrated approach to conservative treatment with a splint, if required, and the subsequent orthodontic teeth alignment.

Finally, I would like to introduce a couple of pharmaceutical studies, which have recently been conducted in our research group, targeting on Celecoxib and Cilengitide, which are expected to prevent and/or repair degenerative changes in the mandibular condylar cartilage. First, Su *et al*.[101] examined the effect of Celecoxib on TMJ chondrocyte under high magnitude tensile stress in terms of PGE_2 production, ECM-related gene expressions, and MMP-1 protein expression. As a result, high magnitude tensile stress-induced PGE_2 level was abolished by Celecoxib. Celecoxib also diminished ECM-degradation and resorted ECM-synthesis gene expressions induced by

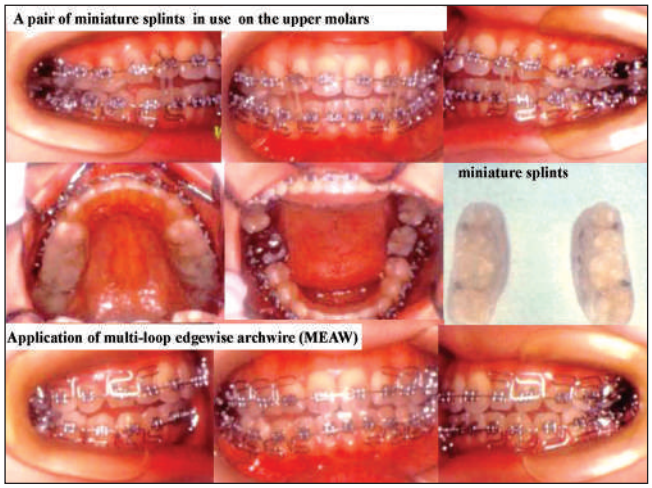

Figure 28: Occlusal reconstruction with orthodontic treatment and splint in use

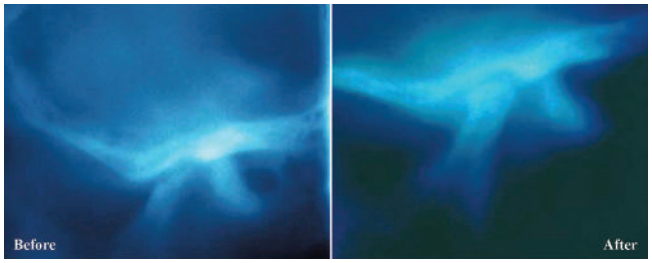

Figure 30: Unexpected functional remodeling of the left condyle leading to the adaptive repair of left condyle, which exhibited prominent resorption before treatment

high magnitude CTS. Furthermore, Celecoxib inhibited enhanced level of MMP-1 protein. It is thus shown that mechanical overload activates COX-2/PGE_2 pathway and PGE_2 exerts catabolic effects partially via EP4 receptor and that Celecoxib has an overall protective effect on TMJ-ECM metabolism by diminishing the catabolic effect of mechanical overload, supporting it a possible anti-OA drug for the treatment of TMJ-OA patients.

Then, Okamoto *et al*.[95] examined the effects of Cilengitide on gene expressions of pre-inflammatory factors by means of a quantitative real-time PCR. In addition, the mechano-transduction through integrin αV, proteins were examined by western blotting about phosphorylation of FAK, Akt, ERK and NF-κB. Treatment of Cilengitide significantly suppressed the gene expressions of COX-2, TNF-α, IL-1 β, MMP-3 and 13 dose-dependently. Protein levels of p-FAK, p-ERK and p-NF-κB were enhanced by excessive mechanical stress and suppressed dose-dependently by treatment with Cilengitide while total FAK and p-Akt were not affected significantly. From these findings, it is thus suggested that excessive mechanical stress activates integrin αV and affect the signaling pathway through phosphorylation of

FAK, ERK and NF-κB in chondrocytes. Moreover, this signaling pathway may modulate the cartilage turnover by regulating the expression of COX-2, IL-1 β, TNF-α, MMP3 and MMP13. Moreover, it is highly emphasized that Cilengitide has a potential availability for the treatment of TMJ-OA by intercepting the attachment of chondrocytes and ECM which receive excessive mechanical stress.

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Paradigm shifts in orthodontic treatment with mini-implant anchorage

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Abstract

After the applications of mini-implant anchorage, the envelope of orthodontic treatment was expanded and some treatment modes were changed because of more predictable tooth movement with empowered anchorage. The author tried to share his experience of TADs applications for clarifying the paradigm shifts of orthodontic treatment assisted with the mini-implant anchorage.

Key words: skeletal anchorage, mini-implant anchorage, temporary anchorage devices

INTRODUCTION

Since the mini-implant anchorage is used in clinical orthodontic treatment widely,[1-7] the treatment planning of orthodontic treatment changes in some aspects basically. For instance, the selection of the extraction sites relies not only on the anchorage condition, but also the conditions of the teeth to be extracted; original extraction cases can be treated without extraction if posterior teeth can be moved distally with the mini-implant anchorage to gain space;[8-11] the protrusive profile after anterior crossbite correction can be avoid by distalize the whole upper and lower dentitions;[12-14] LeFort I maxillary impaction is the only solution for the adult cases with severe gummy smile in the past. With the help of mini-implant anchorage, a large amount of incisor intrusion can be expected, and esthetics can be improved a lot combined with the gingivoplasty.[15-18] Some patients with less than ideal conditions may avoid the orthognathic surgery and get their best orthodontic results with the help of mini-implant anchorage. Molar intrusion used to be very difficult tooth movement before the application of mini-implant anchorage. The use of mini-implant makes the molar intrusion feasible. Consequently, open bite correction with molar intrusion became a predictable treatment strategy.[19-24] The same concept could be applied to the high angle cases for better vertical control.[17,25] These conditions make the orthodontists reconsider the treatment plan with the mini-implant anchorage in mind, because the use of mini-implant shifts the paradigm in orthodontic treatment.

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MINI-IMPLANT ANCHORAGE MAKES DIFFERENCE IN MAXIMAL ANCHORAGE CASES

Some dentists had said that only the orthodontists who are not good at anchorage control will use the mini-implant anchorage for orthodontic treatment. In the past, the author usually had the protrusion patient wear high-pull headgear with J-hook as maximal anchorage control. Now mini-implant anchorage does an even better job than headgear because there is no need for patient compliance, and it works on a full-time basis. Better orthodontic results can be shown on more significant profile change, and better anchorage control can be proved on the cephalometric superimposition. Maybe it will be criticized that different situations make this comparison imprecisely. The author retreat a Class II protrusion case previously treated with high-pull J-hook and bite jumping appliance. There is still some Class II relationship remained after the first treatment. The patient complained of the relapse of protrusion. Retreatment with mini-implant anchorage was

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performed, and satisfactory result was achieved. The authors believe mini-implant anchorage does make a difference with the other anchorage sources [Figures 1 and 2].

WHOLE ARCH DISTALIZATION RATHER THAN MAXIMAL ANCHORAGE

If the protrusion is one of the patient's concerns, extraction treatment will be more satisfactory. The amount of incisor retraction will be more predictable, and subsequent profile improvement will be more pleasing in the extraction treatment. With the help of mini-implant anchorage, some borderline cases can be treated with nonextraction approach but still get pleasing profile change. It is not only more conservative, but also more efficient by reducing treatment duration in the nonextraction treatment. Under certain circumstances, there is no extraction space available in the upper arch and there is a molar space to close in the lower arch, mini-implant anchorage can be used to distalize the whole upper arch to keep proper overjet during lower arch space closure. Exo-dentitional placement of mini-implant is important in this kind of application in order not to touching the roots during tooth movement [Figures 3 and 4].

MOLAR DISTALIZATION IN SEVERE CROWDING CASES

Arch length discrepancy can be resolved by extractions of teeth or arch expansion. If the choice is arch expansion, there are three directions:

1. Anterior
2. Posterior and
3. Transverse.

Anterior expansion makes the incisors advanced and proclined, which is unfavorable for Mongolian patients that are usually more protrusive than Caucasian patients. Transverse expansion is more favorable in the Caucasians because they are more dolichocephalic than Mongolians which are more brachycephalic. Hence, posterior expansion is the best treatment choice for the Mongolian crowding cases. If the molars are not distalized successfully in the Mongolian crowding cases, the incisors will be advanced, and the profile will become protrusive. Exo-dentitional mini-implant can be used to distalize both the upper and lower posterior teeth and get the space to align the whole dentition without anterior expansion [Figure 5].

LOWER MINI-IMPLANT ANCHORAGE TO CORRECT THE ANTERIOR CROSSBITE

Class III malocclusions are quite common in Asian population, and the bimaxillary dentoalveolar protrusion

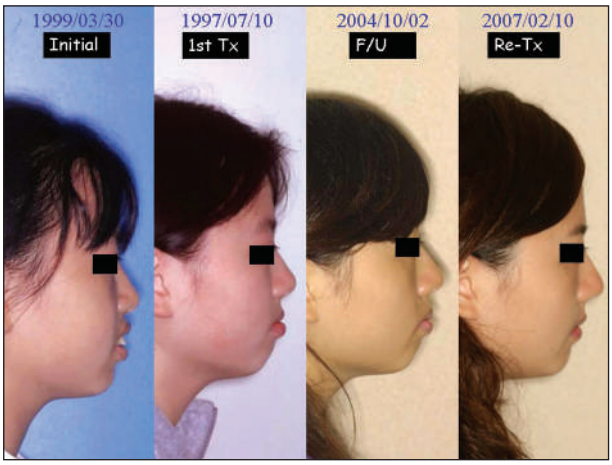

Figure 1: The left two photographs are before and after treatment records of this 4-premolar extraction case. After 5 years follow-up, patient complained of protrusion again. Retreatment with temporary anchorage devices on upper posterior areas end up with a satisfactory profile improvement

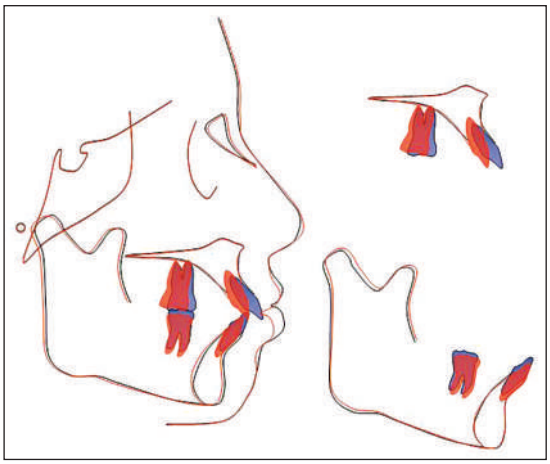

Figure 2: The difference between the cephalometric superimpositions can be referred to the difference of anchorage between extra-oral headgear and mini-implant anchorage

Figure 3: The progressive records of lateral profile revealed the power of mini-implant anchorage for this severe protrusion case

is another common characteristic in oriental races. There is a common problem for the orthodontists to consider whether the patients will become protrusive after anterior crossbite correction. If the answer were yes, then maybe extraction is a better option for the treatment plan. With the help of mini-implant anchorage, Class IIII malocclusion can be treated successfully with nonextraction approach without subsequent perioral protrusion. This paradigm shift in treatment of Class III malocclusion greatly reduces the treatment duration and achieves more pleasing profile change after anterior crossbite correction [Figures 6 and 7].

MINI-IMPLANT ANCHORAGE IS ALSO IMPORTANT IN SOME ADOLESCENT PATIENTS

Usually the anchorage requirement is not very critical in the adolescent patients because there is some growth that may help the correction of malocclusion. But in some severe adolescent patients, anchorage gained from the favorable growth is not enough to correct the skeletal discrepancy. Extra anchorage can be provided by mini-implant without any noticeable side-effects. No interference of growth was observed after the use of mini-implant anchorage. Favorable growth pattern can be seen after the proper use of mini-implant anchorage [Figure 8].

DEEPBITE CORRECTION WITH ANTERIOR SUBAPICAL MINI-IMPLANT

Besides anterior-posterior control, the mini-implant anchorage can be used to control the vertical problem successfully. In fact, this is the first application of mini-implant anchorage proposed in modern orthodontics,

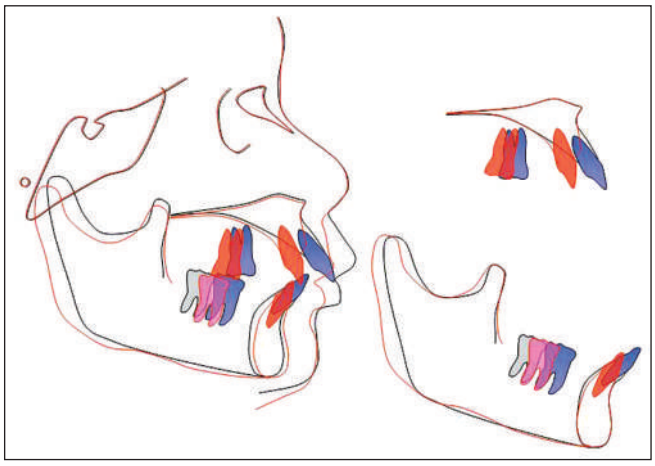

Figure 4: Cephalometric superimpositions showed the upper incisors were retracted about 12 mms at the incisal edge. The achieved tooth movement was not only maximal retraction without any anchorage loss, but also further total arch distalization by 5 mm after the extraction spaces were all closed

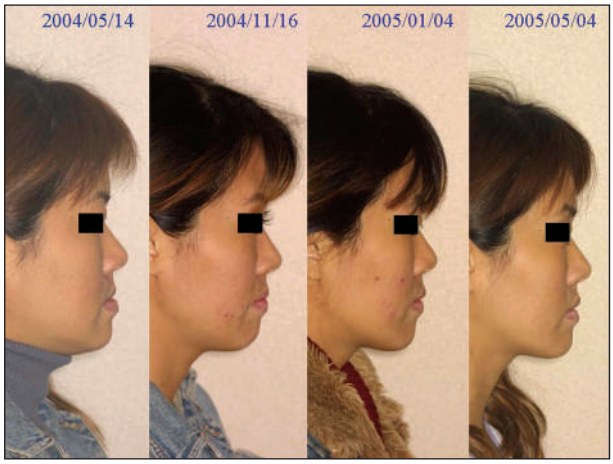

Figure 6: The progressive records of lateral profile of a Class III case with anterior crossbite

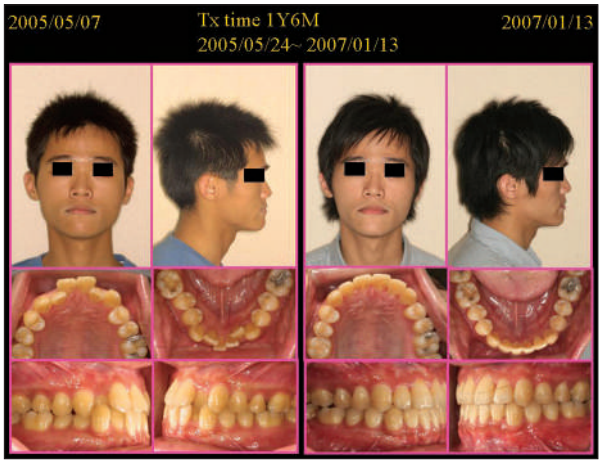

Figure 5: The use of mini-implant anchorage in severe crowding cases can avoid the protrusion in nonextraction treatment and the midface dish-in after extraction treatment

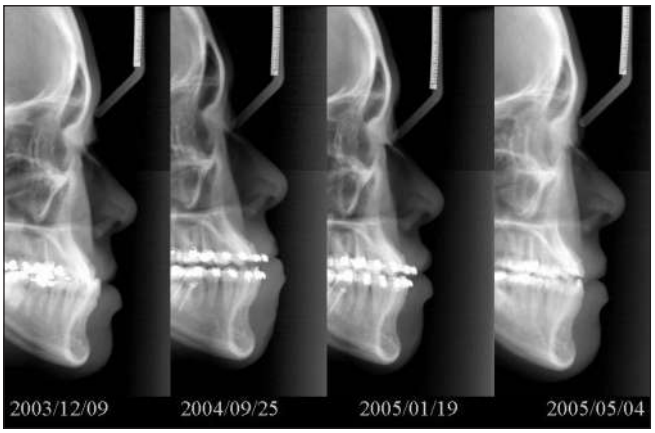

Figure 7: The corresponding cephalograms of the lateral profiles in Figure 6. Correction of anterior crossbite often turned out protrusion in lateral profile, which usually required four bicuspids extraction to retract the profile. With the help of mini-implant anchorage, we can maintain or even improve the lateral profile while the anterior crossbite was corrected in Class III cases

which was published in JCO, 1983. Dr. Creekmore inserted a vitallium miniscrew beneath the ANS to provide the anchorage for upper anteriors intrusion. Although this approach was proved to be effective, many orthodontists still regard this as the last resort because the anatomical limitation in the upper anterior regions makes the patients more discomfort. The authors change the insertion technique to be closed methods in the upper anterior regions so that the extension ligature wire is no more too irritating to use. If the deepbite can be corrected efficiently with mini-implant anchorage, the large overjet can be corrected subsequently without occlusal interference. So with mini-implant anchorage in anterior and posterior regions, a difficult situation of large overjet and deep overbite can be resolve at the same time efficiently [Figures 9 and 10].

AN EFFECTIVE SOLUTION FOR GUMMY SMILE IN ADULT CASES

In the past, the only way to correct gummy smile in the adult cases is LeFort I maxillary impaction. Now, the other way to correct gummy smile is anterior subapical mini-implant anchorage to intrude the upper anteriors. The problem of this approach may exist in some cases with relatively short clinical crowns. Gingivoplasty or crown lengthening may be indicated after or even during orthodontic treatment [Figure 11].

EXTRACTION PATTERN DEPENDS MORE ON THE PROGNOSIS THAN ON THE ANCHORAGE VALUE

The anchorage values of the different extraction patterns change with the application of mini-implant anchorage. The first bicuspids extraction is the regular extraction pattern for the protrusion cases. The choice of this extraction pattern is based upon the anchorage consideration. If mini-implant anchorage can be used, there will be no difference to extract first or second bicuspids. The choice of tooth to be extracted will be focused on the conditions of the tooth, such as large decays or restorations, poor periodontal condition, endodontically involved or crowns [Figures 12 and 13].

GENUINE MOLAR INTRUSION IS FEASIBLE WITH MINI-IMPLANT ANCHORAGE

It is easier for any tooth to be extruded than to be intruded, so leveling is extrusive in nature. Reactive extrusive force is inevitable for any appliance except mini-implant anchorage

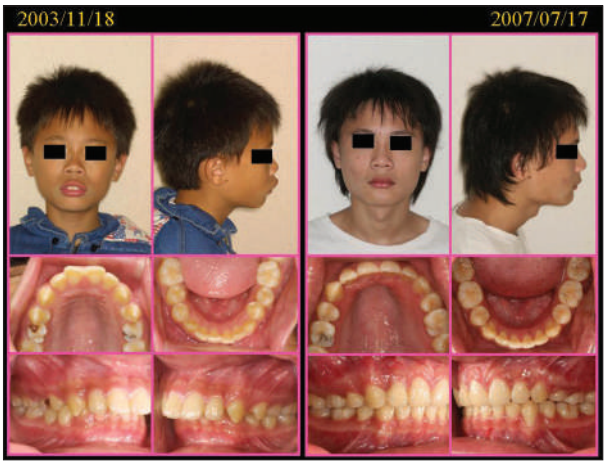

Figure 8: Although the growth potential is good for adolescent patients, which makes the anchorage requirement is not so critical for most adolescent patients, it is still very important for some severe protrusion cases

Figure 9: Anterior subapical miniscrews for intrusion were very efficient for bite opening

Figure 10: Anterior subapical areas were quite safe to insert miniscrews

device. With the help of mini-implant anchorage, genuine molar intrusion is much more predictable. Besides molar elongation, genuine molar intrusion is also very important

for posterior crossbite correction. The force system with mini-implant anchorage avoids the unfavorable extrusive forces of the criss-cross elastics. In some open bite cases, the intrusion of the molars makes the mandible autorotated counterclockwisely to close the anterior open bite. The applications of mini-implant anchorage do change the biomechanical considerations in some difficult situations [Figures 14 and 15].

VERTICAL CONTROL IN HIGH ANGLE CASES: FROM GOOD TO GREAT

The optimal force system for high angle, protrusive cases was proposed to be the upper and lower posterior miniscrews for anterior retraction and the upper and lower anterior subapical miniscrews for overbite control. The vertical control can be achieved simultaneously with A-P anchorage control. The directional force system in Tweed-Merrifield technique cannot be simulated by posterior miniscrews easily because of the proper implant sites are much lower than the ideal implant site for high-pull direction. The combination use of the posterior and anterior miniscrews can simulate the directional force system of Tweed-Merrified technique without patients' compliance. These combination use of posterior and anterior miniscrews on both maxillary and mandibular dentitions makes the mandible rotated counterclockwisely to advance the chin point and get so-called "mandibular response" in adult patients. It helps those high angle, protrusive patients to get the greatest improvement by nonsurgical approach [Figures 16-18].

CONCLUSIONS

All the above are major paradigm shifts during my journey of mini-implant anchorage. I think the applications of mini-implant anchorage have created a new world in orthodontics. It is a quite powerful anchorage device and deserve every orthodontist to keep it in mind during making a treatment plan.

Figure 11: Anterior subapical miniscrews were helpful for the correction of gummy smile, even in nongrowing patients

Figure 12: The applications of miniscrews makes possible to decide treatment plan according to the prognosis of the teeth rather than the anchorage value

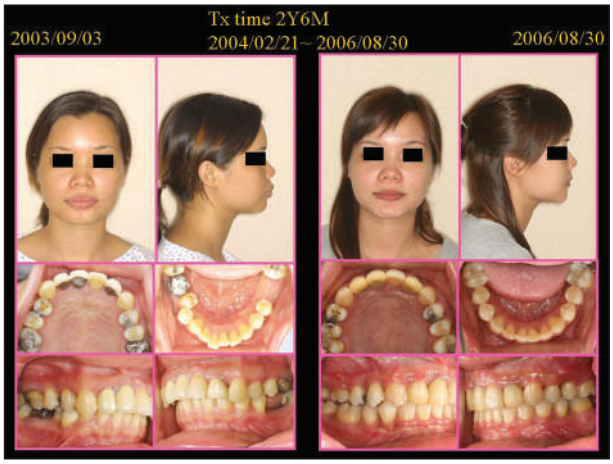

Figure 13: With the help of miniscrews, profile could be retracted successfully by space closure of four first molars

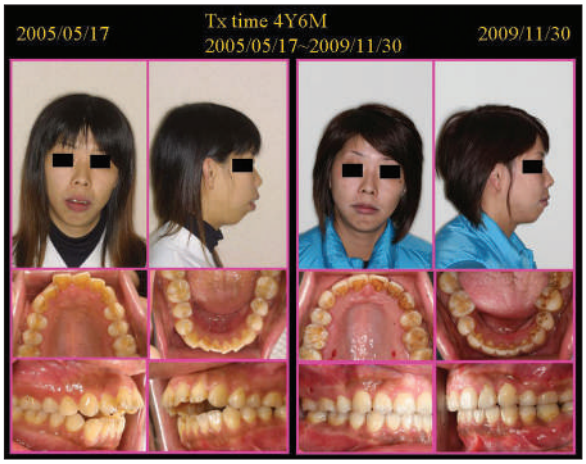

Figure 14: The vertical control by mini-implant anchorage makes the open bite treatment more predictable

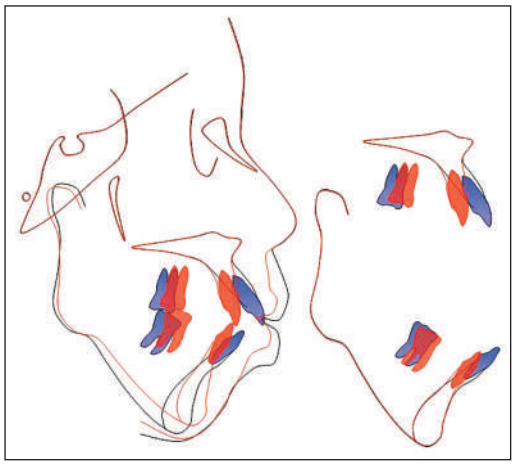

Figure 15: Cephalometric superimpositions showed counterclockwise rotation of mandible by means of posterior intrusion of both arches

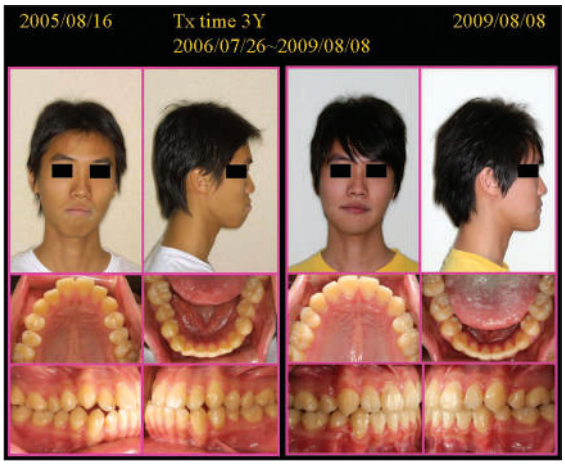

Figure 16: High angle protrusion cases with retruded chin could be treated with mini-implant anchorage to achieve maximal retraction and active vertical control

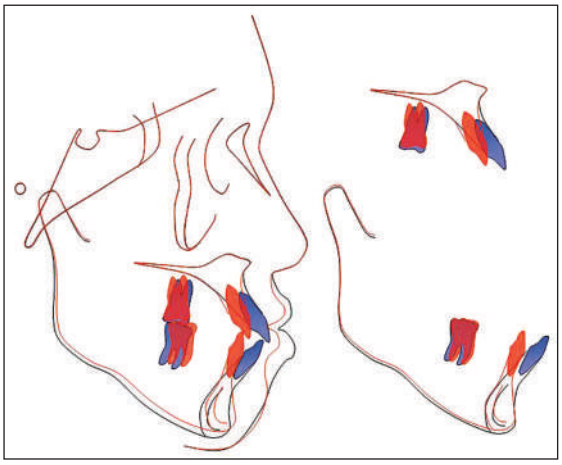

Figure 17: Cephalometric superimpositions showed maximal retraction and overall intrusion on both arches

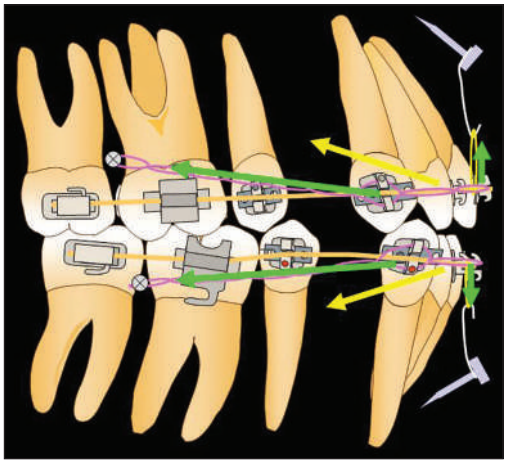

Figure 18: This is the combined intrusion and retraction force system suggested for the high angle protrusion cases

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Enhanced patient care through collaborative team play: An orthodontist and an OMF.Radiologist's collective perspective

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Abstract

The overarching theme of patient-centric care should serve as the fundamental basis for our treatment plans. Treatment plans that best utilize knowledge; training and technology must be developed on current evidence that rests on soundly researched principles. In orthodontics, the evolution of cone beam computed tomography as a new three-dimensional imaging modality has brought a paradigm shift in the radiographic evaluation of the maxillofacial structures. However, the coming of new technology does not warrant its use in routine practice and tight imaging protocols must be developed to include and promote the evidence-based patient-centric approach. This principle is best approached if the effort is a collaborative one. Collaboration between all the disciplines that contribute to patient care must act as a unified force to deliver superior care. In this editorial, we present a successful collaborative effort between orthodontics and oral and maxillofacial radiology that have engaged in collaborative efforts to deliver superior patient care, better predoctoral and postdoctoral training programs and how this effort has yielded excellent contribution to research.

Key words: Two-dimensional imaging, three-dimensional imaging, radiation dose

In every specialty of life, there are going to be some solo travelers and some collaborative team players. We have had the good fortune of having been on the better side of things, where our research and clinical practice have personally benefitted from embracing newer technology and bringing synergistic efforts to be a part of many exciting teams.

Significant changes have happened in the diagnostic and treatment approach landscapes in dentistry over the recent years. One such change that deems special mention is the evolution of cone beam computed tomography (CBCT) and its introduction to dentistry. The coming of CBCT has truly changed the way we diagnose and treat patients in dentistry today. CBCT is a low dose high spatial resolution imaging modality that is becoming the three-dimensional (3D) modality of choice for imaging the maxillofacial region.[1,2] CBCT has brought about a paradigm shift in the use of 3D imaging in orthodontics. Since a vast majority of orthodontic patients are younger individuals who by "tissue age" are highly radiosensitive, the use of 3D imaging has been very limited. This is because conventional medical grade multi-slice computed tomography (CTs) deliver a significantly high amount of radiation dose when compared to conventional two-dimensional (2D) images.[3-6] Hence, based on the criticality of the task at hand, 3D imaging using multi-slice CTs has been very limited for most orthodontic tasks except complex orthognathic surgeries and management of cleft lip and palate patients. Like with most modalities, the first generation CBCT machines were big, expensive and occupied a large footprint, but the second and third generations of CBCT machines have a significantly lower dose, smaller foot print and have become

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very affordable. These changes have brought a true shift in the use of CBCT in dentistry and more specifically in orthodontics.[7]

At the University of Connecticut school of Dental Medicine, we have formed many collaborative teams that function in an interdisciplinary manner, with the association between orthodontics and oral radiology being a very successful collaboration. For well over a decade, some interesting questions have constantly intrigued us and the orthodontic community at large: what happens to the cortical bone immediately after, 6 months and 2 years post expansion? Do we gain or lose the buccal and palatal cortical bone? What happens to the bone levels, when we procline the mandibular incisors? All these questions in their entirety can be answered by acquiring a CBCT scan of a patient pre and post treatment. Our collaboration over the recent years has yielded at least 6 interesting "proof of concept" studies both from a basic science perspective and from a clinical and translatory perspective. These studies have laid the foundation to some more interesting questions that we are currently perusing as a part of our collaborative initiative. Our firm belief is that strong collaborative applications are also the most successful grant applications because they have the fortified strength of knowledge from multiple specialists.

Furthermore, in day-to-day clinical practice, 3D radiographic information plays an important role in diagnosis and treatment planning. However, here is where all of us clinicians have to bring our collective efforts to focus on an important issue. The issue of radiosensitivity and radiation dose delivery. The ubiquitous use of radiation can cause disastrous public health issues. So very tight radiation protocols must be established that enable the use of radiation wherever necessary and curtail unnecessary radiation exposure to patients.

The concept of as low as reasonably achievable (ALARA) is almost a responsibility on every clinician's conscious. This concept is evolving into as low as diagnostically acceptable" or "ALADA" because very low dose and poor resolution images don't often contribute to a successful treatment plan. But from routine orthodontic cases to complex surgical cases, key decisions about imaging protocols are best achieved through successful collaborations between orthodontists and oral radiologists. A campaign that has taken the forefront in advocating radiation safety especially for the children is the "Image Gently" campaign.[8] It has spearheaded a trend where radiation exposure is done with caution, best used when needed and judiciously managed as necessary. The American Academy of Orthodontics (AAO) is the most recent addition to endorse this movement.

So having agreed that 3D imaging has significantly changed our diagnostic capabilities and has impacted how we treat our patients, an interesting perspective that has become obvious to us through this evolutionary process of going from 2D to 3D, is to form trustworthy relationships between the orthodontic team and the OMF. Radiology team who can work together to navigate the intricacies of cases and when necessary find clever ways to wade through tough waters. We have found that having a close connection between the treating teams not only has helped us in delivering better patient care but also in understanding the nuances of incidental findings on 2D and 3D imaging.

Conventional wisdom says that with more power comes more responsibility, similarly with more area being imaged, there is more anatomy to be analyzed. It is at challenging times like these that specialties have to make strategic team plays. As David Turpin, the editor of AJODO stated in his editorial "Befriend your oral and maxillofacial radiologist"[9] that from an orthodontists' standpoint, there are obvious questions that the AAO's Scientific affairs committee suggested which are: We know that 3D imaging is going to be an integral part of our workflow, when we take these scans, who is responsible for interpreting the scan?, Is this cost of reading a CBCT scan included in the scan or is it additional, as in the case of panoramic radiograph, it is the responsibility of the diagnostician. Do patients have a choice regarding the degree of interpretation included? What are the challenges in training and understanding the complex maxillofacial anatomy? How is this problem handled in medicine?

From an orthodontist's view point, we cannot emphasize enough the value of the radiology team's opinion in understanding the scan, dealing with incidental findings and associated liability issues.[10,11] It, of course makes life easy both from a philosophical and from a practical stand point where there is more time on the clinician's hand to focus on patients and on research than hunt the "unknown waters" of a 500-file long CBCT scan. AT UCONN we attest to this strongly as we are a team that has found value in this association.

To serve the patient's best interests, we need to use CBCT technology judiciously in clinical practice but use it when necessary. The value of this wonderful technology must be leveraged, but it needs training, expertise and firm understanding of the physics behind ionizing radiation and its effects on human tissues. This level of training not being easily achievable, the need for a radiologist is obvious. Another area, where we see tremendous value in having a good team, is taking research to the next level and to develop better appliances for the patient and acquiring

3D image of the area of interest is a great advantage to achieve this.

Orthodontists have a responsibility to ensure that the radiographic techniques they employ provide the necessary information, with the least possible radiation exposure. This is especially true when the information obtained may affect the orthodontic intervention, that is, the imaging modality selected must minimize the patient radiation exposure while optimizing maximal diagnostic benefits. To take this into practice, working with the OMF.Radiologist to establish firm selection criteria and workflow patterns must be established, where all the scans have a report for both legal and treatment planning purposes for the benefit of the patient and the treating clinician. AAOMR along with American Dental Association has continuously recommended and advocated "ALARA" for the use of ionizing radiation, this should be a constant reminder for everyone using X-rays.

To summarize our experiences, the Orthodontics and OMF.Radiology team has been a very productive one. It helped in firming up our 2D and 3D imaging protocols for screening, evaluation of impacted teeth, temporomandibular joint diseases, managing syndromic cases and planning orthognathic procedures. We have had tremendous help in image interpretation and on the research end, our collaborative efforts are very promising and delivering results that can only attest to the need for doing more collaborative research. We really feel, that a crosstalk between two largely different specialties like orthodontics and OMF.Radiology can come together for one single cause called "enhanced patient care through research" which can positively impact the lives and smiles of many patients.

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Archwise distraction appliance: A novel approach for developing facial and dental esthetics in cleft lip and palate patients

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Abstract

Cleft lip and palate (CLP) is defined as a congenital deformity caused by failed fusion of medial and lateral palatine processes during 4-12th weeks of embryogenesis, resulting in an open communication between oral and nasal cavities. In CLP patients, maxillary hypoplasia, velopharyngeal insufficiency, and alveolar clefts are the major issues that have to be taken care of after labiopalatal reconstruction. Rather than several consecutive operations, such as bone-grafting and orthognathic surgery, alveolar distraction can be a better treatment option in many cases. Archwise Distraction Appliance (AWDA) is a rigid, tooth-borne, custom-made appliance that is developed to control the distraction vector with double archwire system. Our experiences show that the AWDA is a successful appliance in cases of distraction osteogenesis. Moreover, alveolar distraction has significant advantages over conventional treatment modalities for CLP patients.

Key words: Alveolar distraction, intraoral arch-wise distraction, arch-wise distraction appliance

INTRODUCTION

Cleft lip and palate (CLP) is defined as a congenital deformity caused by failed fusion of medial and lateral palatine processes during 4-12th weeks of embryogenesis. This results with an open communication between oral and nasal cavities. Although the exact etiology is unknown, it is thought to be a multifactorial defect including both genetic and environmental factors.

Treatment of CLP patients starts from birth onward and continues until late adolescence. This requires the care of a crowded team that includes orthodontist, speech therapist, plastic surgeon, neurologist, ENT specialist, pedodontist, prosthodontist, pediatrician, and a pedagogue. The role of the orthodontists usually begins after birth, either with passive feeding plates or active preoperative orthopedics in babies with complete clefts.

Maxillary hypoplasia, velopharyngeal insufficiency (VPI), and alveolar clefts are the major issues that have to be taken care of after labiopalatal reconstruction. Rather than several consecutive operations, such as bone-grafting and orthognathic surgery, alveolar distraction can be a better treatment option in many cases. We will not mention the general consequences

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of orthognathic surgeries here. However, one specific limitation of maxillary advancement in CLP patients is that velopharyngeal distance increases postsurgically. Especially in patients with already existing VPI or in borderline cases, orthognathic surgery may not be the best option. In such cases, intraoral alveolar distraction can be more beneficial for the patient.

Distraction osteogenesis (DO) was first performed by Codivilla,[1] and became widely known after Ilizarov described details of the method and developed innovative devices for this purpose.[2-4] The procedure can be summarized as a periodical distraction of two bone segments that are separated with a smooth osteotomy cut. It depends on the principle of tissue regeneration parallel to the distraction vector between two bone segments. Stretching of the tissues that bone segments are connected to stimulate not only bone regeneration between these two segments, but also regeneration and adaptation of neurovascular bundle, muscles, and surrounding soft tissue.[5] The process begins with the osteotomy of the segments and callus formation in between them, followed by gradual traction forces applied to the bone segments. This creates tensional stress in the callus and continues as long as the tissue is stretched. The stretching activity induces new bone formation and the adaptive soft tissue changes such as formation of mucosa, muscle, nerve, vascular structures, connective tissue, and lymphatic vessels.

Alveolar distraction (first introduced by Ilizarov[2,3]) is a form of bone transport and includes the transport of healthy bone segment to the neighboring defect site. Depending on the vector of force and the movement, it can be defined as vertical or horizontal. In CLP cases, healthy alveolar bone segment(s) (including the teeth) are distracted toward the defect site, until two alveolar segments come in contact. Moreover, sagittal advancement to correct maxillary hypoplasia is also possible.

ARCHWISE DISTRACTION APPLIANCE

In 2000, Liou *et al.* applied horizontal alveolar DO to CLP patients for the first time.[6] He used a custom-made distraction appliance to restore the alveolar defects. However, in many studies, transporting the alveolar bone in the curvilinear fashion has been a challenge. Contemporarily, a new appliance can overcome this challenge: Archwise Distraction Appliance (AWDA).

Archwise Distraction Appliance is a rigid, tooth-borne, custom-made appliance that is developed to control the distraction vector with double archwire system. The appliance consists of three major parts: Cr-Co crowns, two parallel stainless steel (SS) archwires, and distractors.

Predistraction orthodontics

Expansion-if necessary-, leveling and aligning has to be completed before distraction. It is important to create a 2-3 mm space and root divergence between anchorage teeth and the transport teeth to allow vertical osteotomy. If lower arch needs treatment, it should also be treated before distraction stage. This is important to decide for the adequate amount of sagittal advancement. When the patient is ready for the surgery, all the bands and braces in the maxillary arch are debonded, teeth cleaned, and a thick essix plate is prepared for preserving the arch until cementation.

Appliance construction

An accurate two-step impression is taken with polyvinyl siloxane material from the debonded maxillary arch. The crowns are constructed on unprepared teeth. On the cast model, anchorage and transport units and places for tubes and the semitubes are defined and sent for wax modeling of Cr-Co crowns [Figures 1 and 2]. Usually, bilateral molar teeth are the anchorage units and they are connected with a 3-4 mm wide, 1-2 mm thick transpalatal arch to reinforce the anchorage. The orthodontist checks the wax model and makes necessary corrections before casting. Important issues at this stage are the horizontal orientation of the double-tubes and the semitubes. They all have to be positioned on the same plane for passive insertion of the archwires. Double-tubes and semitubes are the accessory units that carry and guide the customized archwires during distraction. Double-tubes are placed on the anchor unit. Semitubes are placed on the interproximal areas on the transport units. They both should have an inner diameter of 2 mm. It is also possible to cover the labial surfaces of the anterior teeth with veneer facets for a more esthetic appliance [Figure 3].

Archwires

In AWDA, distraction progresses on two parallel archwires. When the actual crowns arrive from the laboratory, two customized archwires are bent from 1.5 mm SS wires on the model with crowns [Figure 4]. The wires must be bent according to the arch shape for passive engagement. If only transversal transport is planned in the distraction protocol, the archwires should be cinched back. If sagittal correction is a part of the distraction protocol, then some wire extension should be left distal to the double-tubes before cinching back, according to the amount of sagittal advancement. Placing the double-tubes as mesial as it is possible will help to minimize mucosal irritation due to thick archwires.

Figure 1: Wax models on the model before final construction. Double-tubes and semi-tubes are seen in green wax

Figure 3: Esthetic AWDA on the model, with arch-wires and distractors in place

Distractor

Distractor (Tasarimmed, Istanbul, Turkey) is designed and registered by Dr. Erverdi. It has evolved a lot and reached its final small design, easily tolerated by the patient [Figures 5 and 6]. One full turn with the key creates 1 mm activation. The distractor has infinite activation ability. When the distractor reaches the maximum amount of activation, it can be closed completely and crimpable rings are crimped on the cervical archwire to accommodate the reactivation of the distractor. Before closing the distractor for reactivation, a custom made plier can be used to hold the newly formed distraction space between the teeth to prevent collapsing.

Cementation of the crowns

Cr-Co crowns are first checked on the teeth before final cementation. The crowns should be passive and stable on the teeth. All tubes should be on the same level. They should have small holes for the drainage of excess cement. The appliance is cemented with a dual cure glass ionomer (GIC), 1-2 days prior to the surgery.

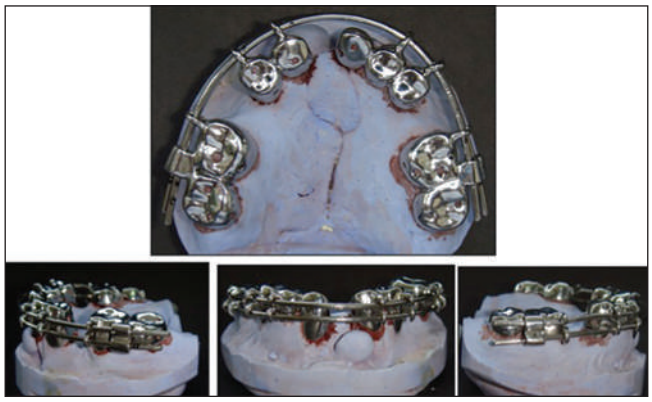

Figure 2: Cr-Co crowns with the archwires placed

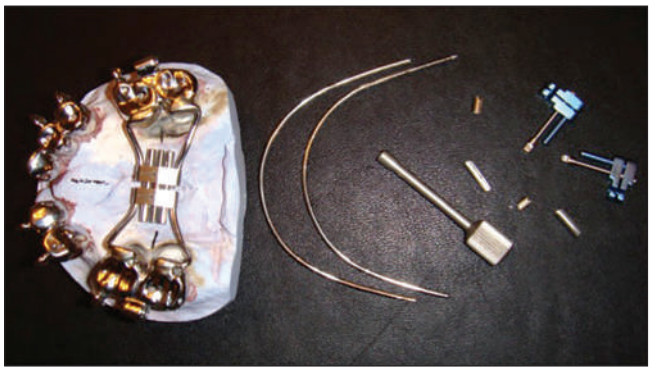

Figure 4: Archwise Distraction Appliance with an expansion screw. Two archwires bent from 1.5 mm stainless steel wires

Surgery

Surgery is performed under general anesthesia. Vertical cuts are made where the root divergence is made. Horizontal cuts are made above the apices and the segments are mobilized. Cleft area is also cleared from any irregular bony edges so that the two segments can get as close as possible. Archwires and distractors are placed during surgery after segments are mobilized. Latency period should be 5-7 days.

Distraction period

After latency, the patient begins the activation; half-turn twice a day (with 12 h interval) and the overall rate is 1 mm/day. If sagittal correction is a part of the treatment plan, it is the first objective during distraction. During activation for sagittal advancement, archwire length on the cleft area must be fixed with crimpable rings, so that, this area is preserved and segments move sagittally. When sagittal correction is achieved with 30% overcorrection; then the rings on the cleft area are removed, archwires are cinched-back to fix the arch length, and distractor is activated for lateral transport until the defect is closed with the contact of transport segment and the opposing sound alveolar bone.

Docking site surgery and consolidation

Docking site is the area where two bone segments meet. At the end of distraction, the edges of the transport bones are hypotrophic and sclerotic.[7] To close this gap and provide an intact alveolar bone bridge, docking site surgery must be performed. At the same surgery, remaining oronasal fistula can be repaired as well. It can be performed early during the consolidation period so that healing occurs simultaneously. In our procedure, consolidation period is set as minimum 6 months with AWDA. During consolidation, rigid fixation of the distracted bone is essential to prevent relapse and to allow proper calcification and solidification of the hard callus into mature bone.[4,6]

Finishing

After adequate consolidation period, the appliance is removed. The regenerated bone in the distraction site is a healthy and young bone suitable for either implant placement or orthodontic tooth mesialization. Because CLP patients usually have missing teeth due to the cleft area, implant placement, and restorations are more frequently adopted.

CASE REPORT

A 18-year-old male patient with a unilateral CLP on the left side. He had maxillary hypoplasia due to the scar tissue after labiopalatal reconstruction. After 6 months of pre-surgical orthodontic treatment, he received AWDA treatment. Distraction was planned bilaterally for the advancement of the anterior segment. Active distraction period lasted 12 days with the overcorrection. After 6 months of consolidation period, 2 implants were placed posteriorly, on the newly regenerated distraction bone. Total treatment time was 18 months. Figures 7-12 summarize the case.

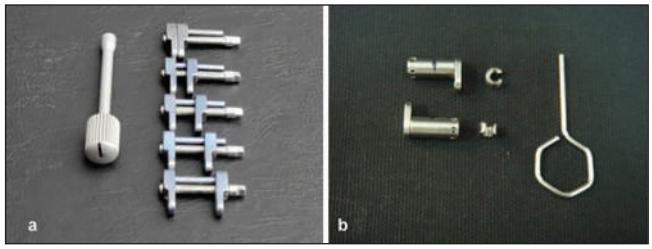

Figure 5: Distractors. (a) previous design, showing activations; (b) new smaller design

Figure 7: Extraoral and intraoral photos at the beginning of the treatment

CONCLUSION

Our studies show that the AWDA is a successful appliance in cases of DO.[8,9] The only disadvantage can be the unaesthetic appearance of the appliance because of the metal casts, but veneer facets can overcome this limitation. Moreover, we clinically observed that it is well tolerated by the patients; they did not complain about esthetics during the 6-7 months' time with the appliance.

Alveolar DO has significant advantages over conventional treatment modalities for CLP patients:

- The cleft area is reduced significantly. This enables to minimize the grafting area, reduces the amount of

Figure 6: Full appliance, with activations

Figure 8: During activation of the distractors. Distraction spaces mesial to 1st molars are getting created

Figure 9: (a) Initial intraoral photos; (b) during consolidation period; distraction is completed, distractors are fixed

Figure 11: Extraoral photos before treatment, during consolidation and completion of treatment

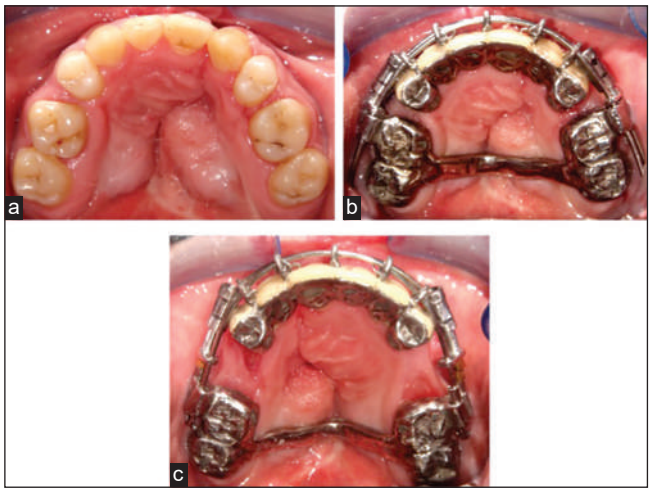

Figure 10: Occlusal photos showing (a) pretreatment; (b) during distraction; (c) after distraction

Figure 12: Panoramic radiographs and posttreatment intraoral photos (a) pretreatment, (b) during consolidation, (c) posttreatment OPTGs, (d and e) posttreatment intraoral photos

necessary graft material, and increases the amount of bone augmentation.

- Since the area is smaller, recurrent bone grafting can be eliminated. Number of surgeries is reduced.
- The risk of relapse is reduced because soft tissue stresses are reduced in comparison to one-step advancement with orthognathic surgery.
- More maxillary advancement is possible.
- New and healthy bone is regenerated at the posterior while defect is being closed anteriorly.
- Maxillary advancement can be performed in earlier ages during adolescence, and this is important to improve the facial esthetics and life quality in CLP patients in earlier stages.[7]
- Velopharyngeal insufficiency problem is overcome since sagittal correction is achieved with DO of the segments mesial to molar teeth. Velopharyngeal distance is not increased at all.
- Cleft lip and palate patients usually have missing teeth because of the defect area. With alveolar distraction, these missing teeth can also be restored with implants posteriorly on the newly-formed and healthy distraction bone while the cleft area is closed anteriorly.
- With the rigid construction and double-arch system of AWDA, it is successful to control distraction vector for preserving the arch shape.
- Distractors can be activated infinitely, and there is no need for secondary surgery to remove them.
- Other than CLP, alveolar distraction with AWDA can be performed in any cases where a big alveolar defect that is not likely to be augmented with grafting exists (due to e.g., cysts, trauma, dentoalveolar retrusion, iatrogenic reasons).[10]

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The Benefit System and its scope in contemporary orthodontic protocols

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Abstract

Currently, the alveolar process is the most preferred insertion site for orthodontic mini-implants. However, due to the varying bone quality and the risk of root contact, the survival rate of implants inserted in the alveolar ridge still needs improvement. Other regions, such as the anterior palate and the mental region provide much better conditions for temporary anchorage device (TAD) insertion since the amount and quality of the available bone are far superior. Mini-implants with different types of abutments and connectors allow the construction of versatile and cost efficient appliances for a large variety of orthopedic and orthodontic applications. Utilizing TAD's in the anterior palate and the mental region eliminates the risk of root injury and takes the implants out of the path of tooth movement. The design of the interchangeable abutment system provides the orthodontist with a skeletal anchorage system that integrates easily into clinical practice and allows treatment of cases that were difficult or impossible to treat previously.

Key words: Class III treatment, distalization, mini-implant, skeletal anchorage, temporary anchorage device

INTRODUCTION

Mini-implants have become a common treatment modality in orthodontics due to their versatility, minimal invasiveness, and cost effectiveness. Still, today, the alveolar process is the most preferred insertion site.[1-5] However, due to varying bone and soft tissue conditions, orthodontists are still confronted with an average loss rate of 16.1%, as reported in recent literature.[6-9]

To enhance success rates five strategies were developed:
1. Selection of the optimum insertion site.
2. Avoidance of root contact.
3. Getting out of the path of tooth movement.
4. Use of tandem implants and.
5. Use of implants with sufficient length and diameter.

Applying these strategies and choosing the anterior palate as insertion site loss rates could be decreased to values as low as 2.1%.[10]

Selection of the anterior palate in the upper jaw and miniplates in the lower jaw rendered the insertion of mini-implants in the alveolar ridges obsolete. Based on clinical examples and scientific evaluation, new solutions for a variety of treatment tasks such as molar distalization and mesialization, molar intrusion and extrusion, asymmetric

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space closure, midline correction, and anchorage of anterior and lateral dental segments are now available.

A new generation of mini-implants with interchangeable abutments (Benefit System, PSM, Germany[11]) was developed that allow integration into the orthodontic mechanics [Figure 1]. For very high demands on the anchorage quality, two mini-implants were used. To couple two mini-implants very easily, a Beneplate[12] (PSM, Germany, [Figure 1h]) is available in two different lengths. For connection to the orthodontic appliance, Beneplates with a stainless steel wire (1.1 mm or 0.8 mm) or a stainless steel bracket are employed. The Beneplate can be adapted to the Benefit mini-implants by bending of the miniplate body as well as the wire [Figure 2].

IMPLANT PLACEMENT AND ADAPTION OF THE MECHANICS

Due to a very good bone quality and quantity, the anterior palate is the favorite insertion site.[13] If the patient is apprehensive about the use of a needle syringe, the miniscrews can be placed using only topical anesthetic (jelly). In adult patients, a pilot drilling (2-3 mm depth) should be performed due to very high bone densities [Figure 3]. In children and adolescents with relatively low bone mineralization, pilot drilling is not needed. Mini-implants with a diameter of 2 mm or 2.3 mm and lengths of 9 mm (anterior) and 7 mm (posterior) are inserted, which provides the best stability [Figures 4-6].[14-17]

In many cases, the appliance could be adapted intra-orally, which, of course, implies some chair time [Figure 7a and b]. The alternative is to adapt the mechanics in the laboratory by taking a silicon impression and transferring the intra-oral setup to a plaster cast using the impression cap and the laboratory analogue from the Benefit System[11] [Figure 1b and c].

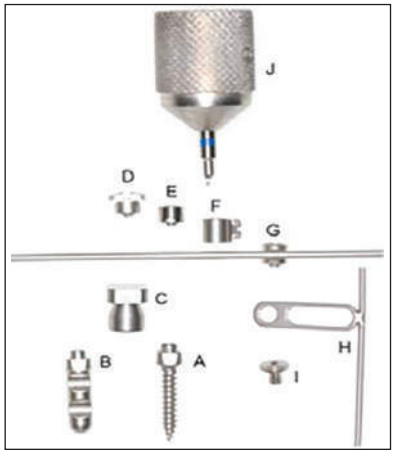

Figure 1: Benefit/Beneplate System: (a) Mini-implant. (b) Laboratory analog. (c) Impression cap. (d) Slot abutment. (e) Standard abutment. (F) Bracket abutment. (g) Wire abutment with wire in place. (h) Beneplate with wire in place. (i) Fixation screw. (j) Screwdriver for abutment fixation

CLINICAL APPLICATIONS

Maxillary molar distalization (Beneslider and pendulum B)

The treatment objective of upper molar distalization may be required frequently during correction of malocclusions.

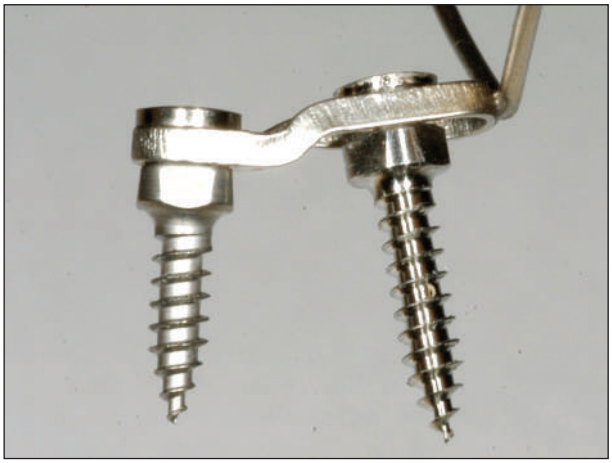

Figure 2: Bending of the Beneplate to fit on two mini-implants

Figure 3: Manual predrilling (only needed in adults)

Figure 4: Manual insertion using the handpiece (PSM, Germany)

The most common indication is a dentoalveolar Class II malocclusion with increased overjet and/or anterior crowding. Another less frequent indication may be to correct dentoalveolar compensation in Class III patients that are undergoing surgery. Due to esthetic drawbacks and the length of time to be worn, molar distalization with a headgear is unpleasant for many patients.[18,19] This has resulted in a tendency to favor purely intra-oral distalization appliances with minimal need for patient cooperation. Unfortunately, most of the conventional devices for noncompliance maxillary molar distalization show some unwanted side effects, such as anchorage loss, especially, when distalization forces are applied buccally.[20] One possibility to reduce unwanted effects of reciprocal orthodontic forces is the use of palatal acrylic pads (Nance buttons). However, the anchorage stability of this soft-tissue borne element is not always certain. Moreover, oral hygiene is impaired due to the partial coverage of the palatal area. If the anchorage unit includes teeth, mesial migration and/or protrusion of the anterior dentition have to be considered as major drawbacks.[21,22] The amount of the anchorage loss of conventional intra-oral devices ranges between 24% and 55%.[23] Although indirect anchorage can be used to support the premolars during maxillary molar distalization, miniscrew tipping and wire deformation may result in anchorage loss and mesial premolar migration. Moreover, after molar distalization, the appliance must be refabricated for distalization of the premolars and anterior teeth. Therefore, direct anchorage is preferable.

Figure 5: Insertion of two mini-implants posterior from the rugae, the distance between the mini-implants should be 8-14 mm

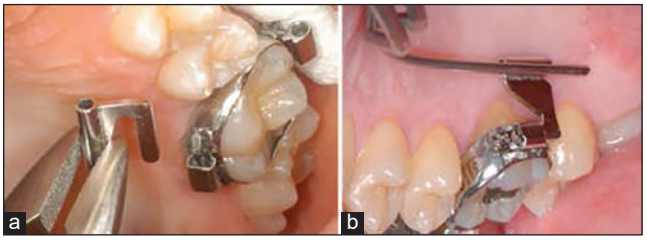

Figure 7: (a) Intra-oral adaption of a Benetube for a Beneslider. (b) Intra-oral adaption of the Beneplate for the Mesialslider

To benefit from the advantages of direct anchorage mechanics and of the anterior palate as the most suitable mini-implant insertion site, the Beneslider[5,11,12,24,25] device has been designed fixed on top of mini-implants with exchangeable abutments. The Beneslider utilizes sliding mechanics and has proved to be a reliable distalization device[25] [Figure 8]. However, if frictionless mechanics is preferred and/or the molars are to be uprighted or derotated simultaneously during distalization, pendulum mechanics can be employed.[26] Several authors introduced skeletally-supported pendulum mechanics to avoid anchorage loss.[27-30] However, all described appliances require additional laboratory work. The pendulum B[31] was designed to have the ability to adapt a skeletal borne pendulum device chair side immediately after mini-implant insertion without a laboratory procedure [Figure 9].

Maxillary space closure (Mesialslider)

Unilateral or bilateral missing upper teeth are diagnosed quite frequently: Congenitally missing lateral incisors/

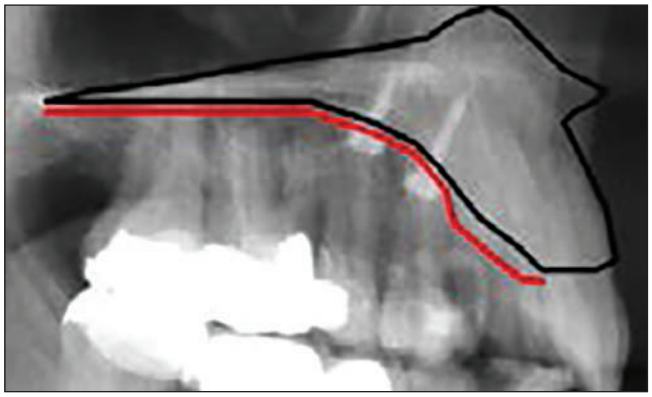

Figure 6: Angulation of the insertion is perpendicular to the bone. The soft tissue anterior is too thick

Figure 8: Clinical example: Beneslider for upper molar distalization

second bicuspids, extremely displaced canines or a severe trauma of a central incisor are potential complaints that result in a reduced upper dentition. The two major treatment approaches are space closure or space opening to allow prosthodontic replacements either with a fixed prosthesis or single-tooth implant. Both of these treatment approaches may potentially compromise aesthetics, periodontal health, and function.[32] In many cases, space closure to the mesial seems to be the favorable treatment goal, since treatment already can be completed as soon as the dentition is complete.[33] Canine substitutions can be accomplished with good aesthetic outcomes by tooth reshaping and positioning, bleaching, and porcelain veneers.[34,35]

The more mesial the missing tooth is, the higher will be the demands for anchorage quality, especially in asymmetric cases with a midline deviation. If the central incisors are in the correct position (midline, torque and angulation are correct), a T-Bow[11,12,36] can be bonded to the lingual surfaces of the central incisors to apply an indirect anchorage with the goal to avoid lingual tipping of the central incisors during space closure.[11,12,36] As an alternative to the T-Bow (indirect anchorage), the Mesialslider[11,12,37] as a direct anchorage device can be used. The Mesialslider enables clinicians to mesialize upper molars unilaterally or bilaterally. Since the incisors are not fixed, a midline deviation can be corrected at the same time. The Mesialslider can be used to close space in the upper arch from distal, e.g., for missing lateral incisors [Figure 10], canines [Figure 11], premolars [Figure 12] or molars. The Mesialslider can also be used for protrusion of the whole upper dentition to compensate a mild Class III occlusion.[37]

Figure 9: Clinical example: Pendulum B for upper molar distalization

Figure 11: Clinical example with missing upper right canine: Mesialslider for unilateral upper mesialization

Asymmetric molar distalization and space closure (Mesial-Distalslider)

In many cases with unilaterally missing teeth, the midline is off. The favored appliance to correct the midline, to close the space on one side and to distalize the contralateral segment is a combination of the Mesialslider and a Beneslider, the Mesial-Distalslider[38] [Figure 13].

Rapid palatal expansion and early Class III treatment

Rapid palatal expansion (RPE) is considered to be the first orthodontic procedure to achieve skeletal widening of the maxilla. Today, RPE is considered to be a method for sutural distraction osteogenesis. For the treatment of patients with a Class III caused by a retrognathic maxilla, RPE is combined with a facemask for the protraction of the

Figure 10: Clinical example with missing upper right lateral incisor: Mesialslider for unilateral upper mesialization

Figure 12: Clinical example with missing upper second bicuspids: Mesialslider for bilateral upper mesialization

maxilla. Since the orthopedic forces are transmitted to the skeletal structures via the anchor teeth, distribution of the forces to as many teeth as possible, as well as completion of root growth, are considered essential. However, besides the therapeutically intended skeletal expansion, side-effects such as buccal tipping of the anchor teeth, fenestration of the buccal bone, root resorptions, and gingiva recessions were reported in some cases.[39,40] To avoid these complications caused by the tooth-borne character of the conventional appliances, some authors reported about pure bone-borne RPE devices. Several palatal distractors have been presented over the last decade.[41,42] However, insertion and removal of these miniplate-borne distractors are invasive surgical procedures with the need of a flap preparation, risk of root lesions and infections.[41,43] As a consequence distractors of this type could not establish themselves as standard devices for RPE. To minimize the surgical procedure, Harzer introduced the Dresden-Distractor that is borne solely on an implant and a mini-implant.[44-46] Due to the risk of a root lesion at the insertion of implants in the lateral posterior alveolar process and lack of available bone in the median posterior palate, we used the 1st molars or 2nd deciduous as posterior anchorage unit. In the anterior median palate, there is more bone available bone for mini-implants[13] and the resulting appliance is a half tooth-borne half bone-borne RPE device called hybrid hyrax [5,11,47-49] [Figure 14].

The application of the hybrid hyrax is minimally surgical invasive compared with pure bone-borne RPE devices like distractors.[41,42] To employ the first molars or second deciduous molars as posterior anchorage unit and mini-implants as skeletal anterior anchorage unit provides several advantages.[47-49]

- Applicable in cases with low anterior dental anchorage quality due to missing deciduous molars or deciduous molar with short roots.
- Applicable in cases with immature root development of the premolars.
- No risk of impairment of root development (curved roots).
- Reduction of the dental side effects, that is, premolar tipping.[48]
- Anterior dentition is not bonded during the retention phase, and thus regular orthodontic treatment could be started earlier.
- Advantageous in cases with need for early Class III treatment, where the RPE supports maxillary advancement by weakening the midface sutures.
- Avoidance of mesial migration of the upper dentition during application of a facemask or the Mentoplate,[47] thus enhancing the skeletal effects.[48]

Skeletal Class III malocclusions are relatively infrequent, and their genesis is usually associated with genetic factors.[50,51] The Class III relationship may be caused by a retrognathic maxilla, a prognathic mandible or both.[50,51] Treatment of young Class III patients with maxillary deficiency is mostly conducted with a facemask. Since the force is applied to the teeth, mesial migration of the dentition is inevitable and may result in severe anterior crowding.[52] On the other hand, the desired skeletal effect of this commonly used approach often turns out to be less than

Figure 13: Clinical example with missing upper right canine and midline shift: Mesial-Distalslider for unilateral upper mesialization and contralateral distalization

Figure 14: Hybrid hyrax. Anterior anchorage is provided by two 2 mm × 9 mm Benefit mini-implants, placed about 5 mm apart. Before and after rapid maxillary expansion and Class III treatment using a facemask

Figure 15: Skeletal born early Class III treatment using the hybrid hyrax and the Mentoplate

expected.[52] To overcome these drawbacks and to minimize mesial migration of the molars, sagittal skeletal support by the hybrid hyrax is very useful. Secondly, to facilitate the advancement of the maxilla, opening of the midface sutures by RPE is recommended.[53] With the goal to avoid an extra-oral device (facemask) and to apply the forces directly to the skeletal structures, De Clerck introduced the use of four miniplates (two anterior in the lower jaw and two posterior in the upper jaw) in combination with Class III elastics.[54] This represents a new purely skeletal approach to correct the skeletal discrepancy. In order to enhance the skeletal effect by opening the midface sutures, we employ the hybrid hyrax appliance in the upper jaw allowing simultaneous rapid maxillary expansion and skeletally borne maxillary protraction. In the lower jaw, the Bollard miniplates by De Clerck are usually inserted after the eruption of the canines. To allow earlier insertion of the miniplate in the mandible, we developed the Mentoplate [Figure 15].[47] Since the Mentoplate is inserted subapically to the lower incisors, it typically can be used already at the age of 8-9 years. By means of the hybrid hyrax in combination with a facemask or a Mentoplate forces are applied to skeletal structures only with the goal to achieve an optimum skeletal effect [Figure 15].

CONCLUSION

To summarize, the Benefit mini-implant in combination with the Beneplate expands skeletal anchorage options in orthodontic treatment and reduces the failure rate significantly. Insertion and removal are minimally invasive procedures: Orthodontists can place the screws by themselves and load them immediately. Usually, the screws can be removed without anesthesia. The anterior palate is our preferred insertion region because of its superior bone quality and relatively low rates of miniscrew instability and failure. The attached mucosa has a better prognosis than other areas, and there is no risk of tooth damage. In the mandible, miniplates such as Bollard plates or the Mentoplate are recommendable for orthopedic and orthodontic purposes.

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Conflicts of interest

There are no conflicts of interest.

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New concept of physiologic anchorage control

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Abstract

Molar anchorage loss in extraction case is believed due to the reaction of mechanical force applied to retract anterior teeth. While it may be close to truth in adult patients, it is certainly not true in adolescents. Studies on molar growth show upper molar move forward as mandible growing forward, probably through intercuspation force. Hence, for adolescents, molar anchorage loss shall consist of two parts. One is from retraction force — mechanical anchorage loss; another from biologic force — physiologic anchorage loss. Since physiologic anchorage loss is caused by the continuous biologic force, the strategy of physiologic anchorage control (PAC) is different from the strategy of mechanical anchorage control. A new PAC method is introduced in this article that can reduce the headgear and temporary anchorage device used as sagittal anchorage dramatically in orthodontic clinic.

Key words: Anchorage loss, mandible growth, physiologic anchorage control

Anchorage is the footstone for moving malocclusion teeth in orthodontic treatment. To make this footstone stable, orthodontists designed different anchorage methods, such as stationary anchorage,[1] headgear, anchorage bends,[2] anchorage preparation,[3] cortical anchorage,[4] transpalatal arch (TPA),[5] Nance arch,[6] and implant anchorage[7-9] in the orthodontic history. The most striking star among the above anchorage measures is the implant anchorage. Before it appears, the maximum anchorage is defined as molar forward displacement less than one-fourth of a premolar extraction space in an orthodontic extraction case.[10,11] However, implant anchorage can make 0 mm molar anchorage loss theoretically. Orthodontists then have the strongest tool to challenge the alveolar limit, especially in cases with skeletal protrusion. The problem is: Is that good for periodontal health?

Figure 1 is an adult bimaxillary protrusion case. To reduce her protrusive lips, we extracted her four first premolars and retracted the anterior teeth with implant anchorage. After both the patient and doctor were satisfied with her profile, we stopped retraction, took impression and cone beam computed tomography (CBCT) as stage records. Superimposing digital study casts on unloaded mini-screw implants, we can see upper molars have not moved mesially at all, and upper incisors retracted apparently.

Since her upper molars did not move mesially at all, we can call this case an absolute anchorage case. Then we were wondering where will be the roots of incisors. Checking her CBCT image, we can see apparent root resorption of upper central incisors and alveolar defect on lingual side [Figure 2a]. We can also see alveolar fenestration of upper left lateral incisor apex on the labial side [Figure 2b]. If we check her lower incisor, more than half of the root on the lingual side is out of alveolar bone [Figure 2b]. More than 70 years ago, Dr.

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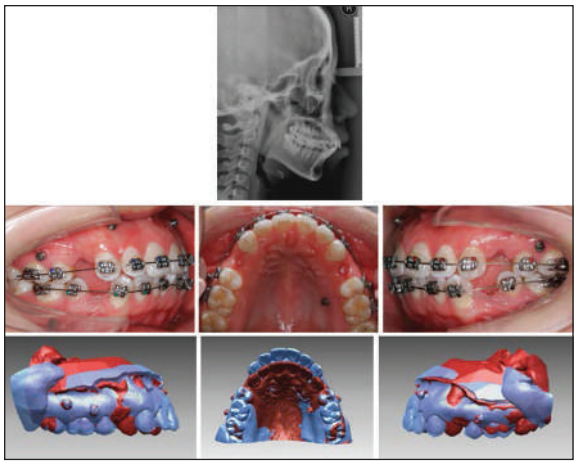

Figure 1: Adult bimaxillary protrusion treated with four premolar extraction and miniscrew anchorage. Superimposition at the miniscrew interface sows retraction of incisors with no anchor loss

Tweed, considered labial limits, advocated extraction treatment.[12] Today, when we have absolute anchorage tools, should not we consider the lingual limits? In physiologic anchorage control (PAC), the first principle is respecting the alveolar limits. Moreover, this limit should not be considered statically physical limit, but physiologic limit changing with growth and bone reconstruction.

If we accept physiologic alveolar limits and believe the treatment objects, we, orthodontists, deal with are not static but dynamic, we will change our paradigm of anchorage control. Orthodontists used to attribute molar mesial displacement in extraction case to the reaction of mechanical force applied to retract anterior teeth. While it may be close to truth in adult patients, it is certainly not true in adolescents. Solow's study[13] on 14 girls with Bjork metallic implant shows that upper molar moved 8 mm downward and 3 mm forward on average during 9-25 years. He also indicated for the forward mandibular rotation cases, upper molar can move forward much more than the average. One case in his sample, upper molar moved forward more than 7 mm, almost a premolar's width. Johnston's recent study[14] on 39 growing subjects from Bolton-Brush growth center shows upper molar move forward approximate to the amount of mandible outgrowing the maxilla. From his sample, upper molar moved forward about 2 mm (more than one-fourth of a premolar extraction space, the amount close to our maximum anchorage control definition) during 11-13 or 12-14, the common age periods at which we treat malocclusion. Moreover, our own prospective randomized clinical trial shows anchorage loss more for growing patient before the growth peak than after the peak.[15] We can, therefore, deduce as mandible outgrowing maxilla, it brings upper teeth moving forward

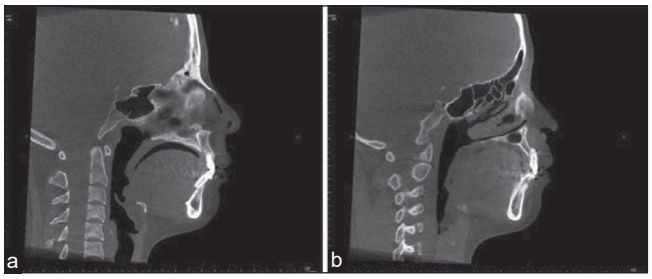

Figure 2: (a) After retraction of incisors with miniscrew implant, alveolar bone of both upper and lower central incisors lost on lingual sides and upper central incisor root apex resorbed; (b) Alveolar fenestration of upper lateral incisor root

through intercuspation force. Other biologic forces to move molar mesially include horizontal components of bite force and periodontal ligament force. Hence, we believe molar anchorage loss during orthodontic treatment shall actually consist of two parts, one part is from reaction, we call it mechanical anchorage loss; and another part is from growth or other biologic force, we call it physiologic anchorage loss. Then, the question is why we should differentiate physiologic anchorage loss and mechanical anchorage loss.

The way we perceive how molar anchorage loss affects the strategy that we adopt to control anchorage. If we believe anchorage loss is totally due to reaction, we deal with reaction only. We use TPA or Nance arch to disperse the reaction on molars; we use headgear to resist the reaction on molars; and we use implant anchorage to bypass the reaction. Take implant anchorage as an example, if we believe reaction is the only source of anchorage loss, detouring reaction from molar to miniscrew will theoretically keep molar stable. Figure 3a shows a high angle Class II adolescent, we extracted her four first premolars and inserted miniscrew implants as anchorage. The first wire is 0.014 nickel-titanium (NiTi), canines lacebacked to miniscrews to relieve anterior crowding. After 2 months, we took impression and made a digital cast superimposition on the stable area that we established by an implant marked study.[16] Although there was no anchorage burden on upper molars, superimposition showed upper molar tipped forward to loss anchorage. Why is that?

Let's check our appliance first. In modern straight wire appliance, we use 0° buccal tube. For patients with apparent curve of Spee in upper arch like this patient, engaging a straight archwire in anterior teeth will tip upper molars forward to lose anchorage [Figure 3b].

Why this happened so easy? Let's look at how upper molar grow without appliance. Baumrind's study[17] on implant superimposition shows upper molars tipped forward

during growth [Figure 4]. Martinelli, *et al.* study[18] on Burlington Class II growth sample shows upper molar tipped 2.8° on average from 12-14 years. Moreover, our own maximum anchorage sample treated with headgear, upper molar tipped forward 7.2° on average during 2.5 years.[15] Hence, upper molar tipping forward is actually normal growth pattern, our modern straight wire appliance just accelerates this kind of physiologic anchorage loss. If we realize the existence of physiologic anchorage loss, we can then try to prevent it with new approaches.

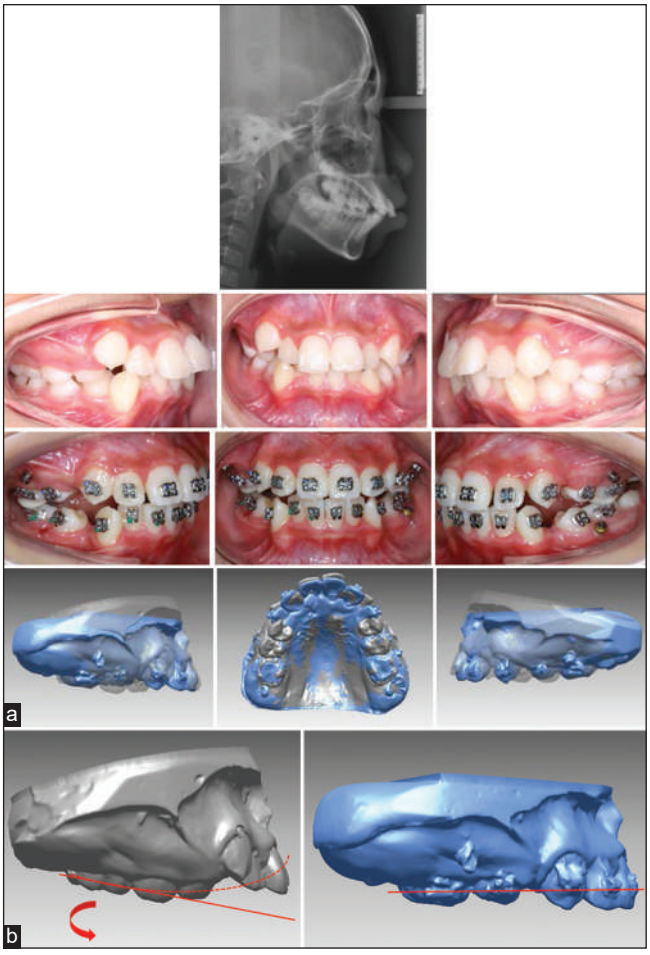

Figure 3: (a) 12-year-old high angle Class II case. Upper molars tipped forward in 2 months even with mini-screw implants as anchorage. (b) Engagement of 0.014″ nickel titanium wire resulted in the molar anchor loss

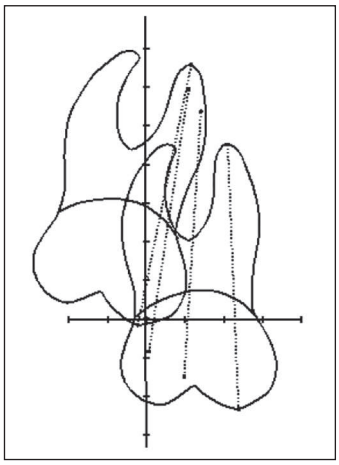

Figure 4: Upper molar growth pattern traced using American metallic implant growth sample. The initial observation age is 8.5 and the last is 15.5; between them are 10.5 and 12.5, respectively. One unit of scale equals 2 mm. Horizontal frame of reference is Downs occlusal plane

Our own way to prevent physiologic anchorage loss is using a special cross buccal tube that consists of two tubes,[19] one −25° round tube and another −7° rectangular tube [Figure 5]. Two tubes cross in front, so we call it cross buccal tube (or brief it as XBT). It is a substitute of a tipback bend in traditional Tweed or Begg, the irreplaceable part is the gentle, continuous moment provided by the initial thin NiTi wire pairing with it. If the physiologic anchorage loss is caused by continuous biologic force, the preventive measures should certainly adopt the same force pattern. If we can prevent molar forward tipping with tipback tube during aligning stage and keep it with proper mechanics until we start to retract anterior teeth, molars will be in a relative tipback position, a posture similar to Tweed anchorage preparation that has been proved good for anchorage control by Tweed practitioner.

Figure 6 is an example treated with the PAC approach. The patient was a 13-year-old girl. She was Class II with lip protrusion [Figure 6a]. We extracted her three first premolars and one second premolar on the lower left side because of the full Class II relationship on that side. Bonding XBT on molars and multi-level low friction brackets[20] on six anterior teeth, we used 0.014 NiTi as the initial arch wire [Figure 6b]. Forty days later, her anterior crowding was relieved and we then bonded her upper 5' and 7' and changed arch wire to 0.016 NiTi with the curve of Spee to keep upper molars in

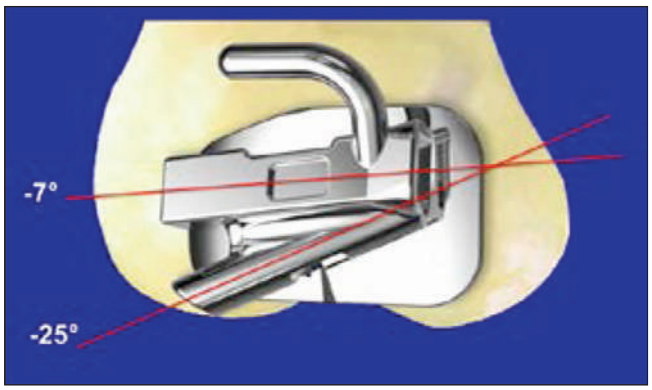

Figure 5: The cross buccal tube designed to prevent physiologic anchorage loss

a relative backward tipping position [Figure 6c] while aligning upper dentition. Following the same procedure, we aligned her lower dentition and proceeded to the space closing stage [Figure 6d]. We finished the whole treatment in 20 months and improved her profile [Figure 6e]. Structure superimposition on maxilla shows her incisors retracted apparently and upper molar anchorage controlled very well, only a little forward tipping [Figure 6f]. Comparing to our headgear sample with 0° buccal tube, upper molar tipped 7.2° forward on average,[15] the XBT tube design serve our purpose to prevent physiologic anchorage loss and then enhanced total anchorage control fairly well.

PAC is a new concept, it has reduced headgear and temporary anchorage device used as sagittal anchorage dramatically in our clinic. I hope it can help more orthodontists in their clinic.

Figure 6: A Class II protrusion case treated with PAC technique

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Conflicts of interest

Dr. Xu is the inventor of the PAC system.

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The development of submucosal injection of platelet rich plasma for accelerating orthodontic tooth movement and preserving pressure side alveolar bone

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Abstract

Although the surgical-assisted accelerated orthodontic tooth movement has been proved to be the most effective one currently, its disadvantages are it is a bone surgery, and it causes loss of alveolar bone that undermines the periodontal support of the target teeth. The submucosal injection of platelet rich plasma (PRP) is a technique developed for accelerating orthodontic tooth movement by simulating the effects of bone insult without surgery and loss of alveolar bone. We have revealed clinically that submucosal injection of PRP accelerated the mandibular or maxillary alignment 1.7 folds faster in average, and the acceleration was dose-dependent when the PRP fold (platelet count in PRP/platelet count in blood) was <12.5. The optimal PRP fold for a more than 2-fold acceleration of orthodontic alignment ranged from 9.5 to 12.5 folds. On the other hand, the injection of PRP on the pressure side of *en masse* anterior retraction decreased 71–77% of alveolar bone loss, and this was dose-dependent. The pressure side of *en masse* anterior retraction had no alveolar bone loss when the PRP fold was higher than 11.0. In conclusion, the optimal PRP fold for the best performance in acceleration of orthodontic tooth movement and preservation of the pressure side alveolar bone is 11.0–12.5.

Key words: Bone, orthodontic tooth movement, platelet rich plasma

INTRODUCTION

Several noninvasive or invasive techniques have been proposed clinically or experimentally for accelerating orthodontic tooth movement. The noninvasive techniques include the biomechanical approach such as the self-ligation brackets,[1-6] the physiological approach such as the direct electric current stimulation,[7-9] low dose laser therapy,[10-17] vibration,[18-22] or photobiomodulation,[23,24] and the pharmacological approach such as the injection of prostaglandin[25-27] or relaxin.[28-32]

Vibration or photobiomodulation is among the latest noninvasive developments that could be the most feasible and practical methods for accelerating orthodontic tooth movement, but they still need more experimental and

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clinical studies to prove their clinical effectiveness.[33,34] Currently, the surgical-assisted approaches have been proved experimentally and clinically to be the most effective technique in accelerating orthodontic tooth movement.[35] These invasive techniques include the rapid canine retraction through distraction of periodontal ligament,[36-40] rapid canine retraction through distraction of dentoalveolus,[41-43] periodontally accelerated osteogenic orthodontics (PAOO),[44,45] corticision,[46] orthognathic surgery,[47] piezocision,[48,49] piezopuncture,[50] and micro-osteoperforation.[51] In comparison to the noninvasive approaches, they all have surgical insults to the bone that trigger a higher osteoclastic activity, resorption of the alveolar bone, decrease of the alveolar bone density, and loss of alveolar bone of the target teeth.[44-51] Their disadvantages are the surgery is not friendly to both of the patients and orthodontists, and the loss of alveolar bone that undermines the periodontal support of the target teeth.

It is, therefore, the PAOO included the bone allograft materials to expand the alveolar bone volume to compensate the extensive loss of alveolar bone after the corticotomy, and the other surgical-assisted techniques tried to reduce the surgery from a radical and extensive surgical insult toward a conservative and limited surgical insult. This could be elucidated sequentially by the change of surgical technique of bone insult from an extensive insult of bone through flap surgery in PAOO to a flapless and moderate insult of bone in corticision or piezocision, and then toward a minimal insult of bone in piezopuncture or micro-osteoperforation.

However, the effect of a minimal insult is not equal to that of an extensive insult. It has been revealed experimentally that the intensity and extensity of accelerating tooth movement depend on the intensity and extensity of the surgical insult.[52] The bigger the intensity and extensity the surgical insult the higher the intensity and extensity of the acceleration. In other words, a minimal insult of bone might not be able to trigger a strong and long lasting effect on accelerating orthodontic tooth movement. To simulate the effects of surgical insult without surgery, the local injection of cytokines or hormone could be a substitute for the surgical insults,[25-27] but it is not practical clinically due to its systemic effects and the need of frequent injections. Injection of autologous platelet rich plasma (PRP) could be a better substitute for bone surgery.

THE PLATELET RICH PLASMA

Platelets are one of the initiators both in the soft and hard tissue wound healing processes. Platelets contain growth factors such as the platelet-derived growth factor, transforming growth factor, endothelium growth factor, and the others. These growth factors are critical in the regulation and stimulation of the wound healing process, and they play an important role in regulating cellular processes such as mitogenesis, chemotaxis, differentiation, and metabolism.[53] Peripheral blood contains 94% of red blood cells (RBCs), 6% of platelets, and <1% of white blood cells (WBCs), while PRP contains 5% of RBCs, 1% of WBC, and 94% of platelets. PRP has been applied in dentistry for its capability of enhancing osseointegration of a dental implant and augmentation of alveolar bone height in maxillary sinus lift.[54-60]

In contrast to the other medical professions, the PRP in dentistry is always prepared by mixing with calcium chloride ($CaCl_2$) and thrombin to coagulate the platelets into a gel form and activate the containing growth factors before being applied to the region of interest through a full thickness flap operation. The $CaCl_2$ and thrombin initiate a burst release and activation of all the growth factors of PRP all at once. It is, therefore, the duration of action of PRP is short. On the other hand, the flap surgery is invasive in nature and causes the regional acceleratory phenomenon that induces a severe alveolar bone resorption and, therefore, might diminish some of the osteogenic effects of PRP. However, due to its gel form, flap operation, and short duration of action, this preparation for PRP is not suitable for orthodontic purposes.

A suitable PRP for orthodontic purposes should be injectable and has a long lasting effect. To develop an injectable PRP with a prolong effect on the target tissue, a simple approach is to prepare the PRP without mixing with $CaCl_2$ and thrombin, so that it could be maintained in a liquid form and be injectable.

THE PREPARATION OF PLATELET RICH PLASMA FOR ORTHODONTIC PURPOSES

The autologous PRP should be prepared under aseptic processing procedures [Figure 1].

- A volume of 60 ml of whole blood is drawn from the medial cubital vein of a patient using three 30 ml syringes that each contained 3 ml of 10% sodium citrate solution as an anticoagulant. Heparin is not recommended for using as the anticoagulant due to its systemic effects and inducing alveolar bone resorption. One ml of the blood is used for checking the platelet counts.
- The remaining 59 ml of whole blood is first centrifuged under 1000 rpm for 12 min at room temperature. The

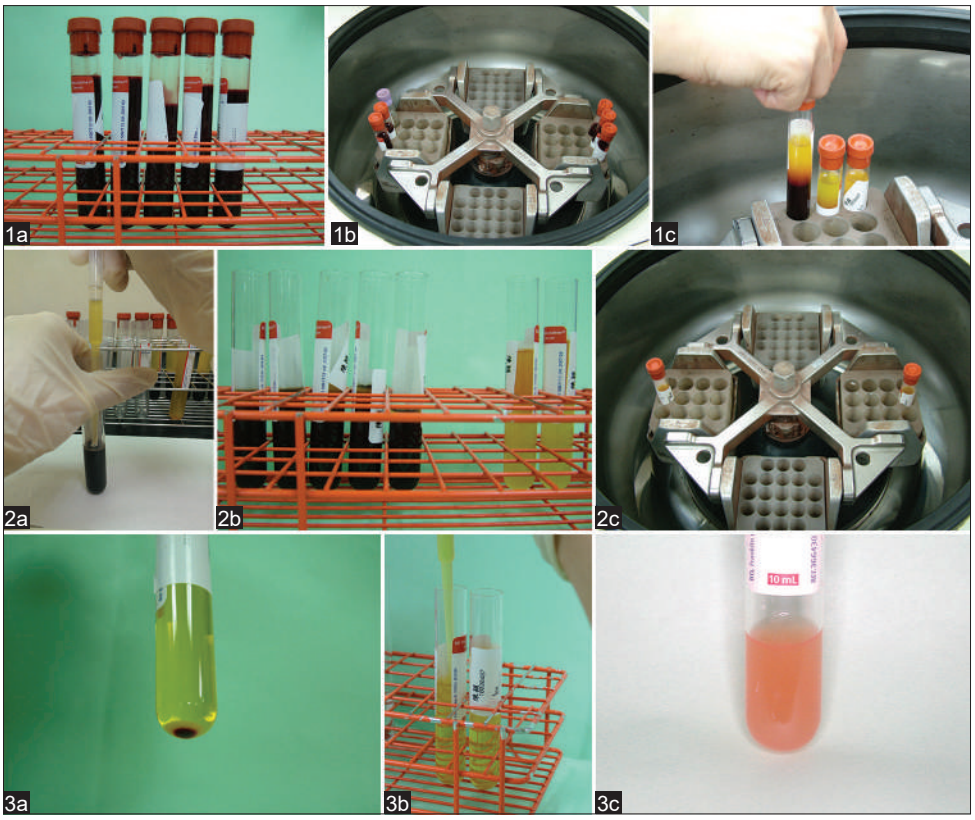

Figure 1: The preparation of platelet rich plasma. (1a-c): The blood sample is first centrifuged under 1000 rpm for 12 min and separated into the red blood cells at the bottom, the buffy coat (platelets) in the middle, and the platelet poor plasma at the top. (2a-c): The buffy coat and platelet poor plasma are pipetted and collected with care, and centrifuged again under 3000 rpm for 8 min. (3a-c): After the second centrifugation, the platelet poor plasma is removed until 4 ml remained and then the remaining platelet poor plasma is mixed with the buffy coat to become platelet rich plasma.

blood is then separated into its 3 basic components as the RBCs at the bottom, the buffy coat (platelets) in the middle, and the platelet poor plasma (PPP) at the top.

- The RBCs is discarded, and the remaining buffy coat and PPP are collected and centrifuged again under 3000 rpm for 8 min. After the second centrifugation, the PPP is removed until 4 ml remained and then the remaining PPP is mixed with the buffy coat to become PRP. One ml of the PRP is analyzed for its platelet count.

Under such a preparation, the PRP contains anticoagulant, high concentration of platelets, and a few of RBCs and WBCs, and it has to be injected shortly after its preparation.

THE SUBMUCOSAL INJECTION OF PLATELET RICH PLASMA FOR ORTHODONTIC PURPOSES

The PRP together with the containing anticoagulant is injected submucosally. Due to the presence of anticoagulant, we surmised that after injection of PRP, only part of the platelets adhere and aggregate little by little on the surfaces of collagen fibers, the intrinsic and extrinsic pathways of hemostasis initiate to generate thrombin gradually, platelet clots lay down little by little above the periosteum, and then the growth factors release and infiltrate little by little into the periosteum and alveolar bone. The procedures of injection are summarized as follows [Figure 2]:

- Before the injection of PRP, local anesthesia (Xylocaine) should be injected at the target sites for the pain control.
- For each target site, 0.7 ml of PRP could be injected. It is better to inject through the attached gingivae into the oral mucosa using a 27-gauge dental needle to avoid leakage of the PRP.
- It is a submucosal injection rather than a sub-periosteal injection. It is just similar to the injection of local anesthesia, and it has no certain injection pattern.
- Acetaminophen (500 mg) could be prescribed for the postinjection pain control. Nonsteroidal anti-inflammatory drug will neutralize the effects PRP and is not appropriated for the postinjection pain control.

Eighty-five percent of the patients reported 6–12 h of acceptable postinjection discomfort including intraoral

mucosal swelling, itching sensation and mild to moderate pain, but 15% of the patients reported severe pain. The intensity of postinjection discomfort varies with the concentration of PRP. It has been observed clinically that the higher the concentration of PRP the more the postinjection discomfort.

THE CLINICAL APPLICATIONS FOR PLATELET RICH PLASMA SUBMUCOSAL INJECTION

The injection of PRP could be applied for accelerating orthodontic tooth alignment and leveling in anterior crowding [Figure 3], and space closure in *en masse* anterior retraction [Figure 3] or molar protraction [Figure 4]. It could also be used for preserving the pressure side alveolar bone of *en masse* anterior retraction.

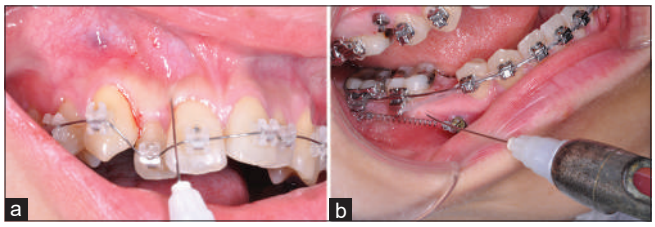

Figure 2: The platelet rich plasma is injected through the attached gingivae into oral mucosa to avoid leakage using a 27-gauge dental needle. (a): The submucosal injection of platelet rich plasma for the anterior teeth. (b): The submucosal injection of platelet rich plasma for the posterior teeth.

- The target sites of injection are the labial and lingual/palatal sides of the anterior teeth when the purpose of injection is to accelerate the alignment and leveling.
- The target site is the lingual/palatal side of anterior teeth when the purpose is to accelerate anterior retraction or to preserve the pressure side alveolar bone.
- The target sites could be the buccal, lingual/palatal, and mesial sides of the posterior teeth when the purpose is to accelerate the protraction of posterior teeth or preserve the alveolar bone of the protracted posterior teeth.

THE DOSAGE AND EFFECTS OF SUBMUCOSAL INJECTION OF PLATELET RICH PLASMA

A single injection of PRP lasts for 5–6 months clinically. It has been observed clinically that the fastest rate of acceleration is during the second to fourth month after the injection. The applied regimen for different purposes is summarized:

- Single injection of PRP in the beginning of treatment for the purpose of alignment and leveling.
- One injection of PRP in the beginning and another boost of injection 6 months after the first injection for the purpose of anterior retraction.
- One injection of PRP in the beginning and another boost of injection 6 months after the first injection for the purpose of protraction of posterior teeth.

Figure 3: The platelet rich plasma application for accelerating the alignment of anterior crowding and space closure in a case treated with upper and lower premolar extraction. (1a-e): The first platelet rich plasma injection in the upper and lower anterior teeth. (2a-e): 3 months after the first platelet rich plasma injection. (3a-e): 6 months after the first platelet rich plasma application and the second boost of platelet rich plasma injection. (4a-e): The extraction space was closed 3 months after the second boost of platelet rich plasma injection.

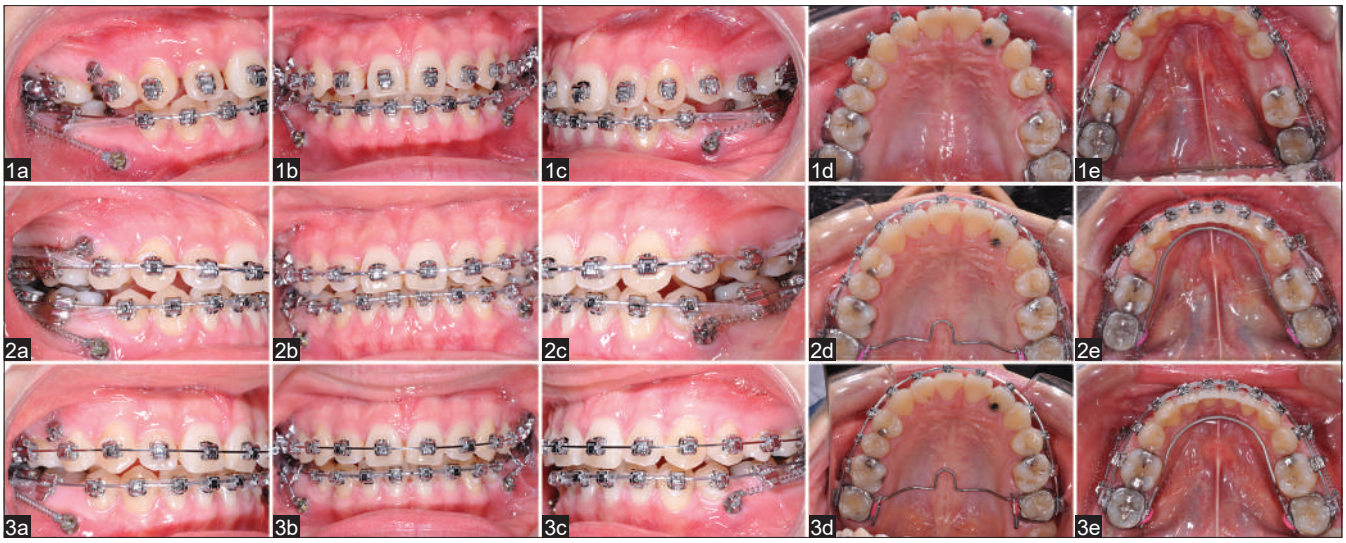

Figure 4: The platelet rich plasma application for upper and lower molars protraction with temporary anchorage devices. (1a-e): The first application of platelet rich plasma at the #36, 46, and #16. (2a-e): The upper space was closed 6 months after the first platelet rich plasma injection, and the second platelet rich plasma was injected for the further space closure in the lower. (3a-e): The lower space was closed 2 months after the second injection of platelet rich plasma.

Our clinical data revealed that the submucosal injection of PRP accelerated orthodontic tooth alignment and decreased the alveolar bone loss on the pressure side of orthodontic tooth movement. The injection of PRP accelerated the mandibular or maxillary anterior teeth alignment 1.7 folds in average (range from 1.3 to 2.1 folds), and the acceleration was dose-dependent when the PRP fold (platelet count in PRP/platelet count in blood) was <12.5. The optimal PRP fold for a more than 2-fold of acceleration of orthodontic alignment was found to be 9.5 to 12.5 folds.

On the other hand, the submucosal injection of PRP in the pressure side of *en masse* anterior retraction decreased 71–77% of alveolar bone loss, and this was PRP dose-dependent. The pressure side was found having no alveolar bone loss when the PRP fold was higher than 11.0.

In summary, the optimal PRP fold for a higher than 2-fold acceleration of orthodontic tooth movement and no pressure side alveolar bone loss is 11.0–12.5.

THE PREPARATION OF OPTIMAL PLATELET RICH PLASMA DOSAGE

The easiest way to prepare an 11.0–12.5 folds of PRP is to dilute a known high concentration PRP with certain amount of PPP. The high concentration PRP could be prepared by removing most of the PPP without disturbing the buffy coat at the bottom after the second centrifuge. For example, we could prepare 1.0 ml of 22 folds of high concentration PRP and then dilute with 1.0 ml of PPP to obtain 2.0 ml of 11.0 folds of PRP.

CONCLUSIONS

The submucosal injection of PRP is a clinically feasible and effective technique to accelerate orthodontic tooth movement and at the same time, preserve the alveolar bone on the pressure side of orthodontic tooth movement, and the optimal dose of PRP for the best clinical performance is 11.0–12.5 folds.

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Conflicts of interest

There are no conflicts of interest.

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Current status of orthodontic professionals in the Asian Pacific region

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Abstract

Asian Pacific Orthodontic Society (APOS) was developed in Tokyo on October 1, 2001. Currently, APOS has grown up to a scientific association specified to orthodontics with 18 affiliated societies. However, the status of orthodontic professionals in each society remains unclear beyond our understanding. To this end, I have recently conducted an internet interview to the representatives of affiliated societies. The questionnaire includes the educational system for dentists and orthodontists, the number of orthodontic departments with post-graduate programs, the number of orthodontists or members of each society, orthodontic treatment fee on average, the prevalence of CLP and the treatment, orthodontic treatment for jaw deformity patients, current status of orthodontic treatment with lingual appliances and TADs, important issues for orthodontic specialists, future plans of each society. It is hopefully anticipated that the current status of orthodontic professionals in the Asian Pacific region are well understood by all the APOS members and will become a great benefit for the development of all the affiliate societies.

Key words: Orthodontic professionals, Asian Pacific region, Educational system, Orthodontic treatment, Malocclusion

INTRODUCTION

History of Asian Pacific Orthodontic Society

Asian Pacific Orthodontic Society (APOS) was inaugurated on October 10, 2001, in Tokyo, Japan, by its nine founding members shown below alphabetically.

1. Association of Philippine Orthodontists (APO)
2. Association of Orthodontists Singapore (AOS)
3. Chinese Orthodontic Society (COS)
4. Hong Kong Society of Orthodontists (HKSO)
5. Indonesian Association of Orthodontists (IAO)
6. Indian Orthodontic Society (IOS)
7. Japanese Orthodontic Society (JOS)
8. Korean Association of Orthodontists (KAO)
9. Thai Association of Orthodontists (ThaAO).

The purpose for which the APOS has been formed is to assist affiliated societies/associations to promote excellence in orthodontics through education and research in the Asian Pacific region. Moreover, the activity of APOS is to disseminate scientific and artistic information relating to orthodontics particularly through its biennial congress, Asian Pacific Orthodontic Congress (APOC).

Footnote:

The content of this article, in part, has already been presented at the 8th WFO-IOC "APOS-World Village Day" held in London on September 29, 2015.

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The first APOC was held in Osaka in 1991. At the meeting, the representative members confirmed a plan to establish APOS and the preparatory committee at the 2nd APOC in Seoul in 1995 and the 3rd APOC in Taipei in 1998, respectively. After that, the representatives meetings were held at every AAO Annual Meeting and the preparatory committee meetings were held in Bangkok, Osaka, and Seoul to prepare the Bylaws. Finally, the representative committee has reached a conclusion to establish APOS in Tokyo in conjunction with JOS Meeting in 2001 [Figure 1].

Currently, the APOS has grown to an academic society specified to orthodontics with 18 affiliate members after the addition of the following societies:

1. Australian Society of Orthodontists (ASO)
2. Bangladesh Orthodontic Society (BOS)
3. Malaysian Association of Orthodontists (MAO)
4. Macau Association of Orthodontists (MacAO)
5. Pakistan Association of Orthodontists (PAO)
6. New Zealand Association of Orthodontists (NZAO)
7. Orthodontic and Dentofacial Orthopaedic Association of Nepal (ODOAN)
8. Sri Lanka Orthodontic Society (SLOS)
9. Taiwan Association of Orthodontists (TAO).

Past APOS Presidents include Dr. Gakuji Ito (JOS), Dr. Hideo Mitani (JOS), Dr. Jae Chan Kim (KAO), Dr. Somchai Satravaha (ThaAO), Dr. Kai-Woh Loh (AOS), and Dr. Kazuo Tanne (JOS). At present, the President of APOS is Dr. Nikhilesh Vaid from IOS [Figure 2].

We have recently achieved the following issues.

1. Official registration of APOS as an academic society
2. Establishment of APOS bank account for maintaining the sound financial status
3. Publication of official Journal "APOS Trends in Orthodontics."

Figure 1: Asian Pacific Orthodontic Society founding members to attend the signing ceremony in Tokyo (October 10, 2001)

With respect to the publication of APOS Trends in Orthodontics, I would like to express a sincere appreciation for the efforts of Dr. Nikhilesh Vaid, who delivered a message shown below.

The year of 2013 was a very important year for "APOS Trends in Orthodontics." I have to thank the dynamic and inspirational leadership of immediate past president of APOS, Dr. Kazuo Tanne for it. We have been indexed by 14 agencies and should be PubMed Indexed in 2014. We have six issues/year, dedicated to Orthodontic Research, Clinical Articles, and Clinical Pearls. All articles are available for free download. In addition, a new feature introduced is the article statistics. We plan to start biannual awards for the most popular and cited articles. The editorial team would love to welcome articles from each affiliated society. All the APOS members can submit it online at http://www.apospublications.com/submitarticle.asp.

Internet interview

As mentioned above, APOS has grown up to an academic association specified to orthodontics. However, the current status of orthodontics in each affiliated society still remains unclear and beyond our understanding. From

Figure 2: (a) Past Presidents of Asian Pacific Orthodontic Society (from left to right, Dr. Gakuji Ito, Dr. Kai-Woh Loh and Kazuo Tanne. (b) Current Asian Pacific Orthodontic Society office bearers at the 8th IOC Asian Pacific Orthodontic Society-World Village Day in London (September 29, 2015)

these considerations, we explored a certain approach to elucidate the nature of orthodontic education and clinical orthodontics in the Asian Pacific region. Since July 2013, I have been conducting an interview with VIPs or representatives of APOS affiliate societies about a series of questionnaires on the current status of orthodontics in the Asian Pacific region. In addition, the results of interview have already been published in the Journal of Orthodontic Practice, an orthodontic journal in Japan, after having translated into Japanese for a better understanding of Japanese Orthodontists. Furthermore, I presented a lecture entitled "Current status of orthodontic professionals in the Asian Pacific region" at the 8th World Federation of Orthodontists (WFO)-International Orthodontic Congress "APOS-World Village Day" held in London on September 29, 2015. Thus, this article was designed to share and disseminate the knowledge about the current status of orthodontics and our professionals in APOS affiliate societies with all the members, students, friends, colleagues, and respectable teachers.

MATERIALS AND METHODS

For a period of July 2013 to February 2015, I requested an internet interview to each of the VIPs in APOS affiliate societies listed below in an alphabet order.

- Dr. Bryce Lee (AOS)
- Dr. Roberto Tan (APO)
- Dr. Zakir Hossain (BOS)
- Drs. Zhihe Zhao and Tianmin Xu (COS)
- Dr. Wilson Lee (HKSO)
- Dr. Himawan Halim (IAO)
- Dr. Nikhilesh Vaid (IOS)
- Dr. Hee-Moon Kyung (KAO)
- Dr. Wei Lin (MacAO)
- Dr. Peter Fowler (NZAO)
- Dr. Dashrath Kafle (ODOAN)
- Dr. Ambreen Afzal Ehsan (PAO)
- Dr. Wickramasinhe M. Senadeera (SLOS)
- Dr. Johnny Liaw (TAO)
- Dr. Somchai Satravaha (ThaAO).

The interview was designed to ask about the following subjects through the internet.

1. Current status of orthodontics in each affiliate society in terms of the number of orthodontists or members in the society, and the numbers of dental schools and/or Orthodontic Departments
2. Educational process to become dentist and orthodontist in each affiliate society
3. Therapeutic system or clinical technique successfully used for good treatment outcome and orthodontic treatment fee on average
4. Supply of orthodontic materials
5. Prevalence of malocclusion
6. Percentage of nonextraction treatment
7. Treatment of jaw deformity patients
8. Prevalence of cleft lip and palate (CLP) and the therapeutic system
9. Current status and future development of orthodontic treatment with lingual appliances
10. Current status and future development of orthodontic treatment with temporary anchorage devices (TADs)
11. Important issues for orthodontic specialists
12. Future plan of each affiliate society.

All the replied information and comments from each interviewee were shown in the text without any substantial modification. In addition, numerical data were summarized in tables.

RESULTS

Current status of orthodontics in each affiliate society in terms of the numbers of orthodontists or members in the society and dental schools and/or Orthodontic Departments

The numbers of Orthodontic Departments and members are shown in Table 1. It should be noted that the number of dental school or Orthodontic Department is zero in MacAO and only one in AOS, HKSO, NZAO, and SLOS. The total number of members in APOS affiliate societies is approximately 18,000. Among these, the members in four big societies, COS, IOS, JOS, and KAO, is more than 80% of the total number.

Table 1: The numbers of orthodontic departments and members in each affiliate society

Affiliate society	Orthodontic departments	Members in each society
AOS	1	about 100
APO	4	125
BOS	2	120
COS	>60	2,421
HKSO	1	about 70
IAO	30	550
IOS	about 100	about 3,000
JOS	30	6,513
KAO	11	>3,000
MacAO	0	14
NZAO	1	78
ODOAN	11	35
PAO	around 50	about 100
SLOS	1	56
TAO	7(16)	602
ThaAO	9	751

The replies or comments from each interviewee are shown below.

Association of Orthodontists Singapore

Our dental school in Singapore, the faculty, is at the National University of Singapore, began a formal training program in orthodontics only about 20 years ago. This is a 3-year program, and we currently train up to 6 orthodontists a year. Prior to this, all orthodontists were trained overseas.

AOS was founded in 1991. We currently have about 100 members in AOS; all of them have undergone formal orthodontic training.

Association of Philippine Orthodontists

To date, there are four universities in the Philippines, which offer postgraduate (PG) orthodontic training programs. These are University of the Philippines (UP), Centro Escolar University (CEU), Manila Central University, and University of the East. All programs award a Certificate of Proficiency in Orthodontics and for most, a degree of Master of Science in Dentistry (Orthodontics) upon completion.

Currently, there are 125 APO members comprising fellow 68, diplomate (included in fellow) 18, active member 2, affiliate member 18, associate member 35, and international member 2.

Bangladesh Orthodontic Society

Currently, there are two Orthodontic Departments that run PG course. In these departments, two students from the Department of Orthodontics, Hiroshima University Faculty of Dentistry, Drs. Zakir Hossain and Saif Uddin, are playing important roles as the chairs. At present, there are 120 BOS members or qualified orthodontists.

Chinese Orthodontic Society

There are over 60 Orthodontic Departments in China. Most of the dental students spend 5 years to get DDS before they can take the entrance examination to be an orthodontic graduate student. After 3 years, orthodontic training, they graduate with an MS degree in orthodontics, or they may spend another 2–3 years to get a Doctoral degree in orthodontics or a PhD. We used to consider them as orthodontic specialists in China. Currently, we have 2,421 COS members.

Hong Kong Society of Orthodontists

Of the 2000 dentists registered under the Dental Council of Hong Kong, there are about 70 of them legally registered as a specialist in orthodontics. The representative specialist society is the HKSO (www.hkso.hk). There is only one dental school in Hong Kong, which is the Faculty of Dentistry of the University of Hong Kong (HKU) (http://facdent.hku.hk/). The dental school was formally established in 1982. Before that, all dentists in Hong Kong were trained overseas, obtained their education from, e.g. Taiwan, Philippines, UK, and USA. Now, the orthodontic discipline under the Faculty of Dentistry offers the only academic training of orthodontists in Hong Kong.

Indonesian Association of Orthodontists

Indonesia has 30 dental schools with five orthodontic programs. IAO has about 550 members.

Indian Orthodontic Society

Today, we have close to 250 dental schools and around 100 of them are offering Master programs in orthodontics. We have close to 400 orthodontists graduating every year. The current number of orthodontic specialists in India who are IOS members is close to 3000.

Japanese Orthodontic Society

In Japan, we have 29 dental schools and 30 Orthodontic Departments with authorized PG orthodontic programs. As of February 21, 2014, the number of JOS members is 6513.

Korean Association of Orthodontists

In Korea, we have 11 dental schools and more than 3000 members in KAO.

Macau Association of Orthodontists

We have 14 members in our association, and there are nine Orthodontic Departments in Macau.

New Zealand Association of Orthodontists

There is only one Dental School in the University of Otago in New Zealand which includes the Orthodontic Department and is located in the South Island City of Dunedin. The current Head of Department is Professor Mauro Farella and each year 3 PG students commence a 3-year Clinical Doctorate Program in Orthodontics (9 students in total).

There are 78 registered orthodontic specialists in New Zealand, of which, 74 are full members of NZAO. In addition, the NZAO has 9 life members, 7 retired members, 10 student members, and 21 corresponding members (overseas). The registered orthodontic specialists must have completed formal PG university-based training. Over 50% of these have been undertaken at the Orthodontic Department, Faculty of Dentistry, University of Otago. The remaining orthodontists have undertaken their specialist training in universities based in the UK, USA, Australia, and more recently Europe.

Orthodontic and Dentofacial Orthopedic Association of Nepal

Academically, we have 11 dental colleges of Nepal with the Department of Orthodontics. The total number of dentists in Nepal is 800. We have 35 orthodontists registered.

Pakistan Association of Orthodontists

We have around 100 orthodontists (qualified) in Pakistan. We have around 50 dental schools and all of them have Orthodontic Departments.

Sri Lanka Orthodontic Society

Sri Lanka has only one dental school under the University of Peradeniya and no private dental schools. Average annual intake is about 70. We have only one PG training program in orthodontics under the University of Colombo. A total number of qualified orthodontists is 56.

Taiwan Association of Orthodontists

The number of Orthodontic Departments in Taiwan is seven. However, the qualified orthodontic institutes providing certified orthodontic programs are totally 16 until now.

The number of active TAO members is 602. In Taiwan, there are two academic bodies for orthodontics, TAO and TOS. In 2010, TAO was assigned to accredit the orthodontic program and certify the licenses of orthodontist. After that, all the new members of TAO are limited to certified orthodontists, whereas TOS includes many dentists who, having no opportunity to enter the certified orthodontic programs, are still interested in orthodontics.

Thai Association of Orthodontists

Thailand has nine dental schools (eight government schools and one private school); only five government schools have PG programs in orthodontics.

ThaAO has 751 members, 507 ordinary members (orthodontists), 100 student members (PG in orthodontics), and 144 associate members (general practitioners [GPs]). Seventy percent of ThaAO ordinary members did their PG studies in orthodontics in Thailand whereas 30% finished their PG studies abroad.

Educational process to become dentist and orthodontist in each affiliate society

Table 2 shows the duration of educational systems for dentists and orthodontic specialists in each affiliate society. In most countries in Asian-Pacific region, it takes 5–6 years to complete dental education for Bachelor of Dental Surgery (BDS) or DDS. It should be noted that dental school system for 8 years has recently been started in Korea. Thus, Korea has two kinds of educational system to become a dentist. Some dental colleges have a traditional system of 2-year predental course plus 4-year dental course. Meanwhile, six dental colleges have changed their educational systems to 4 + 4 system since 2005, which means 4 years of bachelor degree plus 4-year dental school program.

Table 2: Duration of educational systems for dentists and orthodontists

Affiliate society	Dentist	Orthodontist
AOS	6	5
APO	6	2-3
BOS	5	4-5
COS	5	3 (MSc), 5 (PhD)
HKSO	6	6
IAO	6	3
IOS	5	3
JOS	6	5
KAO	6 (2+4), 8 (4+4)	4
MacAO	5-6	2-3
NZAO	5	5 (2+3)
ODOAN	5.5	3
PAO	4	4
SLOS	4	5
TAO	6	5(2+3)
ThaAO	6	2-3

For orthodontic specialists, in general, it takes 3–6 years as either resident or Master or Ph.D. student. It should be noted that, in Hong Kong, it takes at least 6 years after graduation from dental school to become an orthodontic specialist, which seems one of the most difficult PG orthodontic programs in the world.

The replies and the relevant comments are shown below for better understanding of the readers.

Association of Orthodontists Singapore

In order to become an orthodontic specialist in Singapore, one must have undergone 3-year training in a recognized orthodontic program (what we term basic specialist training). Thereafter, each individual must gain experience in orthodontics for at least 2 years (we call this advanced specialist training) before presenting himself for a specialist exit assessment. On passing this assessment, the individual can put his name on the dental specialist register and call himself a dental specialist in orthodontics. This register is new and only started in 2008.

Association of Philippine Orthodontists

To complete the dental education in the Philippines, you need at least 6 years of studies leading to the degree of Doctor of Dental Medicine (DMD). This would be followed by a 4-year Dentistry Proper course. There are

26 dental schools offering DMD. After completing 6 years of dental education, one needs to pass the National Dental Board Licensure Examination. This examination is conducted twice a year and includes theoretical and practical examinations.

The University of Philippines (UP) and CEU are the only recognized Orthodontic Graduate Programs in the Philippines. All graduates of accredited programs are exempt from taking the first phase (dexterity and interview) of the Philippine Board of Ophthalmology (PBO) diplomate examinations whereas graduates of nonaccredited universities are required to take the first phase of PBO diplomate examinations.

Bangladesh Orthodontic Society

Postgraduate course started in 1999. After the completion of 5-year BDS course followed by 1-year internship, there are 4–5-year courses to become qualified orthodontist.

Chinese Orthodontic Society

If somebody wants to be a dentist, he/she must finish a 5-year college study. After a 5-year study, the graduate can get a license to be a general dentist. Then, he/she can apply for qualified examination for further training to be an orthodontist. There are two kinds of orthodontic training: 3-year training for Master degree and 5-year training for Ph.D. degree.

Hong Kong Society of Orthodontists

Since 2012, the undergraduate degree of BDS of HKU is a 6-year program. After at least 1 year of employment in general dentistry, the dentist is eligible to apply for the Master of Orthodontics (MOrth) program at HKU. This is the beginning of the orthodontist training pathway under the College of Dental Surgeons of Hong Kong (www.cdshk.org). It is a full-time 3-year program, with an emphasis in both research and clinic training. After obtaining the Master degree in HKU, the orthodontic trainee will need to pass the Membership in Orthodontics of Royal College of Surgeons of Edinburgh (MOrth RCS Edin) before eligible to proceed to the final 2-year of higher training in orthodontics. The higher training can be done at the government hospital or taking the 2-year part-time Advanced Diploma in Orthodontics (AdvDipOrtho) degree at HKU. Finally, the College of Dental Surgeons of Hong Kong will conduct a final exit examination for the higher trainee before they can officially and legally registered and called themselves the title Specialist in Orthodontics. Overall, it takes at least 6 years after graduation from dental school to become an orthodontic specialist in Hong Kong. Thus, our training is one of the most difficult in the world. It is also hard for foreign orthodontists to obtain a specialist title in Hong Kong since they have to first pass the Hong Kong dentist licensing examination, and then the MOrth RCS Edin examinations before they can be eligible to apply as a higher trainee in the pathway.

Indonesian Association of Orthodontists

Dental school in Indonesia is straight from high school graduate and the time to become dentists takes 6 years and 3 years to complete orthodontic program.

Indian Orthodontic Society

Dental education starts with the basic BDS degree, which is 4 + 1 (compulsory internship) or 5 years. After you graduate as a dentist, you are immediately eligible to apply for a Masters course in orthodontics through entrance exams conducted by various central and state government bodies, and private universities admitting candidates in orthodontics for a Master program. The master program in orthodontics is of a 3-year duration. Hence, it ideally takes 8 years to be an orthodontist.

Japanese Orthodontic Society

It takes 6 years to complete dental education for DDS. After the graduation from dental school, dental license examination is held by the Ministry of Health. After getting the license, all the dentists have to take a 1-year clinical training. Then, they can take a 5-year postgraduate orthodontic program. In completion of the program, they can be given a certificate in orthodontics if they pass an oral examination about two treated cases presented at the JOS annual meeting.

Korean Association of Orthodontists

In Korea, there are two kinds of the educational system to become a dentist. Some dental colleges have a traditional system of 2-year predental course plus 4-year dental course. Six dental colleges have changed their educational system to 4 + 4 system since 2005, which means, to enter the dental schools, the students have to finish 4 years of bachelor degree and then they can take 4-year dental school program.

Specialist programs consist of 4 years in total, 1 year as an intern, and 3 years as a resident in 29 Orthodontic Departments with authorized programs in Korea. They together develop around 45 orthodontic specialists per year.

For the past 7 years from 2008 up to present, 331 orthodontic specialists have finished the program. From 2008, those who finish the orthodontic programs were given the title as "specialist" accredited by the government whereas those who completed the program before 2008 are not approved officially as specialists by the Korean government standards. The number of orthodontic specialists, approved in each year from 2008, is shown herein.

2008	39	2009	47	2010	57	2011	49
2012	47	2013	48	2014	44		

Macau Association of Orthodontists

As in Macau, we do not have our dental school, it means all our dentists studied aboard. Macau citizen can get the license from the government after they finished 5–6 years to complete dental education and got the bachelor degree in dentistry. Moreover, it still needs 2–3 years training for the dentists to become an orthodontist.

New Zealand Association of Orthodontists

Students must complete a 5-year Bachelor in Dental Surgery (BDS) Degree and spend at least 2 years in general or hospital based practice before they can apply to undertake specialist orthodontic training. It is expected that applications for the PG training program to have successfully completed Part 1 of the Australasian College of Dental Surgeon's Fellowship examination or similar, prior to submit their application. Entry to the program is extremely competitive with applicants seeking one of the three positions available every year. The 3-year Clinical Doctorate in Orthodontics commences in February and involves both clinical and research training.

Orthodontic and Dentofacial Orthopaedic Association of Nepal

The duration of dental education in Nepal is 5.5 years which includes 1 year of compulsory internship training. To become an orthodontist, a dentist has to be enrolled into a postgraduate program which is for 3 years in Nepal.

Pakistan Association of Orthodontists

Pakistan has 4-year dentistry program for BDS and 4-year orthodontic residency program which leads to Fellow of College of Physicians and Surgeons or Master of Dental Surgery.

Sri Lanka Orthodontic Society

It takes 4-year undergraduate period to become a dentist. Presently, the PG program is altogether 5 years.

Taiwan Association of Orthodontists

It takes 6 years to complete dental education. The only way to become a certified orthodontist in Taiwan now is to train in a certified orthodontic program. After graduation from dental school, one can apply for the PG orthodontic program to get a Master degree or enter a residency program, which usually consists of 2-year training of general practice and 3-year orthodontic resident training.

Thai Association of Orthodontists

After high school education (12th grade) and after passing the university entrance examination, one can enroll then in the Faculty of Dentistry to study dentistry. Then, one must finish 6 years of university dental education and pass a license examination directed and controlled by the Dental Council of Thailand. Before finishing these 6 years of dental education, one must pass 2 parts of license examination, one written exam and one practical exam, to practice in Thailand as a dentist.

After becoming a dentist, one can apply to study in orthodontic programs which are residency training program, and MS in Orthodontics or Ph.D. program. Residency programs are under the supervision of the Royal Dental College of Dental Surgeons of Thailand while other two programs are under the supervision of the universities. At the time being, there are 4 residency programs at 4 universities and 5 MS and 2 Ph.D. programs at 5 universities. After finishing any of the programs, one can apply to take a board examination which is directed and controlled by the Royal Dental College of Dental Surgeons of Thailand under the supervision of the Thai Dental Council, to be Board qualified as Diplomate, Thai Board of Orthodontics.

Therapeutic system or clinical technique successfully used for good treatment outcome and orthodontic treatment fee on average

In the Asian Pacific Countries, a most popular technique frequently used in daily orthodontic practice is preadjusted straight wire edgewise technique. In addition, TADs or micro-implant anchorages (MIAs) have recently gained a greatest interest or concern in many APOS affiliate societies.

In most countries in Asian-Pacific region, orthodontic treatment fee varies around 2000 USD [Table 3]. Meanwhile, the fee is extremely low or approximately 350

Table 3: Orthodontic treatment fee on average

Affiliate society	Treatment fee in USD
AOS	1,875-3,000 (public) 3,850-4,500 (private)
APO	1,700-2,700
BOS	400-2,000
COS	1,500-2,400
HKSO	4,500 (3000;general dentist-10,000; specialist)
IAO	-
IOS	350
JOS	5,000-8,000
KAO	5,000
MacAO	4,000-5,000
NZAO	5,078-8,463
ODOAN	300-800
PAO	1200
SLOS	1000-1400
TAO	3500-6500
ThaAO	1187-2077(40,000-70,000Bahts)

USD in India. The biggest challenge facing IOS today is the financial health of the contemporary Indian orthodontists.

The replies from each interviewee are presented here for better understanding of APOS members.

Association of Orthodontists Singapore

A large majority of my cases I see at my practice are dental malocclusions. I have a very close working relationship with the pedodontist, prosthodontist, and oral surgeon that work in my practice. We, therefore, approach each case in this multi-disciplinary setting.

Association of Philippine Orthodontists

There are many new developments in orthodontics during the past years from bracket designs to anchorage source using MIAs. In our practice, we explore and evaluate the effectiveness of these new trends in orthodontics, while we keep focus on our treatment goals to achieve a functional, esthetically pleasing, and stable result.

The average orthodontic treatment fee, which includes upper and lower fixed braces, (with an average treatment time of 18–24 months) will cost about $1700.00–$2700.00. This varies depending on case difficulty and the location of the practice of the orthodontist. Orthodontic treatment fees are usually higher in Metro Manila as compared to those in rural areas. The patient is usually given a payment plan. Down payment would usually consist of 50% or half of the total fee whereas the remaining 50% would be payable by installment unless patient prefers to pay in full at the outset. Some would prefer the 40–60% formula and others would have the 30–70% depending on the market profile of their patients. Usually, APO members accept cash/check as payments whereas very few offices accept credit cards as means to settle fees.

Bangladesh Orthodontic Society

Currently, we use the removable technique (40%) and edgewise technique (60%). Use of activator is very popular in mixed dentitions and growing stage to correct Class III and Class II pattern and also to correct mandibular deviation with temporomandibular joint dysfunctions.

Treatment fee varies ranging from 400 to 2000 USD. For both nonqualified versus qualified orthodontists, it will take a few more years to standardize the treatment cost.

Chinese Orthodontic Society

Dr. Zhao

Straight wire technique is the most popular in the Department of Orthodontics, Sichuan University Hospital. Treatment fee in Sichuan University Hospital is about 1500 USD.

Dr. Xu

Straight wire appliances with sliding mechanics are mostly adopted in Peking University Hospital although we also use Tweed, MEAW, functional appliance, and so on. The treatment fee in PKU orthodontic clinic is around 2400 USD on average.

Hong Kong Society of Orthodontists

The most popular fixed appliance technique is the "straight-wire" or preadjusted edgewise fixed appliance with the 0.022-inch slot. The Roth and MBT prescriptions are the most popular specifications. Rapid palatal expansion and functional orthodontic appliance are also popular amongst specialists. Nowadays, due to aggressive marketing by commercial aligner company, removable aligner technique is becoming very popular amongst young adults. Majority of the treatment is provided by general dentists.

As most of the orthodontic treatments in fixed appliances are offered by general dentists, the treatment fee for a comprehensive 2-year orthodontic treatment started from the US $3000 by general dentists to as high as US $10,000 offered by a specialist in orthodontics. The average fee would be estimated at US $4500.

Indonesian Association of Orthodontists

We use growth spurt to treat skeletal malocclusion and extraction to get solve the bimaxillary protrusion cases. Indonesia is diverse country with different levels of income; hence, it is hard to get average fee of treatment.

Indian Orthodontic Society

India is very contemporary in terms of treatment techniques practiced. The standards of care in orthodontic treatment delivery and education are on par with the rest of the world in India. The biggest challenge facing us today is the financial health of the contemporary Indian Orthodontists.

The technique generally used in India is the PEA appliance, though certain quarters also practice Begg, self-ligation, and lingual and aligner therapy. Growth modulation, functional appliances, and surgical orthodontics are also practiced.

The average orthodontic treatment fee in India is around 350 USD, which is very low considering the inflation and financial growth rate of the country otherwise. The average number of patients seen by a practitioner in a year in India is 100. Hence, average gross collections for an Indian Orthodontist are just 35,000 USD/annum, which is far below the rest of the developing and developed world. We, as the IOS, are working very hard to address this issue by organizing workshops and symposia to educate our members about business aspects of orthodontics.

Korean Association of Orthodontists

Korean orthodontists learned and practiced almost all kinds of orthodontic techniques from the world for the last 50 years. They were using so many kinds of orthodontic techniques depending on the individual preference. However, all the techniques became easier and simpler after the use of micro implants as an anchorage.

Macau Association of Orthodontists

Our average treatment fee is around 4000–5000 USD.

New Zealand Association of Orthodontists

Because I work in both private and public hospital based practices, there is an ability to use various clinical tools and interests in either location. At the hospital, the use of distraction osteogenesis for complex cleft and craniofacial patients has resulted in successful outcomes that would not have been achieved with conventional orthognathic surgery and as well as increased stability of the changes achieved. The use of three-dimensional (3D) imaging and printing has aided detailed surgical planning in these cases. In private, the increasing use of Invisalign with auxiliary appliances has enabled more complex cases to be treated successfully in adults who would otherwise not undertake orthodontic treatment or would otherwise have not been for Invisalign alone.

The treatment fee for fixed appliance treatment ranges from approximately $6000 to $10,000 NZD (5078–8463 USD) and the fees charged for Invisalign/Incognito appliances range from $8000 to $12,000 NZD (6770–10,156 USD). This fee includes the 15% government goods and service tax. There is very limited 3rd party or insurance payment for orthodontics and state funding of orthodontics is limited to patients with CLP or craniofacial disorders only.

Orthodontic and Dentofacial Orthopedic Association of Nepal

I am treating most of my orthodontic cases with preadjusted edgewise appliances. However, for the last few years, I have been trained in lingual orthodontics, clear aligners, and self-ligating systems. Hence, I have incorporated those appliances in my clinical practices in recent years.

On average, we are charging 300–800 USD for the orthodontic treatment. Yet it depends upon the doctors to doctors and clinics to clinics. However, government hospitals and university hospitals charge less compared to private practices.

Pakistan Association of Orthodontists

We usually follow the same objectives as are required in the American Board of Orthodontists. This enables us to keep quality control and, later on, appear in other Royal College exams. The average fee is around 1200 USD.

Sri Lanka Orthodontic Society

I manage a considerable number of CLP cases. I have invented a cheap and convenient technique for osteodistraction of the constricted maxilla using a rapid maxillary expansion screw.

Treatment fee for an average case varies from 130,000 to 190,000 SL Rupees, which is something like 1000–1400 USD.

Taiwan Association of Orthodontists

My recent clinical interests are application of TADs in various clinical situations (paradigm shifts of orthodontic treatment with TADs, tough cases made easy with TADs, nonextraction treatment with TADs, active vertical control with TADs in high angle cases, applications of TADs in asymmetry cases, gummy smile correction with TADs), interdisciplinary treatment (the beauty of interdisciplinary treatment, the challenges of adult orthodontics), and autotransplantation (autotransplantation, an alternative to implant prosthesis in mutilated dentitions).

As for the average treatment fee, it ranged from 3500 to 6500 USD among various clinics. For the most clinics, the average treatment fee lies around 4000 USD.

Thai Association of Orthodontists

We use removable appliances, functional appliances, myofunctional therapy, fixed orthodontic appliances, TAD, and others according to the indications. If growth modification is indicated and growth is still present, we do growth modification as the 1st stage treatment procedure, and then fixed orthodontic appliances as the 2nd stage treatment procedure.

I got many referred cases on Class III skeletal malocclusions for early treatment. Another topic is the use of TAD to facilitate orthodontic treatment.

Supply of orthodontic materials

It is shown that most techniques and appliances are available for use in every society. Orthodontic materials, meanwhile, are mostly imported from USA, Europe, China, India, and Japan, but recently produced in some APOS affiliate societies. Representative replies and comments are shown herein.

Bangladesh Orthodontic Society

Most materials are available here imported from abroad. However, one Bangladeshi company is producing orthodontic brackets and exporting to India, Malaysia, and other countries.

Chinese Orthodontic Society

More and more national manufacturers earn their reputation in the local market and some of the foreign markets. Moreover, their products cover almost all

orthodontic line, from traditional orthodontic products to clear appliance, individual lingual system, and so on.

New Zealand Association of Orthodontists

There are no orthodontic manufacturers located in New Zealand. The majority of orthodontic supplies are imported from North America, although others are sourced from Europe or Japan. There are various agents of the main orthodontic supply companies who service the NZ orthodontic practices and most are located in Australia.

Orthodontic and Dentofacial Orthopaedic Association of Nepal

We do not have our own orthodontic products in Nepal. Hence, we largely depend on suppliers who import orthodontic materials from India and China.

Sri Lanka Orthodontic Society

We import all the materials mainly from USA, Germany, and China.

Prevalence of malocclusion

In most countries in Asian-Pacific region, Class I malocclusion with bimaxillary protrusion exhibits higher prevalence. Meanwhile, prevalence of Class II malocclusion with maxillary protrusion is higher in New Zealand, Pakistan, and Bangladesh, similarly to that in Europe and the USA. In addition, this result is similar to the finding about the rate of nonextraction treatment with multibracket appliances to be shown later.

Association of Philippine Orthodontists

It is unfortunate that we do not have an accurate prevalence rate of the malocclusion in our country. Since we are composed of fragmented islands, it is difficult to gather data. However, there are inferential studies done on specific areas in the National Capitol Region. One study done in Caloocan city among 11–13-year-old students revealed the following data:

Class I - 66.67%, Class II div 1 - 10.78%, Class II div 2 - 10.18%, and Class III - 12.57%.

Hong Kong Society of Orthodontists

Of all, the occlusion in Hong Kong Chinese: 50% Class I malocclusion, 20% Class II malocclusion, and 5% Class III malocclusion with the remaining 25% as normal occlusion.

Indonesian Association of Orthodontists

According to our national survey, the malocclusion in Indonesia is above 60%, with Class I, then Class III, and Class II.

Macau Association of Orthodontists

The prevalence of malocclusion in Macau is 68.04% (2343 students with the age from 12 to 22 years were investigated in 2003): Class I-65.20%, Class III-20.10%, and Class II-14.70%.

New Zealand Association of Orthodontists

A recent study of 12–13 years old using the dental esthetic index (DAI) found that 60% required orthodontic treatment ("definite," "severe," or "handicapping" as defined by DAI assessments). An earlier study of children in the mixed dentition suggested orthodontic treatment would be "mandatory" in 30% of the children with an additional 20% being considered as "highly desirable" to undertake orthodontic treatment. The majority of malocclusions would be Class II, Class I, and a small proportion Class III.

Orthodontic and Dentofacial Orthopaedic Association of Nepal

According to the recent research done among high school students, the prevalence of malocclusion is 73%: Class I-59%, Class II-25%, and Class III-16% in Nepal.

Pakistan Association of Orthodontists

Prevalence of malocclusion is in order of Class II, Class I, and Class III although the exact values are unclear.

Sri Lanka Orthodontic Society

According to the latest National Oral Health Survey, the figures are same as the Western figures. However, we have more bimaxillary proclination cases.

Percentage of nonextraction treatment

In most countries in Asian-Pacific region, lateral soft tissue profile tends to exhibit convex or bimaxillary protrusion. Therefore, the percentage of nonextraction is relatively lower than in European and American continents [Table 4].

Table 4: Percentage of non-extraction treatment with multi-bracket appliances

Affiliate society	Percentage of non-extraction treatment (%)
AOS	50
APO	40
BOS	60
COS	35 (Chengdu), 30-40 (Beijing)
HKSO	<50
IAO	40
IOS	45-50
JOS	40
KAO	30
MacAO	20 (in Asian), 80 (in Caucasian)
NZAO	50-70
ODOAN	60
PAO	60
SLOS	very low
TAO	32.5
ThaAO	very low

However, it should be noted that nonextraction treatment is higher in BOS, NZAO, ODOAN, and PAO due to the lateral soft tissue profile similar to the Caucasians and exhibits an increase in association with the extensive application of MIAs in many societies.

Association of Orthodontists Singapore

I believe treatment planning has experienced a paradigm shift in terms of tooth extraction. Our decision to extract teeth or not is influenced greatly by facial proportions nowadays. I believe that orthodontists do not just shape teeth but also shape faces. As an Asian population, a large majority of our patients still present with bimaxillary proclination, extractions, especially in such cases are inevitable. I would say about 50% of my cases are extraction cases. This also reflects what my colleagues in Singapore experience.

Association of Philippine Orthodontists

About 40% of my cases are treated with nonextraction. Predominantly, bimaxillary protrusion, severe crowding, and adult Class II cases comprise about 60% of the cases I treated with extraction using multibracket appliances.

Bangladesh Orthodontic Society

According to recent 4-year data, extraction is 40% and nonextraction is 60%.

Chinese Orthodontic Society

About 35% of our patients are nonextraction cases during the last 10 years. Even the percentage is similar, the composition of extraction cases is different. We emphasized on the occlusion and extracted teeth to get final ideal occlusion. With the application of MIAs and self-ligation system, extraction criterion became strict. Community dental clinics developed very fast in the past 10 years at the same time. As a direct result of this development, almost there are no simple cases in our department recently.

Hong Kong Society of Orthodontists

With successful marketing of certain fixed appliance system, nonextraction orthodontic treatment has become more popular amongst orthodontic patients. In my opinion, it is the orthodontists' skills and techniques which can treat a case with nonextraction and not because of the appliance itself. I believe every patient has an individual limitation in the amount of space we can obtain by widening the arch form or proclination of incisors. As bimaxillary protrusion is popular among Hong Kong patients, it is not uncommon to treat patients by extraction. In addition, patients who seek treatment in the specialist clinic are usually more sophisticated and difficult, the percentage of extraction cases are usually higher in the specialist clinic than in the general clinic. Slightly more than half of my cases require extractions.

Indonesian Association of Orthodontists

In my clinic, the rate of nonextraction treatment is about 40%.

Indian Orthodontic Society

Bracket driven diagnosis is an ill of modern day mechanics that we are all facing due to unsubstantiated claims being made by manufacturers. Long-term stability of the claimed lateral expansion by these manufacturers has not been proven in any clinical trial so far. My criteria for deciding on extractions in borderline cases are these parameters (1) U1/NA, (2) L1/NB, (3) max crowding, (4) mand crowding, (5) soft tissue protrusion (Z angle or E plane), and (6) lower irregularity index. Alignment by proclining teeth is something I rarely do unless the pretreatment incisor positions indicate it.

Today, I am judicious about my choice of extraction because we have data on age changes, but the percentage of extraction cases in my office is still around 50–55%. This is because people rarely seek treatment for minor malocclusions in India.

Japanese Orthodontic Society

Recently, nonextraction treatment has increased by the use of MIAs to induce molar movement to the distal direction more easily than before. However, Japanese population has a tendency of bimaxillary protrusion in the lateral soft tissue profile; therefore, the rate of nonextraction treatment is around 40%.

Korean Association of Orthodontists

We have so many alveolar protrusion patients with crowding in Korea. Hence, the percentage of nonextraction cases is around 30%. After using micro implants, nonextraction treatment rate is increasing, though some borderline cases can be treated without extraction.

Macau Association of Orthodontists

In our clinic, 20% Asian are nonextraction teeth alignment with multibracket appliances. Because most nonextraction case patients prefer using removable appliance (e.g. Invisalign) to align the teeth by general dentists. And 80% Caucasian, they are nonextraction teeth alignment with multibracket appliances.

New Zealand Association of Orthodontists

Approximately, 30% of my patients seen in private have extractions. More than 50% of my patients in the hospital clinic have extractions which reflect more severe

malocclusions and decompensation extractions prior to undertake orthognathic surgery.

Orthodontic and Dentofacial Orthopaedic Association of Nepal

In my practice, around 60% of the cases are treated with nonextraction. In recent years, the extraction has reduced owing to the use of distalization as well as self-ligating system.

Pakistan Association of Orthodontists

The rate of nonextraction treatment is 60%.

Sri Lanka Orthodontic Society

Percentage wise, the number is less.

Taiwan Association of Orthodontists

There is indeed a tendency toward nonextraction treatment after the TADs were adapted to my clinical daily practice. I myself am also interested to know the percentage of nonextraction cases in my own clinic. I checked the percentage of nonextraction cases for last year, and it turned out to be 32.5%. Despite the increased tendency toward nonextraction treatment, there are still 2 times of extraction cases than nonextraction cases in my practice.

Thai Association of Orthodontists

In Thailand, we have bialveolar protrusion and crowding as major malocclusion. Hence, most of our cases if not treated early are treatment with extraction.

Treatment of jaw deformity patients

In most countries, surgical orthodontic treatment with orthognatic surgery is used successfully for jaw deformity patients whereas, in developing countries, the treatment has just introduced and will become more prevalent in near future.

Association of Orthodontists Singapore

I cannot speak for all orthodontists in Singapore, but the majority of us go through the protocol of (1) dental compensation (2) use of TADs to aid compensation, and (3) orthodontic/surgical approach, depending on the severity of the case seen.

Association of Philippine Orthodontists

Adult jaw deformity patients are treated in the Philippines with comanagement among orthognathic surgeons and orthodontists. As the need arise, other specialties get involve in the management of adult jaw deformities.

However, there are only few cases of orthodontic-orthognathic cases being done in private practice by our members. Filipinos have reservations when they come to orthognathic surgery for 2 reasons; (1) they scared to undergo surgery and (2) cost of treatment is too high. The treatment cost can range from US $5500–8000 for single jaw surgery and from US $9000–13,500 for double jaw surgery depending on the hospital of choice of the patient. Unfortunately, there is no subsidy or cost coverage by the government insurance for orthognathic surgery treatment in the Philippines. Meanwhile, adult patients with jaw deformity who do not want to undergo orthognathic surgery are usually treated orthodontically as compromise case with dental camouflage treatment.

Bangladesh Orthodontic Society

There are adult patients with jaw deformity in Bangladesh. In my department, we do functional examination of those patients, and consider treating those cases orthodontically, who can bring mandible either, in forward or backward movement and feel comfortable, we use functional appliance or occlusal splint.

Chinese Orthodontic Society

Orthodontists-orthopedic surgeons' cooperation group in our hospital is one of the first multidiscipline groups for jaw deformity treatment in China; (1) Patient assessment by both orthodontic and orthopedic departments in terms of the esthetics, function, psychology and physiology. (2) Group discussion with patient by use of goal set-up, 3D simulation of treatment goal, treatment schedule set-up. (3) Treatment following the schedule and reassessment if necessary. (4) Minor esthetic modifications after orthodontic and orthopedic treatments.

Indonesian Association of Orthodontists

Orthognatic approach is sole treatment of adult deformity, but since surgery still not popular in Indonesia and expensive, people opted to have compromise treatment.

Japanese Orthodontic Society

Orthodontic treatment including orthognathic surgery is covered by social health insurance.

Korean Association of Orthodontists

Adult patients who receive orthodontic treatment are increasing in Korea too. Many of them need orthognathic surgery because of large skeletal Class III population in Korea. These days, "Surgery First Approach" with 2 jaw surgery became very common. One of the reasons is that some entertainers received 2 jaw surgery for plastic reason to change their face quickly. Hence, laypersons started to prefer "Surgery First Treatment" to change their facial esthetics first. Moreover, many orthodontists started to accept this kind of surgery first approach trend because they became to be able to control the tooth movement more precisely during postsurgical orthodontic treatment

thanks to micro-implants. In addition, many orthodontists agree that they can have more rapid tooth movements after surgery, hence it is likely to reduce total treatment time in orthognathic surgery cases.

New Zealand Association of Orthodontists

Unfortunately, the main health insurance companies have withdrawn funding for orthognathic surgery over the last 5 years. This has resulted in a decline in the numbers of patients who can afford to undertake this type of treatment. Surgical fees in the private sector range from $8 to 10,000 for single jaw and $15 to 20,000 for two jaw surgery. Any patients, who have cleft or craniofacial syndromes, have their orthognathic treatment provided within public hospital clinics and the surgery is undertaken free of charge. A few public hospital clinics will also treat individuals who present with severe skeletal discrepancies, but this is a case by case basis and subject to ranking using a skeletal severity index.

Orthodontic and Dentofacial Orthopaedic Association of Nepal

The orthognathic approach in Nepal is completely new. Only from 2011, orthognathic surgery has been started in one center; however, it is slowly coming up. We are still lacking in this area.

Pakistan Association of Orthodontists

Thirty percent more and minor of jaw deformity patients can be treated with camouflage and severe is treated with orthognathic surgery.

Sri Lanka Orthodontic Society

In Sri Lanka, a lot of orthognathic cases are being done. The average fee in the private sector is about 3000 USD.

Taiwan Association of Orthodontists

Orthognathic surgery is now much more acceptable by the patients in Taiwan than before. The reason for that might be due to the on-line experience sharing of many patients and the surgeons are well experienced so that the treatment results are good and postoperative discomfort is largely reduced to an acceptable range. The risk of orthognathic surgery is decreased and the prognosis is greatly improved. Average treatment fee for orthodontic treatment is about the same as regular orthodontic treatment. The treatment fee for orthognathic surgery is around 8500 USD.

Thai Association of Orthodontists

In Thailand, patients prefer compensatory (camouflage) treatment than orthognathic surgery but the orthognathic surgery must be done when it is a must. The treatment fee for both orthodontic treatment and orthognathic surgery are not covered by any of the government organization. The patients must pay for the cost of the treatments themselves.

Prevalence of cleft lip and palate and the therapeutic system

Prevalence of CLP varies from 0.10% to 0.20% in most countries [Table 5], however, the rate of 0.800% in Indonesia is substantially greater than in the remaining affiliate societies. In the countries excluding Japan, Macau, New Zealand, Sri Lanka, and Taiwan, treatment of CLP is not covered by social health insurance, while under a certain consideration in Singapore, Indonesia, and Korea.

Association of Orthodontists Singapore

Prevalence of CLP patients is 2.07/1000 new-born babies per year (0.207%), cited from Yi, NN. *et al.*, Annals of the Academy of Medicine, Singapore 1999. KK Women's and Children's Hospital (KKH) has the only Cleft and Craniofacial Centre in Singapore. Patients are centrally treated here and have subsidies for the medical treatments, but there is no government subsidy for dental treatment. Most of these cleft patients will receive some form of financial help from the KKH's own funds or from charity organizations that are active in helping CLP patients. The Ministry of Health is currently looking at providing financial assistance to these patients. Once the paper is approved, these groups of patients will then have financial support not just for medical but also for dental as well. The dental treatments that would be covered will include nasoalveolar molding (NAM), orthodontics, orthognathic surgery as well as general dentistry for this group of patients. This answer was provided by the AOS President, Dr. Chng Chai Kiat who heads the Dental Department at KKH.

Table 5: Prevalence of CLP and financial support for the treatment

Affiliate society	Prevalence of CLP (%)	Financial support
AOS	0.207	A
APO	0.200	x
BOS	0.125	x
COS	0.163	x
HKSO	0.120	O (for only surgery)
IAO	0.800	A
IOS	0.100	x
JOS	0.143	O
KAO	0.10 - 0.14	A
MacAO	-	O
NZAO	0.180	O
ODOAN	0.164	x
PAO	0.189	x
SLOS	0.167	O (in state sector)
TAO	0.200	O
ThaAO	0.125	x

O: existed, X: none, A: under a certain consideration

Association of Philippine Orthodontists

The incidence of CLP in the Philippines is 1 in every 500 births or 0.200%. Unfortunately, cleft care is not supported financially by the government. Nongovernment organizations and foundations, consisting of volunteer doctors and other allied medical personnel, mostly support the multi-disciplinary management needs of indigent patients. The APO has partnered with Noordhoff Craniofacial Philippines, Inc., in managing CLP patients. The following protocol in managing CLP patients from birth to adulthood is being used;

0–3 months: NAM with lip tape.
3 months - above: Cheiloplasty/primary lip surgery.
12–18 months - above: Palatoplasty.
2 years old: Evaluation and if needed start of speech therapy by speech pathologist.
2 years old - above: Dental monitoring by dentist and orthodontist.
5–7 years old: If indicated (lateral incisor on the cleft site is erupting), alveolar bone graft (ABG) and phase I orthodontic treatment.
9–11 years old: If indicated (permanent canine on the cleft area is erupting), ABG and orthodontic treatment.
18 years old - above: If indicated, orthodontic treatment and orthognathic surgery.

Bangladesh Orthodontic Society

The prevalence of CLP is approximately 1/800 or 0.125%. We usually receive CLP patient during mixed or permanent dentition. For last one decade, there many overseas team (NGO, Smile Train, etc.,) based on UK, Japan, USA, Scandinavian countries, which give volunteer service for cleft repair. Moreover, oral and maxillofacial surgery and plastic surgery Departments of Medical Colleges do lip surgery. They are also referring us for orthodontic correction

Chinese Orthodontic Society

The prevalence of CLP among new-born babies in China is 1.625:1000 or 0.1625% in 1996–2000 obtained by China's Birth Defects Inspection Center. There is a series of treatment for CLP patients including plastic surgery, orthodontic treatment, speech training, hearing reconstruction, orthognathic surgery, psychotherapy, and so on in our department.

Hong Kong Society of Orthodontists

An estimated incidence of 1.2 CLP/1000 live births (0.120%) was reported in Hong Kong.* These figures are underestimates due to incomplete registration. (*King NM, *et al.*: The management of children born with cleft lip and palate. *Hong Kong Med J* 1996; 2: 153-9.) Due to the advancement in prenatal diagnostic technology, most cleft patients have been diagnosed before they were born. The government or private hospital where the baby was delivered can provide the lip or palate repair surgeries during the first 6–7 years of life. The surgical treatment fee at the government hospital is almost free. During the early mixed dentition, as dental and orthodontic treatments are needed, many patients will go to seek treatment at the CLP joint clinic in the Prince Philip Dental Hospital which is the teaching hospital of the dental school at HKU. The remaining patients would need to seek private treatment.

Indonesian Association of Orthodontists

According to survey done by the Surabaya Centre of CLP, the prevalence ratio is 8:1000 or 0.800%. Most of big cities in Indonesia has CLP center supported by the government.

Indian Orthodontic Society

The incidence of clefts in India is approximately 1 in a 1000 patients or 0.100%. A lot of our members are active in cleft care, along with cleft teams in institutions. Unfortunately most of the funding is still private or through philanthropic donations. Government support toward it still requires some structured effort.

Japanese Orthodontic Society

The prevalence of CLP is varied from 1/500 to 1/700 or has recently decreased from 0.200% to 0.143%; however, the rate is still higher than in Europe and USA. Treatment of CLP and 47 craniofacial anomalies is covered by social health insurance.

Korean Association of Orthodontists

Prevalence of CLP was 0.065% in 1979 and exhibited an increase to 0.10% (Min *et al.*: *Korean J Plastic Surg.* 23:1337-43, 1996) and 0.14% (Su *et al.*: *Korean J Plastic Surg.* 23:98-107, 1996). Unfortunately, CLP patients in Korea can receive benefit of medical insurance in surgical treatment only. In Korea, there is only one medical insurance system which is controlled by government. Other treatments including orthodontic treatment are not covered by insurance yet. However, government is working on the process to cover comprehensive treatment of CLP by medical insurance in near future.

Macau Association of Orthodontists

There is no official information about the prevalence of CLP among new-born babies in Macau. The treatment of CLP is conducted together by the Dental Department, plastic surgeon in government hospital and the support team in near region like Hong Kong. The treatment fee is also supported by our government.

New Zealand Association of Orthodontists

The NZ Cleft Audit has been recording all clefts born in NZ since January 1st, 2000. This is an ongoing audit

of cleft care and runs on 5 yearly assessment cycles. There are approximately 100 clefts born in NZ each year (1 in 556 live births or 0.180%) which is high compared to other international studies. The incidence of isolated cleft palate is unusually high among Maori and the rate higher than any other ethnicity reported internationally. CLP treatment including orthodontics is provided free of charge by the government with treatment often carried out by orthodontists employed by the public hospital Dental Department as part of a multidisciplinary cleft team.

Orthodontic and Dentofacial Orthopaedic Association of Nepal

One of the study done in Nepal in 2011 has shown the prevalence of CLP in Nepal to be 1.64/1000 live birth or 0.164%/year. In urban area, CLP new born babies are taken care by orthodontists, if not by general dentists. Commonly feeding plates, obturators, NAM type of treatment are offered. During mixed dentition, expansion, alveolar bone grafts, and maxillary protraction appliances are also offered by orthodontists. However, as Nepal being very poor country, many cases in rural area are untreated. The government does not support financially CLP treatment. There is one project called Smile Train, which supports for surgery. So far, the orthodontic treatment of CLP patients is not supported by anybody.

Pakistan Association of Orthodontists

Pakistan has very high prevalence of CLP or 1 in 528 new born babies (0.189%) has CLP. It is not supported by government. Usually NGOs are supporting it financially.

Sri Lanka Orthodontic Society

The prevalence is 1 in every 600 births or 0.167%. Sri Lankan health system is having two sectors, State and Private. In the State sector, any treatment for any Sri Lankan is totally free.

Taiwan Association of Orthodontists

The prevalence of CLP in Taiwan is 1:500 or 0.200%. The most part of the CLP patients in Taiwan are cared by the craniofacial center of Chang Gung Memorial Hospital, which is a patient-centered team approach consisted of orthodontics, plastic surgery, ear, nose and throat, speech therapy, and psychosocial therapy. The treatments for CLP are basically covered by the national health insurance. Only the orthognathic surgery is not covered and orthodontic treatment is partially covered.

Thai Association of Orthodontists

The incidence of CLPs to newborns in Thailand is 1:800 or 0.125%. Interdisciplinary treatment is conducted in Thailand for CLPs. We established a national Clinical Practice Guidance for CLPs so the interdisciplinary team knows when it is their turns to treat the patient.

Current status and future development of orthodontic treatment with lingual appliances

Lingual orthodontic technique has become popular and been accepted by adult patients in particular in most counties, but is still under development in the remaining societies due to lack in information and technical skills and the high cost. It is very interesting to know another reason from ThaAO such that patients like to have braces on the labial surfaces of their teeth as fashion statement as well as to show social status and thus less people are for the lingual orthodontics.

Association of Orthodontists Singapore

Treatment with lingual braces swings hot and cold in Singapore. It was very popular before the introduction of clear aligners. Now, it is gaining in popularity again. A certain brand marketed by 3M has gained a lot of interest now.

Bangladesh Orthodontic Society

Lingual orthodontics is yet to be introduced.

Hong Kong Society of Orthodontists

The most popular appliance is currently the Incognito lingual appliance. Lingual appliance is not offered at the government clinic; and of the 45–50 private orthodontists, <10 are regularly treating patients using lingual appliance. The AdvDipOrtho program at HKU offers lingual appliance training and Incognito is the main appliance they teach. With the establishment of the HKSO lingual appliance study group in 2012, we hold 3–4 informal meetings each year to improve our techniques and theories. As the convener of the study group, Dr. Wilson Lee has the responsibility to move the lingual technique in Hong Kong forward and believes lingual appliance would not move too far forward unless the specialists do more public patient education and let them know the advantages and disadvantages of lingual appliance versus removable aligners.

Indonesian Association of Orthodontists

Lingual orthodontics in recent years gains a lot of interest but is less popular due to the financial problem (too expensive) and not many orthodontists offer that service.

Indian Orthodontic Society

India has seen rapid strides in the field of lingual orthodontics during the past decade. India has a Lingual Orthodontic Society that was formed almost 5 years back with the Initiative of two young orthodontists from Mumbai, Drs. Jignesh Kothari and Praveen Shetty. This

body is affiliated to WSLO. In fact, lot of our orthodontists have graduated to CAD/CAM systems such as Incognito and Harmony. We also have Indian manufactured CAD/CAM systems.

Japanese Orthodontic Society

Lingual orthodontic technique has become very popular in association with increasing number of adult patients seeking for invisible appliances.

Korean Association of Orthodontists

With increasing number of adult patients, many of them ask for esthetic orthodontic treatment including lingual orthodontic treatment. Some dental companies and orthodontic laboratories developed many kinds of indirect bonding system. These days, some Korean companies started to make new lingual brackets too. However, large number of patients is hesitating to receive lingual treatment due to the economic situation, because fee of lingual treatment is double of that of conventional labial orthodontic treatment. Hence, many patients tend to receive combination treatment which is using upper lingual and lower labial appliance.

Macau Association of Orthodontists

Lingual braces become more popular than before and we use customized lingual braces in our practice. Increasing patients are also willing to pay more for getting the benefit from it.

Pakistan Association of Orthodontists

It is becoming very popular to use lingual appliances.

Sri Lanka Orthodontic Society

Currently, lingual orthodontic treatment is not so popular in Sri Lanka. Only a few barriers are cost and people are practicing.

Taiwan Association of Orthodontists

In Taiwan, lingual orthodontic technique has recently become very popular. In addition, Lingual Orthodontic Society has also been established recently in Taiwan and the number of the members is increasing.

Thai Association of Orthodontists

Thai patients like to have braces on the labial surfaces of their teeth as fashion statement as well as to show social status. Hence, less people are for the lingual orthodontics.

Current status and future development of orthodontic treatment with temporary anchorage devices

Recent topic in orthodontics with a great concern is TADs or MIAs, which have been successfully used and contributed to optimal orthodontic treatment. However, as pointed by Drs. Xu (COS), Fowler (NZAO), and Satravaha (ThaAO), it should be noted not to use TADs in cases without any need and indication or to limit the application to absolutely-needed and scientifically-indicated cases.

Association of Orthodontists Singapore

MIA or TADs was extremely popular at the turn of the century. I myself remember attending one of Professor Kyung's hands-on courses in the early 2000s. The interest and usage of TADs has now plateaued in Singapore but its usefulness is still undeniable. I have heard many times that the introduction of TADs has changed how we treat our patients. I fully agree with this.

Association of Philippine Orthodontists

The use of micro-implant or MIA started to gain acceptance in our country though barely new. During the past years, many speakers from South Korea, Singapore, Taiwan, and Germany gave lectures and showed the many benefits of the orthodontic anchor screw. With the introduction of the MIA in the Philippines, some of our members started using it in their practice and others are hesitant as they are new in the market. As of today, more and more are using it as they gain more confidence in the use of the MIA and have realized the many benefits of it.

Bangladesh Orthodontic Society

MIA has been recently introduced in the Department of Orthodontics, Dhaka University.

Chinese Orthodontic Society

Dr. Zhao

The MIAs are widely used in my clinic and entire China. MIAs are always used in such situations as strict anchorage control, extra anchorage force application, acceleration of orthodontic treatment, anchorage control for orthopedic force. With quick popularization of MIAs, fundamental researches are needed to discover biomechanical basis and improve the clinical techniques. My department has done a lot of fundamental and clinical studies on MIAs in the past few years, especially in my group. Moreover, these study results were applied to our clinical work very well.

Dr. Xu

Although new generation orthodontists use more and more MIAs in China, I seldom use them in my clinic. To my point of view, sagittal anchorage control doesn't need MIAs if following the Physiologic Anchorage Control Philosophy, which has recently been introduced in APOS Trends in Orthodontics. I use it only for the cases when massive intrusion is desired.

Hong Kong Society of Orthodontists

Anchor screws have been getting more popular in Hong Kong since the introduction of Abso-anchor and

Orlus TADs in 2002. Anchor plates are only popular in university teaching settings, and it is not popular in the private sector, since Hong Kong patients are very reluctant to undergo any minor surgeries to place an anchor plates in the oral cavity. Anchor screws are now much better accepted by the patients in Hong Kong, and all orthodontists know how to use anchor screws in their clinic.

Indonesian Association of Orthodontists

MIAs in recent years gain a lot of interest.

Indian Orthodontic Society

MIAs are the mainstay of anchorage control mechanics in India. A lot of articles have been published about the same, and there is excitement among Indian orthodontists about this technique, as the envelope of discrepancies that can be addressed with this modality has opened new horizons in orthodontics. In fact, the Dewel award, for the most popular article published in the AJODO, was awarded to an Indian orthodontist, Dr. Shakeel Ahmed *et al.* for the research they carried out in the field of MIA. There are Indian manufacturers for MIAs today, and you would rarely encounter an orthodontic office that does not use them.

Japanese Orthodontic Society

TADs have become very popular with the evidences from basic and clinical studies. Currently, various types of screws are produced in Japan. In addition, orthodontic anchor screws have been approved officially by the Ministry of Health and are currently covered by social health insurance.

Korean Association of Orthodontists

Microimplant as an orthodontic anchorage was first introduced by Drs. Seong-Min Bae and Hyo-Sang Park in 1998. They showed so many excellent cases at the Congress of KAO in 1999 using small diameter (1.2 mm) of surgical screws. They could easily place micro-implants between roots without any clinical problems. They showed that most kind of orthodontic tooth movements including *en masse* retraction and molar intrusion are possible with help of microimplants. After then, most Korean orthodontists started to use microimplants and this spread to all around the world. In 2001, our group started to produce orthodontic microimplants of our own design. We are still seeking the best design of microimplants and the best way of surface treatment to increase the success rate and to decrease side effects.

Macau Association of Orthodontists

Anchor screws play a main role in our practice. More and more patients avoid surgery through using anchor screws.

New Zealand Association of Orthodontists

These are being used by most orthodontists but on a "as need basis" with most used to enforce intraoral anchorage as opposed to the limited use of skeletal anchorage where orthodontists are actively trying to achieve orthopedic effects to avoid orthognathic surgery.

Orthodontic and Dentofacial Orthopaedic Association of Nepal

MIA has been started in Nepal recently. We are doing it for maximum anchorage, molar upright, distalization and intrusion. However, we are still lacking in the versatile application of MIAs. In the future, we want to expand the treatment facilities with MIAs.

Pakistan Association of Orthodontists

It is becoming very popular to use mini implants.

Sri Lanka Orthodontic Society

Most orthodontists are already using MIAs. I can predict the usage will be more in the future.

Taiwan Association of Orthodontists

The use of TADs in Taiwan is quite popular. The most often positions of TADs are infrazygomatic crest, interradicular position between U5 and U6 or U6 and U7, buccal shelf of mandible and palatal bone. Most doctors use direct anchorage application instead of indirect. As for the applications, protrusion reduction, deep bite correction, open bite correction, molar protraction, asymmetry and canted occlusal plane management and posterior cross-bite correction are the most often seen case types. In contrast to the predrilling smaller diameter mini-screw made of titanium alloy, the self-drilling larger diameter mini-screw made of stainless steel is a main stream in Taiwan.

Thai Association of Orthodontists

MIA, mini-screw as TADs have been used widely to assist tooth movements in difficult cases in orthodontic treatment. Anyhow, if conservative technique can be used with the same outcomes, it is then preferable.

Important issues for orthodontic specialists

Most societies have two important issues such as orthodontic treatment and inappropriate use of aligners such as Invisalign by GPs. The most important strategy is to appeal the public that orthodontic treatment should be executed by orthodontic specialists because the treatment quality is quite different from that of GPs. Meanwhile, another problem specified to each society can be introduced in the following text.

Association of Philippine Orthodontists

I am not aware of the problems of general dentists against orthodontic specialists in the Philippines. However, I can cite some problems of orthodontic specialists with general dentists today in Philippine. One of the biggest challenges of the orthodontic specialists in Philippines is the growing

number of GPs doing orthodontic treatment. The GPs are supposed to limit their practice to just simple preventive or interceptive orthodontics applying the best prudent judgment to treat simple cases; however, this is not the case. The GPs treat complicated cases and when problem arise, that is when patient seek the help of the orthodontic specialist. The thrust of the APO is to educate the public to choose their orthodontist wisely. However, this is tied up to another problem, which is financial consideration or cost of treatment. Most Filipinos are usually are looking for best bargain for their money and therefore most of the time, the professional fee of a practitioner and not his credentials determine whether or not he will be chosen by the patient to deliver the orthodontic service.

Hong Kong Society of Orthodontists

Most people and parents in Hong Kong are not familiar with the difference in orthodontic treatment provided by general dentist and specialist in orthodontics. They think a dentist should be competent in all types of dental treatment including orthodontics. Thus the dentists usually try to treat the cases themselves and only in very complicated cases they would refer to the orthodontists. Commercial orthodontic companies (like Invisalign) have been aggressive in patient marketing and attract the public to seek orthodontic treatment at their targeted dentists customers whereas trying their best in providing clinical advices to these dentists. There has been large variation of standard of treatment results. Few local dentists have also organized study groups and overseas speakers to provide "mini-residency" training course to dentists, with the aim in profit and sales of their products. This has entailed the interests of young graduates in pursue of the long specialists training pathway in Hong Kong. In the long-term, I think it is not very healthy as the specialty cannot attract the best graduates for the orthodontic training.

Indonesian Association of Orthodontists

Like other part in the world, we have the same problem of dentists doing orthodontics.

Macau Association of Orthodontists

As we do not have dental school in Macau, all our dentists and specialists come from different country. Macau government is going to set up a licensing examination as a prerequisite for dentist registration.

New Zealand Association of Orthodontists

The ongoing and escalating issue of general dentists promoting orthodontic treatment has blurred the distinction between orthodontic treatments by specialist and general dentist. As a consequence, the public of New Zealand often does not know the difference. Recently, NZAO has embarked upon a public awareness campaign to explain the differences between the orthodontic specialist and general dentist by highlighting evidence-based orthodontic treatment planning. In addition, NZAO has launched a public health initiative where specialist's orthodontic treatment is provided to children who would not be unable to access such care. This has been organized through "Wish For A Smile Trust" and is aimed at children with severe malocclusions and who have limited financial resources.

Pakistan Association of Orthodontists

Usually, orthodontists are also doing general dentistry as referral system is not strong. Same is a problem as they refer patient, it is mostly not referred back.

Thai Association of Orthodontists

Normally, dental schools and hospitals provide consultations from dentists or orthodontists in private clinics when there are difficult cases or cases which needed cooperation such as orthognathic surgery, CLP treatment, distraction osteogenesis and so on.

Future plan of each affiliate society

The extreme goal of each society is to enhance the academic and clinical levels of orthodontics. To this end, research activity in both scientific and clinical aspects is of most importance or indispensable. In addition, we APOS may have to assist the developing societies in terms of the education for scientific knowledge and clinical skills in orthodontics according to requests from some affiliate societies. Actual plan of each society is presented herein for a special reference to all the APOS members.

Association of Orthodontists Singapore

A very experienced orthodontist once told me. "Never stop learning. The day you stop learning would be the day you retire." I totally believe in this adage, and I would like to convey this to the rest of my orthodontic colleagues in Singapore and the region. I still have much to learn.

Association of Philippine Orthodontists

Future plans of APO as a scientific association is to continue keeping ourselves up to date with the latest in dental and orthodontic technologies, to strengthen the graduate programs in the country, to enthuse more faculty members and to have more graduate schools accredited. The APO is also committed in supporting financially the research studies conducted by the graduate students of the accredited orthodontic program in the Philippines.

Bangladesh Orthodontic Society

Recently, overall clinical dentistry and orthodontics have improved a lot, and we are capable of rendering clinical

service almost similar to regional and global standards. We need to improve our research capability. However, adequate fund is required, which is a great limitation for us.

Chinese Orthodontic Society

To improve orthodontic education continuously, the development of orthodontics depends on the improvement of education. Besides of strengthening the international competitive power of famous dental school, we try to improve overall orthodontic education quality in the whole country.

To enforce the international exchange and cooperation of COS, to send more students to foreign famous school and to invite the foreign student to our school; i.e., to set up more international cooperation project; to take part in more foreign project actively and so on.

To minimize the gap between urban and rural and to try to lead specialists to work in the rural area; to improve the continuous education and so on.

To improve the orthodontic specialist certification system further, at the basis of a combination of local situation and foreign experiences.

To focus on independent research and development of orthodontic materials. To improve the international competitive power of the Chinese Orthodontic Industry.

Hong Kong Society of Orthodontists

The HKSO will continue to increase our effort in patient education and awareness of the excellent orthodontic service we could provide to the children and adult patients. We will continue to host annual orthodontic symposium amongst local orthodontists to improve our member relationship and knowledge. We will work closely with Hong Kong University and provide the best support to the trainee during the long training pathway.

Indonesian Association of Orthodontists

One of the IAO goals is to improve the knowledge and clinical skills of its members, by bringing world speaker to speak to our members.

Indian Orthodontic Society

India has made rapid strides in all spheres in the last two decades. It is a must see destination for a lot of tourists and pilgrims alike. With respect to orthodontics in India, we have a large base of orthodontic education with close to 100 masters programs in orthodontics globally. However, we are concerned about the private practice scenario where the financial health of Indian orthodontist needs to be improved. The quality of treatment, we have noticed is higher in segments, where the treatment fees are on the higher side, which is obvious.

This is a question very close to my heart. IOS has made rapid strides in the past and celebrated the Golden Jubilee year (50th anniversary). Some of the notable achievements that I've been a part of are the IOS Newsletter, working toward getting our Journal indexed, being a part of the team that formed the Research Foundation of the IOS. We have formed a Council for Scientific Affairs. We are looking at administrative reforms soon to cater to our large numbers.

On the academic front, we have also founded an Educators forum of the IOS that will deliberate training across the country, and recommend skills and information that are current.

We have initiated a massive public awareness program to increase awareness about orthodontics, and treatment of orthodontic problems by a qualified specialist to the Indian population. We also see a greater role of IOS on the international arena both in the academic and social aspects.

Macau Association of Orthodontists

As a scientific association specific to orthodontics, we would like to organize more continuing education course to improve our knowledge and open our mind to become a high skills clinician. We encourage government for establishing the specialist training system qualified the standard of developed nation and compatible with WFO and APOS standards of orthodontic specialist. We also want to provide more public seminars and conducting educational activities to Macau citizens. We hope that APOS journal will cover more technical and clinical studies or may be some experience sharing in orthodontic field. Education information for the public is also desired.

New Zealand Association of Orthodontists

The NZAO has supported the formation of the Foundation for Orthodontic Research and Education Trust, which provides funds for both undergraduate and PG orthodontic researches in New Zealand. The Sir John Walsh Research Institute based at the Faculty of Dentistry helps to focus research activity. This research is both clinical and laboratory based with strong leadership by the current Head of the Department, Prof. Mauro Farella. He has a special interest in TMJ, genetics (accessing "Zebra fish"), establishing a genetic bank to investigate the role of genetics in craniofacial form and the use of 3D imaging.

If the APOS plays a role in the scientific endeavors of the NZAO, it may be in the form of establishing relationships and collaboration between research institutions and the

Orthodontic Department, Faculty of Dentistry, Otago University.

Orthodontic and Dentofacial Orthopaedic Association of Nepal

ODOAN would really like to improve the quality of orthodontic treatment in Nepal. For this, we are planning to have series of hands-on training from world acclaimed clinicians. ODOAN is thankful to Drs. Kazuo Tanne, Hee Moon Kyung and Nikhilesh Vaid for their great contribution during our 3rd International Conference in September 2013. APOS has been always supportive toward ODOAN.

Pakistan Association of Orthodontists

PAO representatives want to bring their own orthodontic board. We need guidance and support. Pakistani orthodontists are really doing quality work as they get the opportunity to gain extra qualifications by the presentation of their finished cases at other Royal Colleges.

Sri Lanka Orthodontic Society

As you know, presently, we are a small group. We are growing slowly while maintaining a high standard. We look forward to work closely with other APOS friends in order to uplift the quality of our profession. SLOS will be happy if we have a way to exchange and gain knowledge from other APOS nations.

Taiwan Association of Orthodontists

As a member of APOS, TAO will collaborate with all the other members to elevate the standard of orthodontic care for the patients and also communicate with all colleagues of APOS friend associations to uplift the academic level of orthodontics in Asia-Pacific regions, and in turn, all over the world. The orthodontist in Taiwan is officially recognized as a specialist by the government and regulated by the Ministry of Health and Welfare since 2010. TAO will work diligently to elevate the standard of orthodontic care and academic level of orthodontics in Taiwan. These goals will be achieved by accreditation of the training institutes, supervision of the training programs of all training institutes, constant domestic continuing educations, increased international communication via speakers recommended by various friend associations, hosting Taiwan International Orthodontic Forum to catch up the most updated knowledge and techniques in orthodontics and TAO will encourage all the members to attend various international orthodontic conferences to participate the academic progress of orthodontic world.

Thai Association of Orthodontists

ThaAO will continue to do its duties; it is doing now which are to continue the duties (disseminate knowledge in orthodontics and keep a high standard in orthodontic treatment) which will be beneficial to its members, to the public under good moral and ethical bases. The activities, which to be chosen to do or to promote in the future, will be suitable to time and the situations in the future under good moral and ethical bases

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Use of Iowa Spaces for the orthodontic management of mandibular postsurgical skeletal relapse

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Abstract

It has been documented that there is a tendency for skeletal relapse after orthognathic surgery. This relapse occurs more often following mandibular bilateral sagittal split osteotomy setbacks. The possible causes for lack of postsurgical stability as well as the clinical recommendations to manage the relapse are presented. Among these recommendations is the creation of Iowa Spaces.

Key words: External apical root resorption, Iowa Spaces, margin for adjustment/compensation, orthognathic surgery, skeletal relapse

INTERVIEW

1. What are Iowa Spaces and what are they used for?

Iowa Spaces are 2 mm spaces created bilaterally, distal to the maxillary lateral incisors [Figure 1].

These two maxillary spaces are purposely created, prior to orthognathic surgery, to allow the surgeon to achieve a fully seated posterior occlusion without interference by the anterior teeth [Figure 2].

During a conversation I recently had with Dr. John S. Casko, Past-Chair of the Orthodontic Department at the University of Iowa, he shared with me that in the past he had seen too many surgical orthodontic cases finished in less than a full Class I canine occlusion because it was not possible to seat the presurgical models into a full Class I due to a lack of overjet; that by advancing the maxillary incisors and leaving spaces distal to them (Iowa Spaces), it was possible to fully seat the presurgical models; and that if excess anterior overjet remained postoperatively, it only took one or two appointments to close them, as opposed to needing many more appointments to correct a slightly Class II posterior occlusion.

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2. Why these spaces are called Iowa Spaces?

Dr. Casko let me know that the term "Iowa Spaces" was coined by participants who learned about the spaces during courses given by him. He stated that it is a simple concept that became popular because it made a big improvement in the quality of the final occlusal results, which the meeting participants saw when they went back to their practices.

3. How many years of clinical experience have you had with Iowa Spaces in your office?

I started using the Iowa Spaces in my own practice over 20 years ago after hearing Dr. Casko's lecture at one of the College of Diplomates of the American Board of Orthodontics' meetings.

After a few years of using Iowa Spaces in the upper arch, it occurred to me that it would be a good idea to create Iowa

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Spaces in the lower arch in patients in whom mandibular surgical setbacks were planned [Figure 3a and b].

Figure 1: Presurgical lateral intraoral view of Patient A, who will undergo mandibular advancement surgery. Note 2 mm Iowa Space created distal to the maxillary right lateral incisor. Not able to be observed in this view is another Iowa Space on the opposite side, distal to the maxillary left lateral incisor. These two Iowa Spaces facilitate a fully seated posterior occlusion during surgery

Figure 2: Immediate postsurgery lateral cephalogram of Patient B following combined surgery (mandibular surgical set-back and maxillary surgical advancement). At this time, the patient still has the 2 mm maxillary Iowa Spaces present, creating a temporary anterior overjet, which allowed a fully seated posterior occlusion during surgery, without interference by the anterior teeth

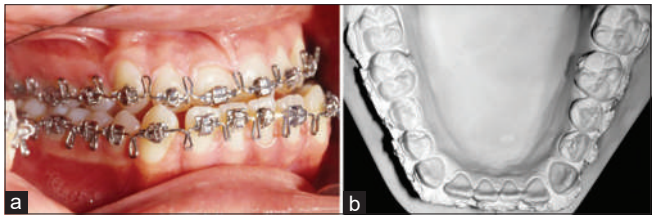

Figure 3: (a) Presurgical lateral intraoral view of Patient C with bilateral 2 mm Iowa Spaces created distal to the mandibular lateral incisors. This patient will undergo mandibular surgical set-back combined with maxillary surgical advancement. (b) Presurgical occlusal view of Patient C's mandibular dental cast. Note bilateral 2 mm Iowa Spaces distal to the mandibular lateral incisors

These mandibular Iowa Spaces provide a margin for adjustment to compensate a possible postsurgical skeletal mandibular relapse in a forward direction, which frequently occurs following mandibular surgical setbacks using the bilateral sagittal split osteotomy (BSSO) procedure.

Proffit *et al.*[1] reported that in one-fourth of the patients who received wire fixation and in nearly half of the patients who received rigid internal fixation, the chin moved forward more than 4 mm following mandibular surgical setback using BSSO.

4. What is the evidence that postorthognathic surgical skeletal relapse occurs?

It has been documented that there is a higher tendency for skeletal relapse following orthognathic surgery of certain surgical procedures. Proffit *et al.*[2] ranked the various types of orthognathic surgical movements according to their postsurgical predictability and stability, i.e., a hierarchy of surgical procedures according to their predictability/stability. These authors grouped the relapse tendency into four categories: (1) Highly stable, (2) Stable, (3) Stable if rigid internal fixation is used, and (4) Problematic, defined as 40–50% of chance of having 2–4 mm postsurgical change, and a significant chance of having a >4 mm relapse.

They derived the predictability/stability hierarchy data from the University of North Carolina Dentofacial Program database, which by the year 2004[3] contained over 3000 initial records of nonsyndromic patients, and over 1400 patients with at least 1 year follow-up, treated with maxillary and/or mandibular orthognathic procedures to correct developmental deformities.

These researchers found that the surgical procedures to correct Class II problems (maxilla up, mandible forward, and the combination of the two procedures) are more predictable and stable than the procedures for Class III problems (maxilla forward, maxilla forward plus mandible back, mandible back, and maxilla down).[4]

BSSO is widely used for mandibular surgical setbacks due to many advantages it provides (the mandible can be moved forward or backward, the distal segment can be rotated down anteriorly when additional face height is desired, rigid internal fixation can be used thus requiring no maxillo-mandibular immobilization, and excellent bone-to-bone contact occurs minimizing healing problems). In spite of the many advantages that the BSSO procedure provides, it unfortunately falls into the problematic category because of its high tendency to relapse in a forward direction.

Figure 4a and b of Patient D serve to illustrate that mandibular postsurgical skeletal forward relapse does indeed occur. Patient D's cephalometric superimposition of the presurgical cephalometric tracing, age 14–8, and the immediate postsurgical cephalometric tracing, age 14–11 [Figure 4a], demonstrate the changes that occurred due to the triple jaw surgery (maxilla up and forward, mandible back, and chin up and forward) undergone by this patient. The objectives were to correct this patient's long face, to increase the midfacial anteroposterior deficiency, and to correct the mandibular prognathism [Figure 4c].

Patient D's cephalometric superimposition of the immediate postsurgical cephalometric tracing, age 14–11, and the long-term follow-up cephalometric tracing, age 21–2 [Figure 4b], demonstrates that the mandible relapsed 3 mm forward. The patient and the orthodontist were fortunate that postsurgery the maxillary incisors also moved 3 mm forward autonomously, compensating the skeletal relapse. It is interesting to observe that the ramus inclination was increased during surgery [yellow arrow in Figure 4a]. This increase in the ramus inclination could be one of the reasons for a mandibular forward relapse, a topic that will be addressed in the interview question number 5.

Patient D's presurgical facial profile photograph can be seen in Figure 4c. A long face, a midfacial anteroposterior deficiency, and a mandibular prognathism can be observed. The patient will undergo triple jaw surgery.

Figure 4d shows Patient D's immediate postsurgical facial profile photograph. Note dramatic improvement due to the surgery. The maxilla was moved up and forward, the mandible back, and the chin up and forward.

The semi-transparent superimposition of the presurgery facial profile photograph with the immediate postsurgery facial profile photograph demonstrates the dramatic facial change that occurred due to the surgery [Figure 4e].

Figure 4f exhibits Patient D's 1 year and 2 months postsurgical facial profile photograph. Note that the upper lip has moved forward as the upper incisors tipped forward, compensating a postsurgical mandibular forward relapse, resulting in a diminished nasolabial angle.

Figure 4g shows Patient D's facial profile photograph 6 years postsurgery. A pleasing profile can still be observed.

However, the semi-transparent superimposition of the immediate postsurgery facial profile photograph with the 6-year postsurgery facial profile photograph [Figure 4h] demonstrates the magnitude of mandibular forward relapse that occurred, which fortunately was compensated by the maxillary incisors moving forward, as well as the upper lip.

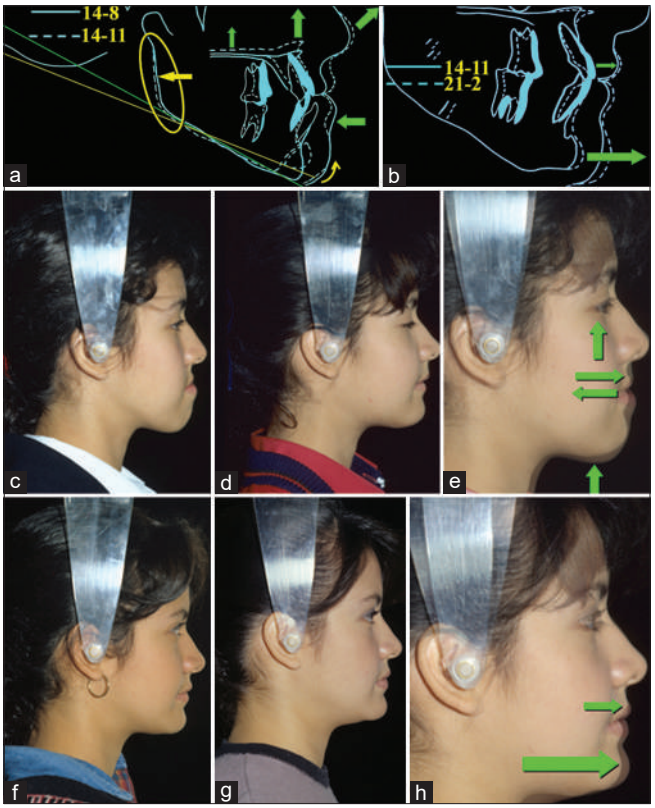

Figure 4: (a) Patient D's cephalometric superimposition of the presurgery tracing (age 14–8), and the immediate postsurgery tracing (age 14–11). Patient underwent triple jaw surgery (maxilla up and forward, mandible back, and chin up and forward) to correct the long face, the midfacial anteroposterior deficiency, and the mandibular prognathism. The green arrows indicate the direction of the surgical movements. Mandibular plane was reduced 8° in the direction indicated by the curved yellow arrow. Note that the mandibular ramus was pushed back during surgery (straight yellow arrow), which could potentially lead to a postsurgical mandibular forward relapse. (b) Patient D's cephalometric superimposition of the immediate postsurgery tracing (age 14–11), and the 6-year postsurgery tracing (age 21–2). The patient underwent triple jaw surgery during which the mandibular ramus was pushed back (increased ramus inclination). Note that postsurgery the mandible relapsed forward 3 mm (large green arrow). The maxillary incisors autonomously moved forward 3 mm (small green arrow), thereby compensating the mandibular relapse. The upper lip also moved forward resulting in a diminished nasolabial angle. The patient's surgery took place 3 years postmenarche, so the relapse cannot be attributed to growth. Note additionally that no vertical growth occurred, further suggesting that the relapse was probably not due to growth. (c) Patient D's presurgery facial profile photograph (age 14–8). Note long face, midfacial anteroposterior deficiency, and mandibular prognathism. The patient will undergo triple jaw surgery. (d) Patient D's immediate postsurgery facial profile photograph (age 14–11). Note dramatic facial improvement. (e) Patient D's semi-transparent superimposition of presurgery facial profile photograph (age 14–8) and immediate postsurgery profile facial photo (age 14–11). The arrows indicate the direction the jaws were moved during surgery. Note dramatic facial change. (f) Patient D's 1 year 2 months postsurgical facial profile photograph (age 16–0). Note that the upper lip has moved forward as the upper incisors tipped forward, compensating a postsurgical mandibular forward relapse, resulting in a more acute nasolabial angle. (g) Patient D's 6 year 2 months postsurgery facial profile photograph (age 21–2). Note pleasing profile was maintained in spite of the mandibular forward relapse. (h) Patient D's semi-transparent superimposition of immediate postsurgery facial profile photograph (age 14–11) and 6 years 2 months postsurgery facial profile photograph (age 21–2). Note facial change due to mandibular forward relapse

In Patient D, no Iowa Spaces were created because at the time the author treated this patient, he was not aware of the advantages of creating these spaces. Thus, no margin for adjustment to compensate for relapse was incorporated presurgery. Had mandibular Iowa Spaces been created (prior to orthognathic surgery), the surgeon would have been obligated to fixate the mandibular distal segment (mandibular body) further back. This would have been advantageous from the standpoint of the final treatment result because if the mandible was to relapse forward postsurgically (as occurred in Patient D, and occurs in one-fourth of the patients who receive wire fixation and in nearly half of the patients who receive rigid internal fixation),[1] the orthodontist would have been able to compensate this undesired skeletal movement by closing the Iowa Spaces, moving the lower incisors lingually. On the other hand, if no skeletal relapse would have occurred, the orthodontist could have closed the Iowa Spaces by moving the posterior teeth forward, as illustrated in Figure 5a.

Thus, mandibular Iowa Spaces give the orthodontist a mechanism through which he/she can, fully or partially, compensate the mandibular forward skeletal relapse by moving the lower incisors back into these spaces. Mandibular Iowa Spaces provide a "margin for adjustment" following mandibular surgical setbacks [Figures 3a, b and 5a, b].

Figure 5c shows Patient C's surgical movements carried out during the orthognathic procedure (maxillary surgical advancement and mandibular surgical setback). The superimposition corresponds to the presurgery cephalometric tracing (age 15–0) and the immediate postsurgery cephalometric tracing (age 15–4). Note that the inclination of the mandibular ramus was not pushed back (was not increased). In spite of this, mandibular skeletal relapse occurred; Figure 5a demonstrates this relapse.

5. *What causes the lack of stability following mandibular surgical setback when using BSSO?*

Proffit *et al.*[4] found that postsurgical mandibular forward movement (relapse) is frequently due to the inadequate surgical management of the proximal segment (mandibular ramus) at the time of surgery. They found that if the ramus is pushed back at surgery, the mandibular muscle sling almost always moves it forward to its original inclination during the first postsurgical year, and that the more firmly the ramus is fixed to the body postsurgically (e.g., rigid internal fixation), the greater the likelihood that the chin also will go forward when the ramus uprights. The authors state that this skeletal mandibular relapse occurs after maxillo-mandibular fixation is released and function is resumed.

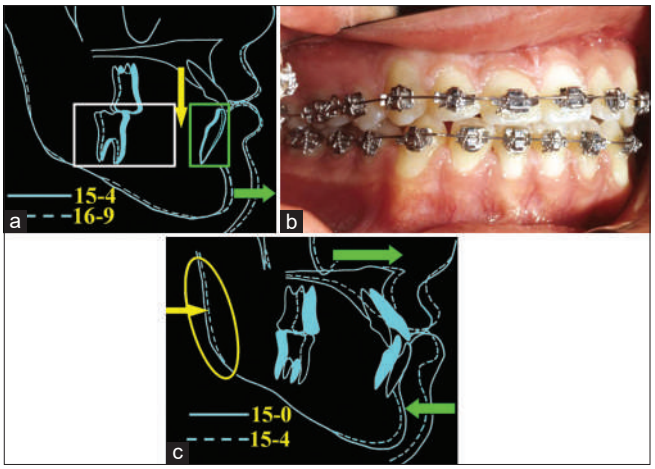

Figure 5: (a) Cephalometric illustration of mandibular Iowa Spaces as a method to compensate for mandibular postsurgical forward relapse. Note that the mandible did indeed relapse forward postsurgery (green arrow), as can be observed in Patient C's cephalometric superimposition (immediate postsurgery cephalometric tracing, at age 15–4, and cephalometric tracing 15 months postsurgery, at age 16–9). In spite of the mandibular forward skeletal relapse, the orthodontist was able to compensate this undesirable outcome by moving the lower incisors toward the lingual using the mandibular Iowa Spaces (yellow arrow). Teeth inside the white box (canines to molars) correspond to the posterior dental segments, and teeth inside the green box (4 incisors) correspond to the anterior dental segment. (b) Patient C's mandibular Iowa Spaces [Figure 3a and b] have been closed by moving the incisors lingually, since a mandibular postsurgical forward relapse occurred, as evidenced by the cephalometric superimposition in Figure 5a. (c) Patient C's cephalometric superimposition shows the changes that occurred during a combined maxillary surgical advancement and a mandibular surgical set-back (green arrows). The presurgical cephalometric tracing corresponds to age 15–0 and the postsurgical cephalometric tracing corresponds to age 15–4. Note that the surgeon did not push the mandibular ramus back; in fact, it is further forward (yellow arrow). In spite of this, a mandibular skeletal relapse occurred, as demonstrated in Figure 5a

Figure 4a illustrates this phenomenon very clearly. Note that the mandibular ramus was indeed pushed back (is now more vertical) which could lead to a mandibular postsurgical forward relapse, which in this Patient D did in fact occur.

Another possibility of forward movement of the chin postsurgically, mentioned by Proffit *et al.*,[1] is an adjustment of condyle–fossa relationships as a correction for condyles that were retropositioned at surgery.

Taking into account the above information, it is proposed that the creation of presurgical mandibular Iowa Spaces allows the orthodontist to compensate, partially or fully, for both causes of postsurgical mandibular forward relapse (ramus inclination pushed back and/or retropositioned condyles).

6. *What other procedures do you use, in addition to creating mandibular Iowa Spaces, to counter or manage the tendency for skeletal relapse in*

patients who undergo BSSO to correct mandibular prognathism?

Based on the information presented in the previous section, it is important to recommend to the surgeon that he/she should not increase the ramus inclination during surgery.

The additional procedures I recommend to improve postsurgical stability, following mandibular setback, are the following:

- Have the patient use an extra-oral traction appliance (chin-cup) postsurgically to attempt to maintain the corrected skeletal relationships while the mandibular muscle sling adapts to the new position. The chin-cup appliance should be used 10–14 h per day the first 3 months following surgery and then another 3 months nights-only. Perhaps, this appliance should not be used if the patient undergoes simultaneous genioplasty due to the pressure exerted by the chin-cup against the recently surgerized chin
- Postpone surgery until it can be documented that the patient's growth has ceased (e.g., by superimposing two successive lateral cephalometric head films separated by 1 year) and,
- Recommend surgical procedures that provide greater stability, for example, using combined maxillo-mandibular surgeries, where possible, to reduce the magnitude of the mandibular surgical setback.

7. What would you recommend as a routine protocol for the creation of Iowa Spaces in preparation for orthognathic surgery?

- If the patient has pretreatment dental spacing, I would recommend closing all spaces in three separate segments, i.e., close all spaces in the posterior segments (from canines to molars) and close all spaces in the anterior segment (from lateral incisor to lateral incisor), leaving 2 mm spaces distal to the lateral incisors. In mandibular surgical setbacks, the Iowa Spaces should be created in the lower arch [Figures 3a, b and 5a]; in mandibular surgical advancements, the Iowa Spaces should be created in the upper arch [Figure 1]
- If the patient has no dental spacing and will need bicuspid extractions, I would recommend closing the extraction spaces partially, leaving 2 mm spaces, but transferring these to the distal of the lateral incisors
- If the patient does not need bicuspid extractions but has no spacing, I recommend using bilateral compressed open coil springs placed between canines and lateral incisors to create the Iowa Spaces, taking care that these four teeth do not rotate due to the activated coil springs. This means using a full-sized wire to prevent these rotations from occurring while the spaces are being created. Iowa Spaces, once created, should be maintained open with closed coil springs.

8. At what point in treatment would you recommend closing the Iowa Spaces?

I recommend maintaining the Iowa Spaces a minimum of 3 months postsurgery. This period allows the orthodontist to assess whether skeletal relapse is occurring. The Iowa Spaces can then be closed either by moving the anterior segment toward the lingual or the posterior segments toward the mesial, depending on the direction and magnitude of the mandibular skeletal relapse [Figures 3a, b and 5a, b].

9. What problems have you encountered with the Iowa Spaces?

The only problem I have encountered with Iowa Spaces is the tendency of the canines to rotate toward the distal when using compressed open coil springs to create these spaces. That is the reason why I recommend opening the Iowa Spaces only until a full-sized SS wire can be tied in to all the brackets.

10. Why should orthodontists consider orthognathic surgery as a root sparing treatment regime?

In the litigious environment in which we live today, it is very important to prevent iatrogenic problems from developing. Orthognathic surgery should be considered a root sparing treatment regime, since the orthodontic movements required prior to surgery are decompensatory, meaning that they do not move roots toward cortical bone.

Unfortunately, the current trend in the orthodontic world is to avoid orthognathic surgery, partly because insurance companies often refuse to pay for these procedures. This trend puts patients at an increased risk of external apical root resorption (EARR). Orthodontic treatment without orthognathic surgery, in patients for whom surgery is indicated, obligates the orthodontist to move tooth apices large distances, which is a treatment-related risk factor for EARR.[5-16] Moving apices large distances increases treatment duration, which is also a treatment-related risk factor for EARR.[7-12] Both of these factors, plus root proximity to cortical plates,[6,17,18] create a higher risk of EARR development.

A patient presented in Chapter 2 of a book I recently published (titled "Iatrogenic Effects of Orthodontic Treatment: Decision-Making in Prevention, Diagnosis and Treatment")[19] serves as an example of the use of

orthognathic surgery to avoid overcompensating tooth positions, which may lead to EARR. The best EARR prevention measure is not to treat patients who require orthognathic surgery, but who refuse to undergo surgery.

CONCLUSION

Orthodontists and maxillofacial surgeons are highly trained dental caregivers obligated to abide by the Hippocratic Oath of doing no harm. It is my hope that this interview, on the use of Iowa Spaces, will make clinicians aware that the creation of these Spaces, prior to orthognathic surgery, is a valuable aid in the management of mandibular skeletal relapse.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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Deproteinization of tooth enamel surfaces to prevent white spot lesions and bracket bond failure: A revolution in orthodontic bonding

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Abstract

Orthodontic treatment success is jeopardized by the risk of development of white spot lesions (WSLs) around orthodontic brackets. Unfortunately, the formation of WSLs still remains a common complication during treatment in patients with poor oral hygiene. Nearly 75% of orthodontic patients are reported to develop enamel decalcification because of prolonged plaque retention around brackets. It is the orthodontist's responsibility to minimize the risk of patients having enamel decalcifications as a consequence of orthodontic treatment. This can be achieved by using hybrid, fluoride-releasing, glass ionomer cement to bond brackets, with deproteinization of the enamel surface before phosphoric acid etching.

Key words: Acquired pellicle, conditioning, deproteinization, enamel, etching patterns, Hippocratic Oath, moistening, resin-modified glass ionomer cements, white spot lesions

INTERVIEW QUESTIONS AND ANSWERS

1. What is the prevalence of white spot lesions (WSLs) in the scientific literature?

A review of the scientific literature indicates that there is a high prevalence of WSLs that develop during comprehensive orthodontic treatment. Richter *et al.*,[1] using the photographic method to detect WSLs, found that 72.9% of 350 orthodontic patients treated with comprehensive orthodontics between 1997 and 2004 in the Department of Orthodontics at the University of Michigan had developed new WSLs. These 350 patients were selected at random from the photographic records of 2300 patients treated at that institution. Boersma *et al.*,[2] using the quantitative light-induced fluorescence method to detect WSLs, found that 97% of 62 patients who were evaluated immediately following comprehensive orthodontic treatment were affected with WSLs. Ogaard,[3] using the clinical inspection method to detect WSLs, in a study of 51 patients treated with comprehensive orthodontics, found that the prevalence of WSLs on vestibular surfaces 5 years posttreatment was significantly higher than in a matched control sample of untreated individuals. Van der Veen *et al.*[4] used the quantitative light-induced fluorescence method in 58 patients to determine whether WSLs diminish after orthodontic treatment (through the natural remineralization process). These researchers found that 6 months after bracket debonding, while 33% of WSLs did remineralize somewhat (lesion regression), the majority of WSLs remained unchanged, and 10% worsened (lesion

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progression). They concluded that in spite of some WSL natural remineralization occurring postorthodontic bracket removal, these lesions generally do not disappear.

The results from all the above-mentioned studies indicate that methods of prevention for WSLs must be strongly considered.

2. What is the scientifically proven effect of fluoride-releasing resin-modified glass ionomer cements (RMGICs) on WSLs?

RMGICs have been proposed as bracket bonding materials due to their continuous fluoride-releasing properties throughout the orthodontic treatment. RMGICs act as fluoride pumps because they continuously absorb fluoride from the environment (e.g., fluoride in dentifrice, in oral rinse, and in potable fluoridated water) and subsequently re-release it precisely in the areas most susceptible to WSLs. These are the gingival third of the teeth, the bracket perimeter and voids beneath the bracket base. *In vivo*,[5,6] *ex vivo*,[7,8] and *in vitro*[9] studies plus systematic reviews[10,11] have documented that RMGICs do protect the enamel from the development of WSLs. These studies confirm that less demineralization occurs during fixed orthodontic appliance treatment with RMGICs than with traditional resin-based adhesives.

3. What kind of etch-pattern types are currently known?

There are three enamel etch-pattern types. They are known as types 1, 2, and 3.[12] Examples of these three can be observed in Figures 1-3, respectively.

Figures 1 and 2 show ×2000 scanning electron microscope (SEM) photographs of enamel surfaces moistened with 5.25% sodium hypochlorite (NaOCl) for 1 min (to deproteinize the enamel surface) and etched with 35% phosphoric acid, applied for 15 s. The high number of microporosities created in these good-quality etching patterns are characteristic of type 1 etching (in which the enamel rod, or prism, heads are dissolved [Figure 1]), and type 2 etching (in which the enamel interprismatic substance is dissolved [Figure 2]). These microporosities allow the adhesive to penetrate the enamel surface increasing the bond strength due to the many adhesive tags created.

Figure 3 shows a ×500 SEM image of an enamel surface etched with 35% phosphoric acid applied for 15 s without prior deproteinization. This low-quality etching pattern type, called type 3 (also known as superficial etching), is characterized by some areas which are well etched, while many are etched poorly, or not etched at all.

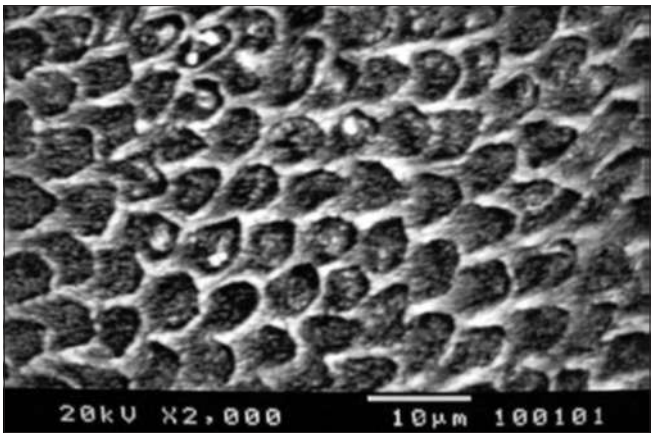

Figure: 1: Enamel moistened with 5.25 sodium hypochlorite for 1 min and etched with 35% phosphoric acid for 15 s. Observe type 1 etching pattern (scanning electron microscope, ×2000) (courtesy: Dr. R. Espinosa, Universidad de Guadalajara, Mexico)

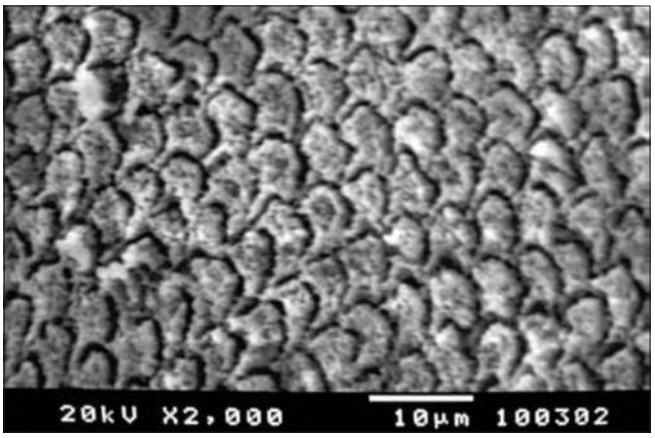

Figure 2: Enamel moistened with 5.25 sodium hypochlorite for 1 min and etched with 35% phosphoric acid for 15 s. Observe type 2 etching pattern (scanning electron microscope, ×2000) (courtesy: Dr. R. Espinosa, Universidad de Guadalajara, Mexico)

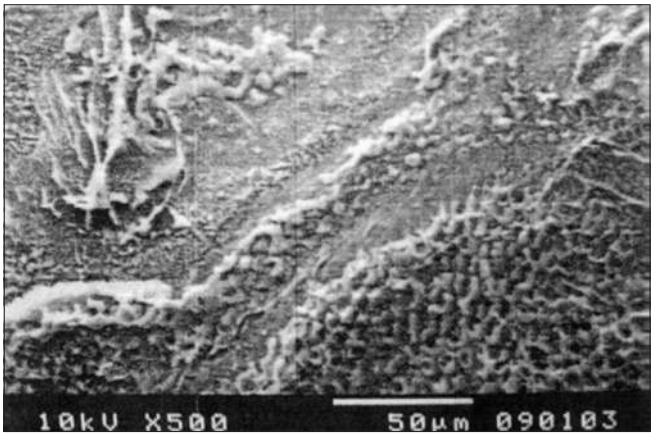

Figure 3: Enamel etched with 35% phosphoric acid for 15 s (no sodium hypochlorite was used). Observe type 3 etching pattern (scanning electron microscope, ×500) (courtesy: Dr. R. Espinosa, Universidad de Guadalajara, Mexico)

Hobson *et al.*[13] reported that the majority of phosphoric acid enamel etchings carried out by dentists result in type 3 etching patterns. These researchers demonstrated that the typical enamel surface etch pattern was as follows: 22% of the surface not etched at all, 7% with a tenuous etch, 69% with type 3 etch, and only 2% with type 1 and 2 etch.

The low-quality type 3 etching pattern has two important associated issues: It provides diminished micromechanical retention, and it allows the creation of voids between the bracket base and the enamel.

Even though orthodontists pumice the teeth before etching, organic material (the acquired dental pellicle) still remains attached to the enamel surface. The dental pellicle layer plays an important role in maintaining tooth integrity by controlling mineral dissolution dynamics at the enamel surface and confers resistance and stability against chemical dissolution and attack by acidic agents.[14] Thus, the pellicle does not allow adequate etching of the enamel surface,[14-16] which can lead to both bracket bond failure and WSL development on the periphery of the bracket base. Voids in the areas close to the bracket base perimeter create a particular risk for WSLs because biofilm can be trapped in them. Normal brushing cannot adequately clean these areas leading to WSL development.

Enamel deproteinization, to remove the surface organic layer, is, therefore, an important step, before etching the enamel, to allow the creation of types 1 and/or 2 etch patterns. Either of these two etch patterns should be obtained to increase the success rate of brackets bonded with composite resins and with RMGICs; the latter providing the added benefit of minimizing WSL development.

4. What is the preferred shear bond strength (SBS) in orthodontics?

Reynolds[17] determined that for a bracket adhesive to be clinically acceptable it should have tensile bond strength (TBS) of a minimum of 5.9 MPa. This figure is called the Reynolds number. Orthodontists are more interested in the SBS than in the TBS. The reason is that bracket failure mostly occurs due to shear rather than tensile forces. Still, the Reynolds number is used. Ideal SBS should be around 9 MPa because higher SBSs could damage the enamel surface at the time of debonding. Bracket failure most frequently occurs either at the enamel-adhesive interface or the bracket-adhesive interface. Bracket failure at each of the two interfaces has its own advantages and disadvantages. Bracket failure at the bracket-adhesive interface is advantageous as it indicates good adhesion to the enamel. However, considerable chair time is needed to remove the residual adhesive, with the added possibility of damaging the enamel surface during the cleaning process. In contrast, when brackets fail at the enamel-adhesive interface, less residual adhesive remains on the enamel, but then accidental bracket failure probably occurs more often during treatment, disrupting chair time, and prolonging the duration of orthodontic treatment.[18]

5. Can SBS of fluoride-releasing RMGICs be increased?

Yes, it can, provided additional microporosities are created on the enamel surface. This goal can be achieved by removing all the organic material on the enamel surface (dental acquired pellicle and organic material from the enamel cuticle and subcuticle) with 5.25% NaOCl, as demonstrated by Justus *et al.*[18] By removing this organic material, the 37% of phosphoric acid etching agent (not the 10% polyacrylic acid conditioning agent) can attack the enamel surface creating type 1 and 2 etch patterns, thereby increasing bracket SBS. This study demonstrated that by deproteinizing the human enamel surface before 37% phosphoric acid etching for 30 s and moistening the enamel surface after acid etching, the mean SBS of an RMGIC (Fuji Ortho LC) increased almost 70% (from 5.7 to 9.6 MPa)), and the mean SBS of a composite resin (Transbond XT) increased from 8.1 to 9.4 MPa. This clinically important, and statistically significant increase in SBS, in the case of the RMGIC, finally allows orthodontists to reliably use RMGICs to bond brackets, thereby minimizing the risk of WSL development and also bracket bond failure. Clinicians still using the traditional resin-based composites as bracket adhesives may reduce their bracket failure rates by deproteinizing the enamel surface for 1 min before etching. This simple step can reduce accidental bracket failures because bracket SBS is increased.

Moistening the enamel surface when using RMGICs, as per the manufacturer's instructions (GC Corp., Tokyo, Japan) of Fuji Ortho LC, is also an important step to increase bracket SBS; this was validated by Larmour and Stirrups.[19]

6. Is there a difference in bracket placement time with RMGICs when compared with a composite resin?

In the litigious environment in which we live today, it is very important to prevent iatrogenic problems from developing, particularly WSLs. That is why I recently published a book titled Iatrogenic Effects of Orthodontic Treatment: Decision-making in Prevention, Diagnosis, and Treatment.[20] The first chapter of this book, published by Springer-Verlag, is dedicated to the prevention of WSLs, with the main goals of protecting the health of the patient's teeth (Hippocratic Oath) and also protecting the clinician from malpractice lawsuits.

The small extra time it takes to bond brackets with RMGICs is nonimportant compared with the time having to spend with posttreatment patient complaints due to WSLs. The auxiliary help in my office are the ones who bond the brackets using the direct bonding method. However, it is me who does the final positioning of the brackets before photocuring the adhesive. In my office, the total time it takes my auxiliaries to bond a single full arch is 20–25 min, deproteinizing, etching, moistening, bonding, and photocuring two teeth at a time. However, it takes only 7 min of my own time because I solely adjust the final bracket positions. It should be noted that more than two teeth can be bonded at a time, as is discussed in the answer to question number 9.

7. How many years clinical experience have you had with RMGICs in your office?

Sixteen years, the last 6 years using deproteinization of the enamel surface with 5.25% NaOCl before phosphoric acid etching. In all these years, the only WSLs I observed in my practice occurred in patients who were transferred to me with their brackets already bonded, probably with the traditional resin-based composites.

8. What is your bracket failure rate in your office?

Anecdotally, in my office the bracket failure rate is approximately 5%. To my knowledge, no clinical research has yet been published on bracket failure rates when brackets are bonded with RMGICs, having the enamel surface been deproteinized/etched/moistened. However, it has been my experience that if a bracket fails it usually happens during the 1st month after bracket bonding, particularly in the lower arch due to chewing on hard foods. The patient pretty quickly learns what not to chew on. Investigators have evaluated various methods to increase bracket SBS of brackets cemented with RMGICs, such as using different enamel conditioners and concentrations, for different time periods, and increasing the light-curing time. Still, the resulting bracket SBS was inadequate until Justus *et al*.[18] suggested deproteinizing with NaOCL, etching with H_3PO_4 and wetting the enamel surface with a water-moistened cotton roll, all these steps before photocuring.

9. What would you recommend as a routine protocol for bracket placement?

To reduce the risk of WSL development during orthodontic treatment, I recommend bonding orthodontic brackets with Fuji Ortho LC, which has been the most frequently used RMGIC in published studies and is thus the industry standard. Taking into account the fact that the acid-base reaction in Fuji Ortho LC takes 24 h to set, I recommend the following protocol for bracket placement:[20]

- Pumice prophylaxis with a rubber cup for 5 s per tooth
- Rinse and dry
- Apply 5.25% NaOCl with a microbrush to two (or more) teeth at a time [Figures 4 and 5], rubbing the solution for 1 min on the enamel surface where the brackets will be placed (the saliva suction tip should be positioned in such a fashion as to suction away any NaOCl excess. Patients do not perceive the odor of the bleach because a very minute amount is used to deproteinize the enamel surfaces of the teeth)
- Rinse and dry
- Etch with 37% phosphoric acid for 15–30 s
- Rinse and dry
- Wet the etched enamel surface with a water-moistened cotton roll
- Mix powder and liquid as per manufacturer recommendations, taking note that the operator has less than a minute or two (depending on room temperature and the ambient light) to position the brackets before the resinous fraction of this adhesive begins to harden/polymerize. It is therefore recommended to prepare adhesive for only two teeth at a time. However, if the clinician wishes to bond more than two brackets per mix, a cold slab can be used to mix the powder and liquid. GC Corp., now offers a no-mix Fuji Ortho LC for the clinician who wishes to avoid the mixing procedure. This 2-paste adhesive can be refrigerated so more than 2 teeth may be bonded at a time
- Load the adhesive onto the bracket bases and press them against the enamel surface making sure that the brackets do not contact the opposing teeth while in occlusion
- Remove excess adhesive with a sharp scaler
- Light cure and remove excess adhesive.

Once all brackets have been bonded, tie in a very light wire (0.010" SS or a NiTi) avoiding full bracket engagement in severely malaligned teeth to prevent bracket failure, since the glass ionomer fraction of RMGICs takes 24 h to set. Keeping brackets away from occlusion is also critical to help avoid bracket failure.[20] Hegarthy and Macfarlane, in a clinical trial comprising 61 patients, compared the clinical performance of a RMGIC adhesive with a resin-based adhesive over a 12-month period. The split-mouth technique was used to analyze bracket retention. Both adhesives had 4 times more bracket failures when opposing occlusion was present.[21] Thus, keeping brackets away from occlusion is critical to minimize bracket failure. The use of occlusal stops, when indicated, should be considered to avoid bracket failure. The brackets with the RMGIC adhesive, in the Hegarthy and Macfarlane study,[21]

Figure 4: A glass container with a 5.25% sodium hypochlorite solution. This dark container helps prevent the deactivation of this solution by light (left). Dappen Dish containing the sodium hypochlorite solution and a microbrush used to transport it to the labial/buccal surfaces of the teeth (right) (reprinted with permission from Justus *et al.*)[18]

Figure 5: Clinical example of enamel deproteinization by applying 5.25% sodium hypochlorite solution to the enamel surface for 1 min with a microbrush. The objective is to eliminate the acquired pellicle so the 37% acid etch can create improved etching patterns on the enamel surface to increase bracket shear bond strength (reprinted with permission from Justus *et al.*)[18]

were bonded using the traditional method, specifically without deproteinizing or phosphoric acid etching the enamel surface. Brackets bonded with RMGICs using the traditional method have a much lower initial SBS than composite resins,[22] so many additional micromechanical retentions must be created on the enamel surface to increase the initial bracket SBS and thus be able to successfully use these adhesives. To increase this inadequate initial SBS of the RMGICs, three steps have been recommended: Deproteinizing the enamel surface with 5.25% NaOCl, etching the enamel surface with 37% phosphoric acid, and moistening the enamel surface, preferably with water since saliva contains proteins.

10. Are there disadvantages of RMGICs in clinical orthodontics?

RMGICs have three disadvantages:

1. Fuji Ortho LC requires a longer time to fully harden than composite resin (even though Vivanco[23] determined that the SBS was adequate 30 min after bonding)
2. Deproteinization of the enamel surfaces with NaOCl for 1 min, to increase bracket SBS, is imperative
3. Mixing Fuji Ortho LC powder and liquid takes additional chair time. Although the manufacturer is now selling a no mix Fuji Ortho LC, which this author has not yet tried, it would be advisable to carry out laboratory studies before using it on patients.

CONCLUSION

Clinicians need to consider the properties of RMGICs to be able to use them successfully. Because of the recent improvements in the bracket SBS with deproteinization, and the fluoride-releasing and uptake properties of RMGICs, it is suggested that these adhesives should see greater use in bonding orthodontic brackets in the future. The advantages of using RMGICs far outweigh the disadvantages.

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Conflicts of interest

There are no conflicts of interest.

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Special Feature

A century of the edgewise appliance

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Abstract

The edgewise appliance, born in the mind of Dr. Edward Angle and first introduced on June 2, 1925, has withstood the test of almost a century of time and usage. The 022 standard appliance that Angle described in a series of four articles in Dental Cosmos is being used by many orthodontic clinicians in fundamentally the same form as it was presented in 1928 and 1929 in Dental Cosmos. Yes, it has been modified in innumerable ways. However, to use one of the modifications, the clinician must understand and respect the fundamentals of its use. This treatise describes the appliance's evolution from Angle to its use today. The force system of today is simpler and more refined than what Angle envisioned but the appliance is "intact." It is as modern as tomorrow and will continue to be used as long as the specialty exists. It was Angle's greatest contribution.

Key words: Edgewise, ribbonarch, pin and tube

The edgewise appliance has been used in orthodontics for almost a century. It had its beginnings in the mind of Edward Angle, the "father of orthodontics" [Figure 1]. During the early 1900s, angle constantly tried to improve the appliances that he used — and that he sold through dental supply houses. Angle's ribbon arch appliance and the older pin and tube appliance were proving difficult to use. Other "appliances" were marketed, but most of them were a hodgepodge of expansion screws and finger springs. In the mid-1920's, Edward Angle felt the necessity to "invent" something that was better than anything available. On June 2, 1925 at the Fourth Annual Meeting of the Edward Angle Society of Orthodontists, he gave the fledging orthodontic specialty a glimpse of the edgewise appliance. He described his new appliance again in a 1926 lecture in Pasadena, California and once more during another lecture on June 28, 1928 at the Seventh Annual Meeting of the Angle Society. Because his new appliance had not been widely accepted, angle decided that he must describe the appliance in detail in printed form. He did so in a popularly circulated journal, the Dental Cosmos. Because it is fascinating to read Angle's description of his struggles with his edgewise appliance, the following is a direct excerpt from the Dental Cosmos article of December 1928.[1] The excerpt gives one a good understanding of the introduction of the edgewise appliance and the mental anguish that it caused for its inventor, Edward Angle. [Angle used Figure 2 in his article to illustrate the appliance. It is Figure 2 in this article as well].

Few of you will be able to realize what a struggle it has cost me to introduce a seeming rival to my own precious offspring, the ribbon arch mechanism. However, we are not our own masters. Some invisible hand is always pushing us on to do, or try to do, what it seems we must, not always what we would. So far, in reality, we shall later see that the new is not truly a rival, but that by their union the two mechanisms may be made harmonious and even cooperative, in many instances to the benefit of both, especially to the ribbon arch mechanism, and that thus

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Figure 1: E.H. Angle

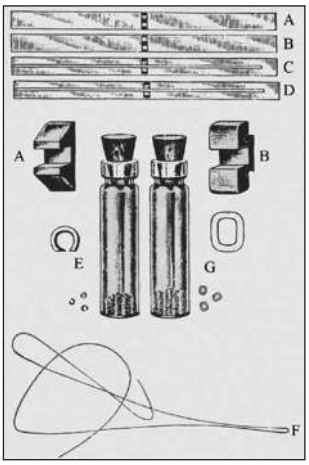

Figure 2: Edgewise appliance

our mechanical resources for treatment are widened and strengthened.

The principles of application and operation of the mechanism, which I shall now describe, are, in the main, along the line of those with which you are already familiar, those of the time-honored labial arch mechanism here made use of in devices of further refinement. In fact, as we shall see, in this mechanism are combined most of the best points of all my former types of expansion arch mechanism, that is, the arches E and B, the arch with pin and tube attachments, and all forms of the ribbon arch mechanism, and, besides, it has many other distinct advantages peculiar to itself. Figure 2 illustrates all of the various parts of the new mechanism.

A shows a band which is 1/8 inch wide, 1¾ inches long, and 0.004 inch thick, with a bracket brazed to the center of its labial surface. The bracket is made from a solid block of metal and has a slot cut horizontally across it midway of its length. The outer ends of the bracket are beveled from the slot to the edges of the band. You will note how delicacy and strength are combined in its proportions. It is designed, especially for use on anterior teeth, although it may be used in any part of the mouth. This will be known as open-face bracket No. 1.

B shows another band of the same dimensions as that shown at a, but bearing a somewhat different type of horizontally slotted bracket, the portions of the bracket above and below the slot, instead of being beveled, forming overhanging flanges or wings. It is designed for use on buccal teeth and will be known as open-face bracket No. 2.

The slots in both brackets are for the reception of metal arches, the active or power members of the mechanism.

C and D show the two types of bracket bands, seated within the brackets of which are segments of two types of elastic arch material of which the arches are to be made, the form of arch used to be determined according to the requirements of particular cases. The one shown at C is rectangular in form and made from a bar of metal of the same material as that of which the tiny ribbon arches, used on deciduous and mixed dentitions, are made. It is carefully drawn to the dimensions of exactly 0.022 inch in thickness and 0.028 inch in width, and it most accurately fits the slots in both brackets. That at D is round and but 0.022 inch in diameter, of the same material as that you have been using for spurs, retention and, occasionally, for arches in the tiny ribbon arch mechanism.

The two types of arch shown at A and B are interchangeable in the two types of brackets.

It will be noted that the rectangular arch is applied edgewise to the brackets instead of sidewise or flatwise, as in its use in the ribbon arch mechanism. For this reason, it will hereinafter be designated the edgewise arch, to distinguish it from the ribbon arch that also is rectangular in form. Used in this novel manner, the arch is more delicate and graceful in appearance, besides having greater power under certain conditions and far greater elasticity or range of operating force under others, as in widening dental arches, effecting some forms of root movement, tipping teeth into their correct upright axial relations, etc.

Dr. Edward Angle described the edgewise bracket and the use of the appliance in a series of three more articles in the Dental Cosmos.[2-4] He died on August 11, 1930 at the age of 75. He did not have time to teach the appliance's manipulation or to make any improvements. These duties had to be left to others — his students and colleagues. In his lecture on June 28, 1928 at the Seventh Annual Meeting of the Angle Society at New London, Connecticut,

Angle touted the fact that the edgewise appliance, as he saw it, was much simpler and much easier to use than the ribbon arch. He talked about its efficiency and told his audience that actual clinic patients would be available for examination by all attendees later during the day of his lecture so that everyone could critically inspect the results edgewise obtained with the appliance.[4] When the appliance was introduced, several of Angle's earlier students, one in particular, Dr. Allen G. Brodie, used the edgewise appliance exclusively. These practitioners echoed Angle's claims that the newly introduced appliance was much more "user-friendly" than anything else available.

Charles Tweed graduated from an improvised Angle course that was given to him and four other students by George Hahn and some Angle school graduates. It was an improvised course because Angle accepted the five students and subsequently closed his school. The students showed up for Angle's school, but Angle had gone to Hawaii. George Hahn organized the 1928 session — the last session of the Angle school. Angle returned and interacted with Tweed and his classmates, gave some lectures, etc. Tweed's graduation date was 1928. Charles Tweed was 33 years of age while he was studying in the Angle school. Immediately after his schooling was completed [Figure 3], Tweed helped Angle with the Dental Cosmos articles that were being readied for publication. Angle convinced young Tweed that he (Tweed) could never master the edgewise appliance unless he limited his practice solely to its use. Charles Tweed returned to his home of Phoenix, Arizona and established a pure edgewise specialty practice. Tweed worked closely with Angle for the last 2 years of Angle's life. It is documented by letters between the two men housed in the Tweed Memorial Library that Tweed took many of his active treatment patients by train to Pasadena to have Angle examine them. Angle would offer Tweed a plan for each patient's next course of treatment. Tweed would return to Phoenix with his patients and complete the treatment advised by Edward Angle. The two men became very close friends and were in constant contact during the last 2 years of Angle's life.

Tweed used Angle's nonextraction philosophy until he became disheartened with the protrusive faces that he was creating. By 1932, he had decided that he must study his failures and his successes. During the 4 years period from 1932 until 1936, Tweed made many important observations. One of these was that the patient who had the best balance and harmony of facial proportions had mandibular incisors that were not protruded off the basal bone. He concluded that one must, in many instances, extract teeth to upright mandibular incisors to have a balanced face. In 1936, Tweed delivered to the membership of the Angle Society an "extraction" paper. He was severely criticized.

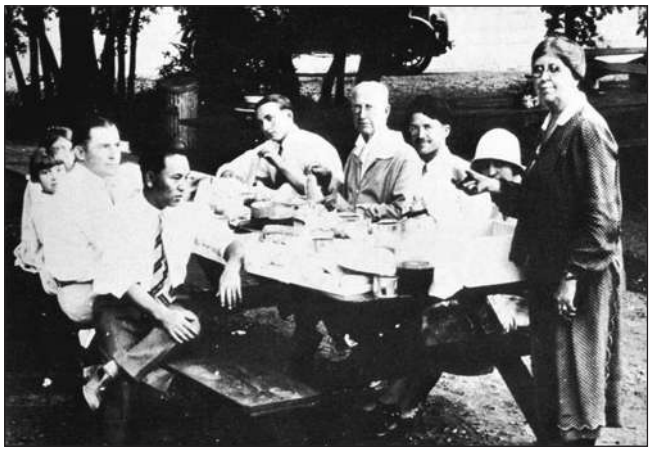

Figure 3: Tweed at a picnic with Angle

He subsequently published this paper on the extraction of teeth for orthodontic malocclusion correction.[5,6] The paper caused quite a stir throughout the orthodontic world. Tweed continued his work, and by 1941 had become known for his clinical expertise and his skill at the manipulation of the edgewise appliance. The Tweed Study Course was born as a result. The purpose of the Course was to teach Tweed's treatment planning protocols as well as the use and manipulation of the edgewise appliance.

The 1941 Tweed Study Course was held in Joe Doebrick's machine shop. World War II intervened. The Course was started again in 1946 in a "new" facility, one that is still in use. Tweed continued to organize his Tweed Study Course and taught literally thousands of orthodontists, both those who were university trained as well as preceptees, how to use the edgewise appliance. He lectured and published[7-14] extensively during the 1950's and 1960's. His 1966 two volume text[15] is copiously illustrated with wire manipulation bends and wonderful drawings of hand positions with very detailed explanations of how each finger should be moved to make a particular bend in the archwire. What Tweed did that Angle did not have time to do was devise a force system that would allow the appliance to work as it should work.

The malocclusion of the patient determined, in many instances, how Tweed used the appliance. Whether or not the patient had to be treated with extractions or treated without extractions had a great bearing on the archwires and on the extraoral forces that were employed. To look at the pictures of the various typodont malocclusion corrections that were photographed and illustrated in Tweed's textbook is a very interesting and eye-opening experience.

In Tweed's day, each patient's malocclusion correction would require between 10 and 12 sets of archwires

[Figures 4 and 5]. Because of the many elastic and headgear forces that were applied to the archwires, the big unknown was patient cooperation. On page 176 of volume 1 of his text, Tweed states, "With these reactions thoroughly understood, it becomes obvious that patient cooperation is most important for success in treatment objectives. If the forces are not controlled because the patient does not follow instructions, disaster lies ahead, particularly in nonextraction cases. If second order bends are placed in the maxillary archwire unaccompanied by Class II intermaxillary force, the uncontrolled forces will move the root apices of the teeth in the buccal quadrants from the terminal molars to cuspids in a mesial direction, with no appreciable distal movement of their crowns. In such instances, treatment will produce a mesial displacement of the teeth in the buccal quadrants of both arches and the end result will be a bimaxillary protrusion due to forces improperly utilized." Tweed went on to talk about the creation of anterior openbites if the patient did not properly wear the forces during en masse anchorage preparation. Tweed essentially used Angle's edgewise appliance in the following manner. The steps were:

1. Leveling and alignment — A series of round archwires was used. During his later years, Tweed used directionally controlled headgear applied to the canines to begin canine retraction on these round archwires [Figure 6].
2. If teeth were extracted, mandibular extraction space closure was accomplished after leveling and alignment. This was done with a 0.020 × 0.025 working archwire that had closing loops incorporated into them [Figure 7].
3. Mandibular anchorage preparation — To prepare mandibular anchorage, Tweed bent a stabilizing archwire for the maxillary arch and a working archwire for the mandibular arch. All mandibular second order bends were placed, at one time, into the archwire [Figure 8]. To control these second order bends, Tweed used Class III elastics, an intermediate headgear to the maxillary arch and vertical up and down elastic force.[8]
4. After en masse mandibular anchorage had been prepared, the mandibular arch was stabilized with an 0.0215 × 0.028 archwire that was continuously tied in the posterior segments. This stabilizing archwire was an exact "duplicate" of the previously used working archwire, only larger. The maxillary archwire was changed to a smaller dimension maxillary working wire. Tweed then distalized the maxillary arch if the treatment was nonextraction or retracted the maxillary anterior teeth if the patient had extraction space mesial to the distalized maxillary canines. The patient generally wore Class II elastics, anterior vertical elastics, and again, a headgear.
5. The final step was to finish the correction of the malocclusion. Tweed used 0.0215 × 0.028 rectangular archwires with soldered spurs and vertical elastics to effect the proper interdigitation of the teeth.

This treatment protocol, devised by Tweed, was very effective. Patient cooperation was the key. A noncooperative patient presented problems. The fabrication of 10 to 12 sets of archwires for each patient was, to say the least, a concern for many who used Tweed's methods.

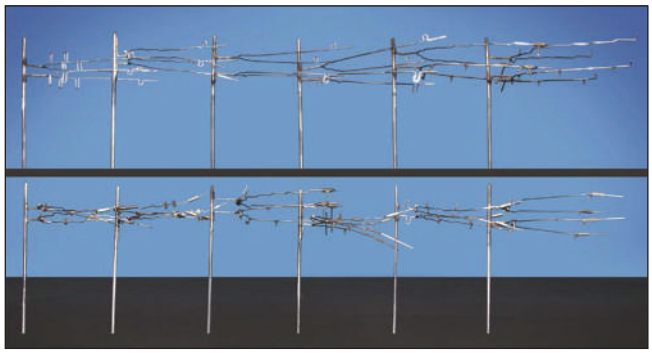

Figure 4: Twelve sets of archwires

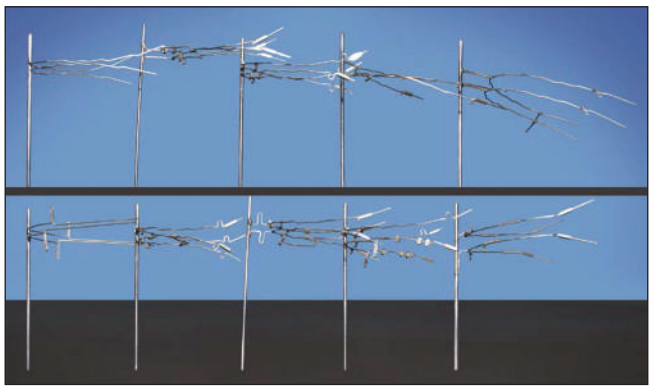

Figure 5: Ten sets of archwires

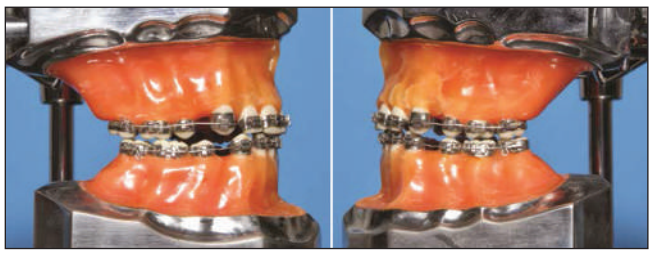

Figure 6: Round archwires used during leveling

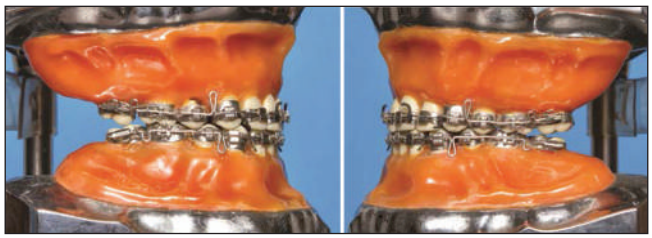

Figure 7: Closing loop archwires

In 1970 L. Levern Merrifield [Figure 9] of Ponca City, Oklahoma became the Tweed Study Course Director. He and Tweed had worked closely together and discussed many, many things about the edgewise appliance and its use during their years as co-directors of the Course from 1960 until Tweed's death in 1970. Levern Merrifield was determined to make the use of the appliance more "efficient" while remaining true to Tweed's concepts of anchorage preparation with vertical control during protrusion reduction. After years of study and experimentation, Merrifield introduced a totally new concept: Edgewise Sequential Directional Force Technology.[16] This system would "streamline" the use of Angle's invention — the edgewise appliance. Merrifield's diagnostic and treatment concepts[17-20] included total space analysis, differential diagnosis, sequential appliance placement, directional force control during treatment, sequential tooth movement and, most important, sequential mandibular anchorage preparation. Sequential appliance placement made it possible to use only edgewise archwires. Round wires were eliminated; the dentition was therefore under more control from the outset. Headgear cooperation was essential for directional force control, but sequential tooth movement, particularly sequential anchorage preparation, made patient cooperation much less intense and more manageable. Gone were the Class III elastics for en masse anchorage preparation and the tax that this elastic force levied on the maxillary arch.

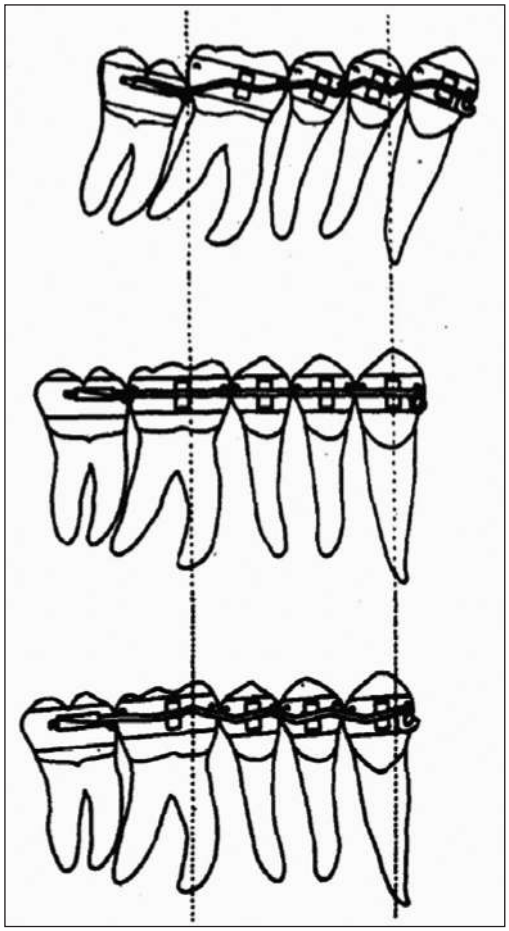

Figure 8: En masse anchorage preparation

Merrifield's Tweed-Merrifield Force System revolutionized the use of the edgewise appliance. This force system, along with a differential diagnostic analysis system, has been taught since 1982 to thousands of students who have taken the Tweed Study Course.

Merrifield's concepts remained true to Tweed's philosophy; they simply made malocclusion correction more reliable and predictable. Since Merrifield's original work, Herb Klontz[21-23] and other Tweed Study Course instructors have further refined the use of the edgewise appliance. The edgewise appliance of today is as modern as next week; it is efficient; it gives the clinician a very predictable, high-quality result for each patient. A description of the steps of treatment with illustrations follows.

Steps of treatment

Tweed-Merrifield edgewise directional force treatment can be organized into four distinct steps: Denture preparation, denture correction, denture completion, and denture recovery. During each step of treatment, certain objectives must be attained.

Denture preparation

Denture preparation prepares the malocclusion for correction. Objectives include the following:

1. Leveling.
2. Individual tooth movement and rotation correction.
3. Retraction of maxillary and mandibular canines.

The denture preparation step of treatment takes about 6 months. One mandibular archwire and one maxillary archwire are used to complete this step.

Figure 9: Levern Merrifield

The teeth of the original malocclusion are sequentially banded and bonded [Figure 10]. After the placement of the appliance, an 0.018 × 0.025 inch resilient mandibular archwire and an 0.017 × 0.022 inch resilient maxillary archwire are inserted. The mandibular second molar receives an effective distal tip that will upright its mesial inclination. In the maxillary arch, a 20° tip is placed in the wire distal to the omega loop stop to maintain the distal inclination of the second molar.

High pull J-hook headgear is used to retract maxillary and mandibular canines. After the 1st month of treatment, the maxillary first molars are banded, and after the 2nd month of treatment the mandibular first molars are banded. As the canines retract, and the arches are leveled, the lateral incisors are ligated, and power chain force to aid canine retraction can be used [Figure 11].

At the end of the denture preparation stage of treatment the dentition should be level, the canines should be retracted, all rotations should be corrected, and the mandibular second molars should be level [Figure 12].

Denture correction

The second step of treatment is called denture correction. During denture correction, the spaces are closed with maxillary and mandibular closing loop archwires. Vertical support to the maxillary arch is achieved with J-hook headgear attached to hooks soldered to the maxillary archwire between the maxillary central and lateral incisors. Vertical support of the mandibular anterior teeth is accomplished with anterior vertical elastics. The mandibular archwire is an 0.019 × 0.025 inch working archwire with 7.0 mm vertical loops distal to the lateral incisor brackets. The 0.020 × 0.025 inch maxillary archwire has 7.5 mm vertical loops distal to the lateral incisor brackets. In both arches, the omega loop stops are immediately distal to the brackets of the first molars [Figure 13]. At the end of space closure [Figure 14], the curve of occlusion in the maxillary arch should have been maintained, and the mandibular arch should be completely level. The dentition is now ready for mandibular anchorage preparation.

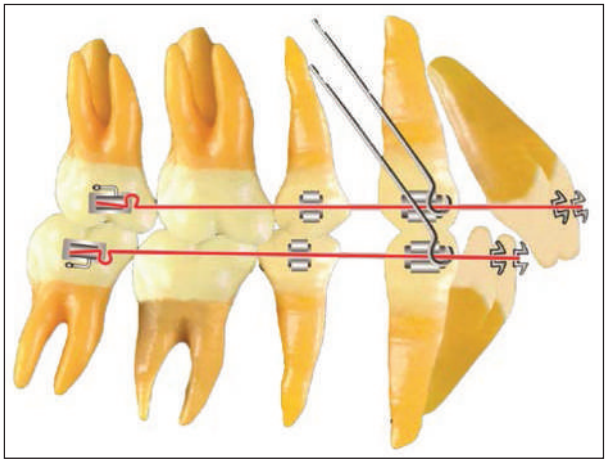

Figure 10: Denture Preparation: Initial arch wires. Initial arch wires consist of a 0.017 × 0.022 inch resilient mandibular arch wire

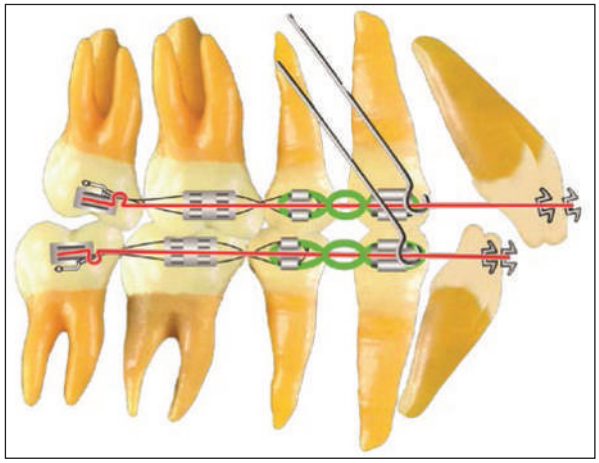

Figure 11: Denture Preparation: Canine retraction. The canines are retracted with a J-hook headgear during denture preparation

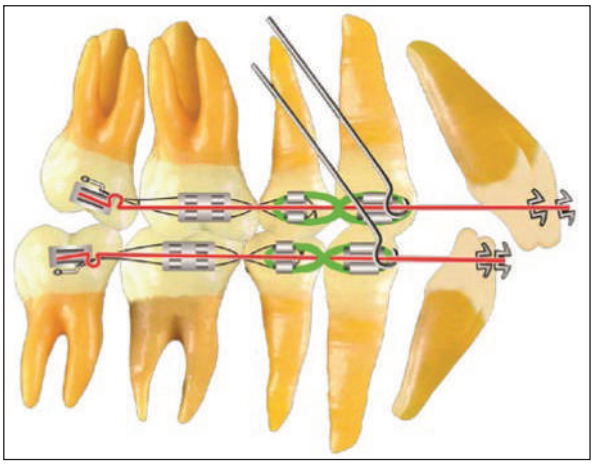

Figure 12: Completion of denture preparation

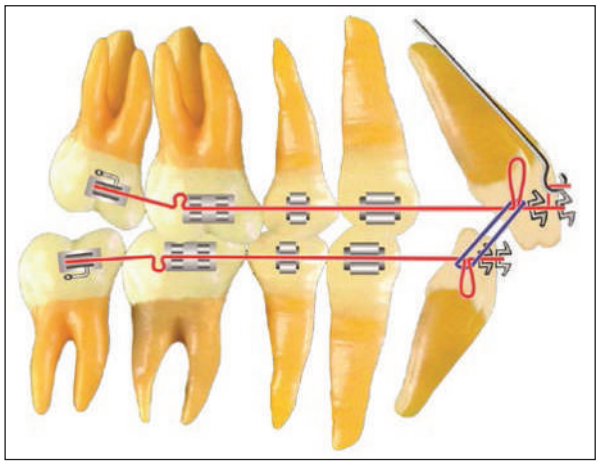

Figure 13: Denture correction: Closing loop application

Sequential mandibular anchorage preparation

An 0.019 × 0.025 inch archwire with the omega loop stops bent flush against the second molar tubes is fabricated. First and third order bends are ideal. Gingival spurs for anterior vertical elastics are soldered distal to the lateral incisors.

To tip the mandibular second molars to an anchorage prepared position, a 15° tip is placed distal to the omega loop stop. The second molar is tipped to an anchorage prepared position. It should have a distal inclination of 10 to 15° that can be verified with a readout [Figure 15].[22]

After the second molar has been tipped the first molar is tipped to its anchorage prepared position by placing a 10° distal tip 1 mm mesial to the first molar bracket. When this first molar tip is placed in the archwire, a compensating bend that maintains the 15° second molar inclination must be placed mesial to the omega loop stop [Figure 16].

The archwire is now passive to the second molar and crosses the twin brackets of the first molar at a 10° bias. After 1 month, the archwire is removed and readout should show a 5 to 8° distal inclination of the first molars. The second molars should continue to readout at 15°.

The denture correction step of treatment should now be complete for the Class I malocclusion. The objectives of the denture correction step are:

1. Complete space closure in both arches,
2. Sequential anchorage preparation in the mandibular arch,
3. An enhanced curve of occlusion in the maxillary arch, and
4. A Class I intercuspation of the canines and premolars.

Class II force system

For patients with an "end-on" Class II dental relationship of the buccal segments at the conclusion of space closure, a new and different force system must be used to complete the denture correction stage of treatment. A careful study of the cusp relationships will determine the force system required. Making a final diagnostic decision for Class II correction is usually based on:

1. The ANB relationship,
2. A maxillary posterior space analysis, and
3. Patient cooperation.

The Class II force system cannot be used unless compliance requirements are strictly followed by the patient. If one attempts to use the Class II force system without cooperation, the maxillary anterior teeth will be pushed forward off the basal bone.

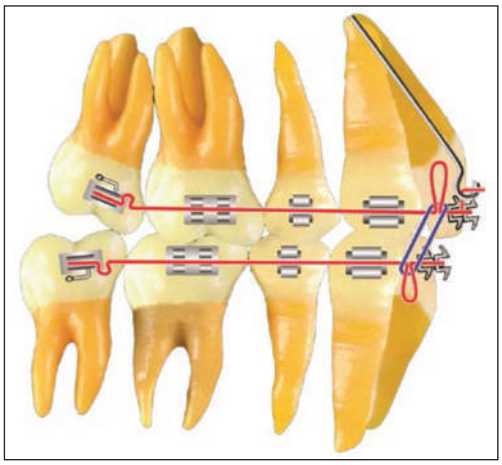

Figure 14: Space closure. After space closure the arch is level

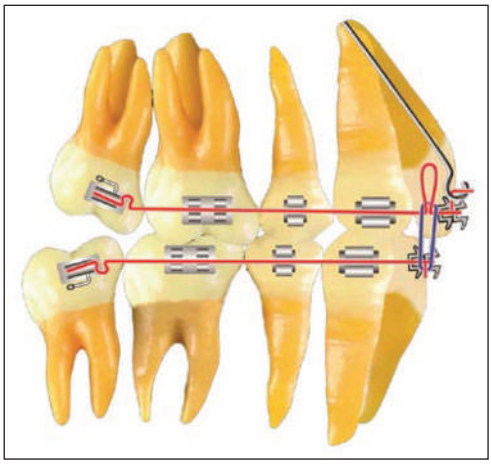

Figure 15: Mandibular anchorage preparation. The second molar is tipped to its anchorage prepared position

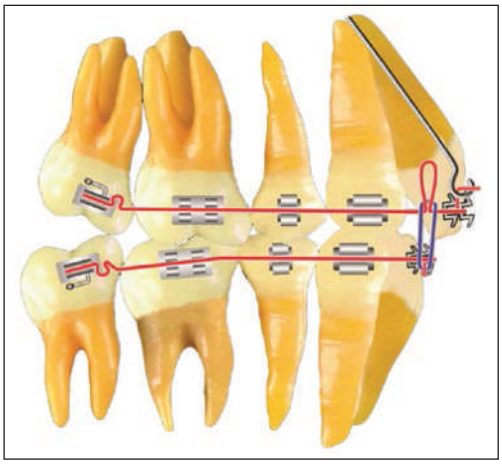

Figure 16: Mandibular anchorage preparation. The first molar is tipped to its anchorage prepared position

Class II force system

At the end of sequential mandibular anchorage preparation, a mandibular 0.0215 × 0.028 inch stabilizing archwire is

fabricated. Ideal first, second, and third order bends are incorporated into the archwire. The omega loop stop must be 0.5 mm short of the molar tubes, and the wire must be passive to all the brackets. Gingival spurs are soldered distal to the mandibular lateral incisors. The wire is seated and ligated, and the terminal molar is cinched tightly to the loop stop.

An 0.020 × 0.025 inch maxillary archwire with 7.5 mm closed helical bulbous loops bent flush against the second molar tubes is fabricated. This archwire has ideal first and second order bends. A gingival spur is attached to the archwire immediately distal to the maxillary second premolar bracket. Gingival high pull headgear hooks are soldered distal to the central incisors. Class II "lay on" hooks with a gingival extension for anterior vertical elastics are soldered distal to the lateral incisors. Prior to archwire insertion, the closed helical bulbous loops are opened 1 mm on each side. Class II elastics are worn from the hooks on the mandibular second molar tubes to the Class II hooks on the maxillary archwire. Anterior vertical elastics are worn from the spurs on the mandibular archwire to the gingival extension hooks on the maxillary archwire. The high pull headgear is worn on the maxillary headgear hooks [Figure 17].

This force system is used to sequentially move the maxillary second molars distally. The activation of the maxillary archwire is repeated until the second molars have a Class I dental relationship [Figure 18]. When the Class I relationship of the second molars has been established, a closed coil spring is "wound" distal to the second premolar spur and compressed between the spur and the first molar bracket when the maxillary archwire is inserted. (The coil spring length should be 1.5 times the space between the second premolar and the first molar brackets). An elastic chain is stretched from the second molar to the distal bracket of the first molar. The spring and the elastic chain create a distal force on the maxillary first molar. In addition, Class II elastic is continuously worn from the mandibular second molar hook to the Class II hook on the maxillary archwire. An anterior vertical elastic is worn 12 h each day [Figure 19]. The high pull headgear is worn 14 h/day on the spurs soldered to the maxillary archwire.

After the first molars have been moved distally into an overcorrected Class I dental relationship, [Figure 20], the spur that was attached distal to the second premolar bracket is removed. The coil spring is moved mesially so that it is compressed between the lay on the hook and the canine bracket. Subsequently, the maxillary second premolars and the maxillary canines are moved distally with elastic chain and headgear force [Figure 21].

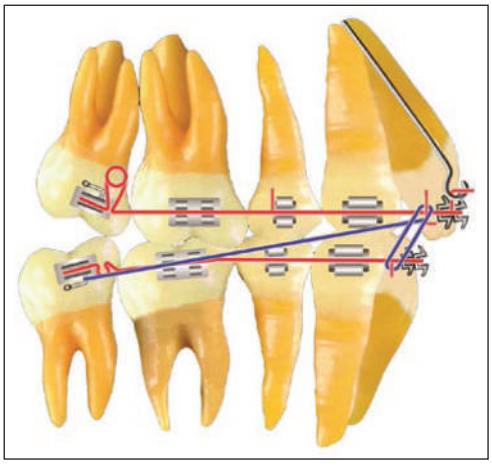

Figure 17: Class II force system

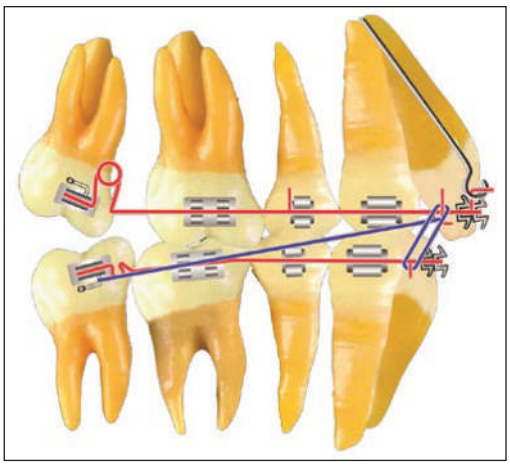

Figure 18: Class II force system. Denture Correction: The helical bulbous loop pushes the maxillary molar distally

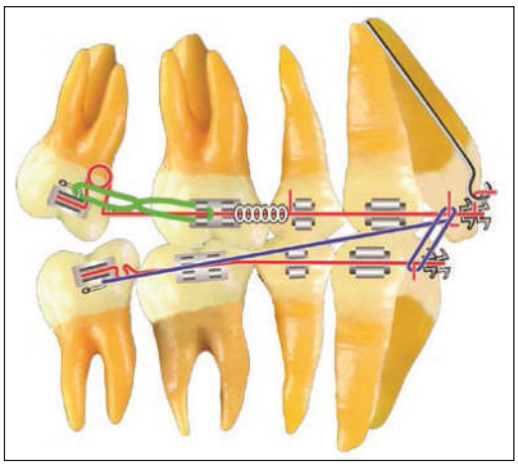

Figure 19: Class II force system. Denture correction: A coil spring is trapped mesial to the first molar

After overcorrection of Class II dental relationship, an 0.020 × 0.025 inch maxillary archwire with 7.5 mm closing loops distal to the lateral incisors is fabricated. Gingival headgear hooks are soldered distal to the central incisors

[Figure 22]. The closing loops are opened 1 mm per visit by cinching the omega loop stops to the molar tube. Class II elastics, anterior vertical elastics and the maxillary high pull headgear are used.

Denture completion

The third step of treatment is identified as denture completion. Ideal first, second, and third order bends are placed in finishing mandibular and maxillary 0.0215 × 0.028 inch resilient archwires. The mandibular archwire duplicates the previously used mandibular stabilizing archwire. The maxillary archwire has artistic bends and hooks for the high pull headgear, anterior vertical elastics and Class II elastics. Supplemental hooks for vertical elastics are soldered as needed [Figure 23].

The forces used during denture completion are based on a careful study of the arrangement of each tooth in each arch. The orthodontist must also study the relationship of one arch to the other and the relationship of the arches to their environment. Denture completion can be considered as minitreatment of the malocclusion. During this treatment step, the orthodontist uses the forces that are necessary until the original malocclusion is overcorrected.

Denture recovery

An ideal occlusion will be present only after all treatment mechanics are discontinued and uninhibited function and other environmental influences active in the post-treatment period stabilize and finalize the position of the total dentition. When all appliances are removed, and the retainers are placed, a most crucial "recovery" phase occurs. During this recovery period, the forces involved are those of the surrounding environment, primarily the muscles and the periodontium.

The posttreatment occlusion, which is carefully planned, sometimes referred to as Tweed occlusion but properly identified as transitional occlusion [Figure 24], is

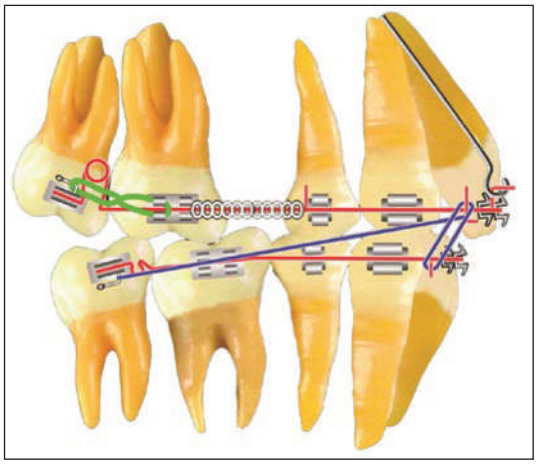

Figure 20: Class II force system. Denture correction: Maxillary first molar distalization

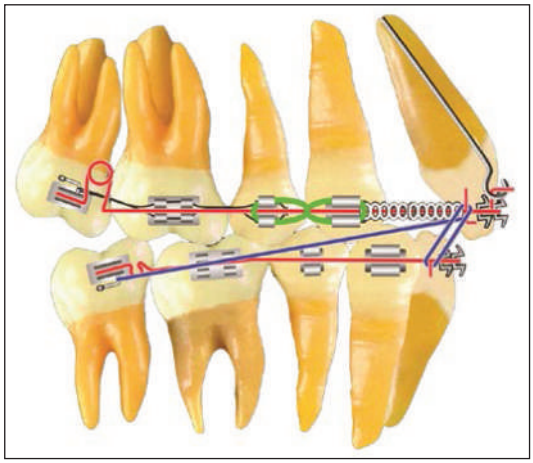

Figure 21: Class II force system. Denture correction: Maxillary second premolar and maxillary canine distalization

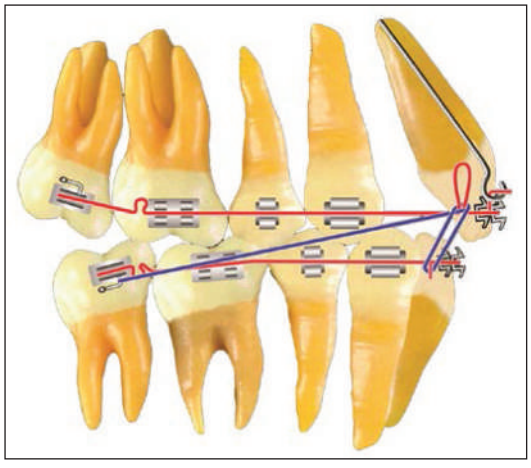

Figure 22: Class II force system. Denture correction: Maxillary anterior space closure

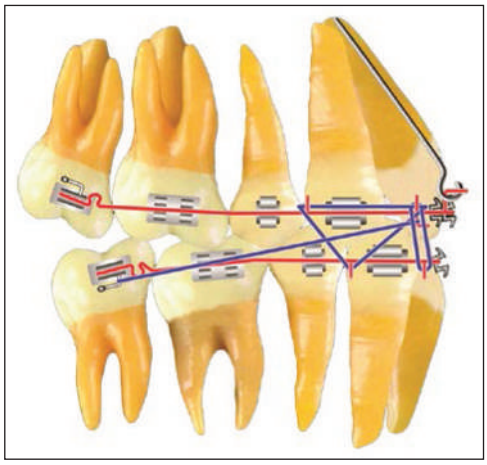

Figure 23: Denture completion. Maxillary and mandibular stabilizing wires, along with the proper elastics and headgear force, are used to complete the orthodontic treatment

Figure 24: Transitional occlusion

Figure 25: Final occlusion is characterized by the teeth settling into their most efficient, healthy, and stable positions

characterized by disclusion of the second molars. The mesiolingual cusp of the maxillary first molar is seated into the central fossa of the mandibular first molar with the mesial inclined plane of the mesial cusp of the maxillary first molar contacting the distal inclined plane of the mesial cusp of the mandibular first molar. This arrangement allows the muscles of mastication to effect the greatest force on the "primary chewing table" in the midarch area. The slightly intruded distally inclined maxillary and mandibular second molars now can "reerupt" to a healthy functional occlusion without trauma or premature contact [Figure 25].

Angle's invention, the edgewise appliance, has stood the test of time. Many orthodontists around the world use it today in the form in which it was invented by Angle and refined by Charles Tweed. Orthodontists who use one of the many modifications of the appliance should be very grateful to Angle, to Tweed and to all of those who have laid the foundation for the use of the appliance. Because without a knowledge of the appliance's foundation, one cannot successfully use any modification.

The standard edgewise appliance is as modern as tomorrow and delivers a very high-quality treatment result to each orthodontic patient. It was Angle's greatest contribution to the specialty of orthodontics. In today's world of preadjusted appliances and temporary anchorage devices, a knowledge of and appreciation for the standard edgewise appliance is critical to patient care. The clinician must understand first, third, and second order bends because no appliance is magic — no variation of the standard appliance is magic. The "magic" lies in the proper treatment plan and in one's ability to use an appliance. Therefore, knowledge of how the standard appliance is currently used is fundamental to the use of any of the innumerable modifications that have been made to Angle's invention.

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Conflicts of interest

There are no conflicts of interest.

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Lingual orthodontic education: An insight

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Abstract

Despite increasing demand for lingual orthodontics, the technique is not very popular among the orthodontists in general. Lingual orthodontics differs from the conventional labial technique in all aspects. Lack of comprehensive training in this field is a major obstacle in popularizing this science of invisible orthodontics. At present, short-term courses and part-time degree programs are the means to learn this technique and the demand for more comprehensive lingual orthodontic education is on a rise among orthodontists. Lingual orthodontics as a super specialty discipline with full-time residency program can be a step forward. This will groom orthodontists to acquire the finest skills to finish lingual cases but also help to the science to grow with dedicated research work.

Key words: Challenges, education, lingual orthodontics, super specialty course

INTRODUCTION

It is interesting to learn that Kinja Fujita introduced lingual orthodontics to his practice to prevent trauma from conventional labial attachments and accessories while performing martial art activities in Japan. He developed the Fujita Brackets with occlusal, horizontal, and vertical slots and practiced multibracket lingual technique using mushroom-shaped archwire.[1-3] During the same era, Kurz worked on lingual orthodontics and developed Kurz lingual brackets. The Kurz lingual brackets, later on, evolved into seventh generation lingual brackets (Ormco) in 1990 and became popular worldwide.[4]

Though lingual orthodontic technique was introduced in the 1970s and witnessed expansion in 1990s, its acceptance among orthodontists is poor despite the fact that lingual orthodontics offered truly invisible treatment modality for any malocclusion. In the United States, after initial period of euphoria, there followed a period of decline in its acceptance.[5] This decline could be attributed to poor understanding of the technique, different biomechanics than labial, increased chair-side time, postural difficulties, poor laboratory facilities, and compromised clinical results. Thanks to the dedicated clinicians like Thomas Creekmore, Jim Wildman, Giuseppe Scuzzo, Didier Fillion, Pablo Echarri, and many others, the beginning of the 21st century marked the resurgence of lingual orthodontics. Now, the clinical results achieved by lingual technique can be compared to the best of conventional labial techniques. But till today, the sense of rejection for lingual orthodontics is quite common among orthodontists. The number of orthodontists practicing lingual orthodontics is limited throughout the world in general. This is evident from the fact that the number of active members of the World Society of Lingual Orthodontics and European Society of Lingual Orthodontics, the two largest lingual societies in the world, is very limited compared to a number of orthodontists worldwide [Table 1].[6,7] An introspection is needed to understand the reason behind this trend. Lingual technique differs from conventional labial orthodontics

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Table 1: Online search results on articles published on lingual orthodontics

Name of the search/journal	Number of search displayed online	Number of best match found by manual evaluation	Name of the website	Date of access
Angle Orthodontist	1228	18	www.angle.org	2016 May 31
European Journal of Orthodontics	753	20	ejo.oxfordjournals.org	2016 May 31
Journal of Clinical Orthodontics	163	54	www.jco-online.com	2016 May 31
American Journal of Orthodontics and Dentofacial Orthopedics	34	27	www.ajodo.org	2016 May 31
The Korean Journal of Orthodontics	95	4	e-kjo.org	2016 Jun 03
APOS Trends in Orthodontics	140	9	www.apospublications.com	2016 Jun 04

in all aspects including patient counseling. Unpredictable lingual surface requiring customization of the brackets and lingual biomechanics (especially loss of torque in the anterior teeth during retraction)[8] are the main subjects of concern in finishing of a case. Increased chair-side time and operator's postural problems are other issues for poor acceptance of lingual orthodontics by orthodontists. The lingual appliance causes more discomfort and speech distortion to the patient than labial appliances.[9-11] Though it is more difficult to maintain oral hygiene with lingual appliances in place[11] but the incidence of white spot lesions is reported to be decreased by WIN lingual appliance compared to conventional multibracket system.[12]

Orthodontists, even today, rely on eloquence-based experts or a colleague's advice, when faced with a clinical uncertainty, rather than follow an evidence-based practice to change their practice philosophy. This can be addressed by initiating programs and continuing education that will help with skill sets to have an in-depth understanding of the knowledge base available to us.[13] Unfortunately, poor availability of evidence-based studies on lingual orthodontics is a matter of great concern. The number of clinical and research work relating to lingual orthodontics is less represented in literature. An online search in leading orthodontic journals could fetch very limited number of articles relating to lingual orthodontics [Table 2]. This trend is very unfortunate for the science because without independent research studies, there is every possibility that this science of invisible orthodontics would eventually be controlled and duly promoted to their advantage by companies who have a commercial interest in the field.

Is there a scope to improve the scenario? The issues like increased chair-side time and postural problems can improve only by vigorous clinical training because every individual goes through a learning curve to improve his skill. For example, the operator can do ligation of maxillary anterior teeth without bending his back or neck by an indirect vision from clinical photography mirror. However, ligating the arch wire through indirect vision needs practice. Similarly, the problems of bond failure or finishing and detailing can be taken care with a proper understanding of the subject and clinical practice. Experience will improve the accuracy of laboratory work and hence the end result.

Unfortunately, the exposure to lingual orthodontics is very limited in the regular postgraduate orthodontic curriculum worldwide. At present, the only way to learn lingual technique now is through short-term courses, part-time multi-module workshops, etc., Although these workshops help in orienting the orthodontist to lingual technique but they fail to offer comprehensive clinical training. Thus, the actual clinical learning curve begins with the orthodontist starting up lingual cases in his own setup. Mid-treatment complications, finishing, and detailing are reasons of worry as he has to find the solutions on his own. It is in this stage that many quit their journey citing poor treatment outcome. However, one should realize that it is unfair to judge the technique without expertizing the skill to perform. After all, we never had an opportunity to learn lingual technique as comprehensively as labial conventional orthodontics.

In contrary, the medical education system in different universities around the globe offers full-time super-specialization courses such as Doctor of Medicine, and Master of Chirugie (M.Ch.), after specialization in basic medical branches such as medicine, surgery, orthopedics, and ophthalmology. For example, in India, All India Institute of Medical Sciences offers three years super-specialization M.Ch. residency course in urology to the applicants who have completed their postgraduate specialization in general surgery (MS). The preamble of this course is quoted bellow.[14]

"The objective of M.Ch. (Urology) degree course is to produce highly competent medical manpower in urology. The training ingredients should provide in-depth knowledge of the entire urology and relevant basic allied subjects. The course is expected to bring about a change in attitude toward better scientific approach with logic and analysis. More stress should be given to the development of psychomotor skills. This should culminate in shaping of a shrewd clinician, confident surgeon, and a knowledgeable

teacher insured to basic research methodology. The basis of an ideal training program will be a powerful urology service complete in every sense…"

Thus, the main objective of super-specialization courses is to produce a highly competent medical manpower in a specialized area who is groomed to be a shrewd clinician and knowledgeable teacher. Both clinical and nonclinical research work carried out by the candidate during their course curriculum help immensely to expand the science.

Introducing a similar model of education (full-time super-specialty residency program) on lingual orthodontics will be a step forward. We have to understand the current scenario and challenges for the same. Few suggestions for true implementation will also be discussed in the following sections.

CURRENT SCENARIO

The regular orthodontic postgraduate curriculum offers very little clinical training in lingual technique. Most of the orthodontists worldwide depend on various lingual education programs as listed in Table 3. The company sponsored certificate training programs are usually for 1 or 2 days duration wherein the specific laboratory technique and bracket customization system are highlighted with supporting case reports (e.g., Incognito™, Harmony, etc.). Though it delivers orientation toward a specific system but offers limited hands-on and no clinical training. These courses are useful for orthodontists who are already practicing lingual technique and now interested for the specific laboratory system for various reasons, but it offers very little to the beginners in contrary to the general belief.

Table 2: Number of active members in World Society of Lingual Orthodontics and European Society of Lingual Orthodontics

Name of the society	Number of active members
World Society of Lingual Orthodontics	130*
European Society of Lingual Orthodontics	231*

*Number also includes the members common to both the societies

Table 3: Currently running lingual orthodontic training programs

Type	Duration
Certification courses (company promoted)	1-2 days
Short-term orientation programs with hands-on training	3-7 days
Mini-residency programs (part-time)	1 year
Master's degree programs (part-time)	2 years

Hands on training programs of 3–7 days have the advantage of a better understanding of laboratory procedures if it is demonstrated live. Workshops of longer duration, i.e. 7 days offer hands-on training for customization of brackets, transfer tray making, and clinical observation also. These workshops are helpful to the beginners to start simple nonextraction cases. But here, the drawback is a lack of comprehensive clinical training.

Another model of lingual education is part time residency extending over 1–2 years. The total course duration of the training program is covered in multiple modules designed months apart. For example, Hannover University, Germany offers M.Sc. course in lingual orthodontics, where study curriculum includes one introduction module, eight main modules, as well as writing master thesis with plea and oral exams.[15] Similarly, Basel University, Switzerland runs a part-time master in the lingual orthodontic course of 2 years duration and eight modules.[16] Thus, the students are privileged to have chair-side clinical observations or perform clinical procedures on the on-going lingual cases till their completion. Though presently this is the best model of lingual orthodontics education available, but it cannot be compared to full-time comprehensive residency programs.

CHALLENGES

As discussed earlier, lingual orthodontics is a completely different concept from the conventional labial technique. It needs dedicated clinical training and protocol. Unfortunately, in the present scenario, no institute or university offers full-time residency program. There is a shortage of faculties which can be a part of this education system. Limited available literature and study materials are also a concern. Furthermore, in recent years, the courses, education, and research are being increasingly sponsored and promoted by private companies with commercial interest. Thus, independent research and proper documentation are the need of the hour for this truly invisible orthodontic technique to flourish.

Despite these challenges, present decade has witnessed a rise in the popularity of lingual technique. Thanks to the determined clinicians and world leaders in this field for sharing their knowledge and work. If we think futuristic, there is a need to evolve lingual orthodontics into a super specialty branch for the orthodontists. Introducing a proper educational system is the need of the hour now. We have to move on in a very systematic realistic manner for the same.

A SUPER SPECIALTY PROGRAM

Orthodontics is credited as the oldest specialty of dentistry, thanks to the visionary Dr. Edward H. Angle. Soon after obtaining his dental degree in 1878, Angle became interested in "regulating" teeth. By 1886, he had achieved enough of a reputation to be appointed as the chairperson of the Orthodontic Department at the University of Minnesota (1886–1992). His address at the Ninth International Medical Congress in Washington, DC (1887), calling for the separation of orthodontics from dentistry, caused a reaction that marked the beginning of a life of controversy.[17] He declared that "not until orthodontia is studied as a distinct branch in dentistry will it ever obtain success. There should be specialists in orthodontia and general practitioner should send to practitioner freely."[18] In the year 1900, he started the first school of orthodontia – The Angle school of orthodontia.

From then to now orthodontics has evolved into one of the most demanding postgraduate specialties in dentistry. Moreover, we are discussing history here to learn the course of evolution of our specialty-orthodontics and dentofacial orthopedics. We must realize that all the challenges that we discussed about lingual technique were also present during that era for conventional labial orthodontics. Hence, we need an optimistic approach for elevating lingual orthodontics to a super-specialty branch.

Full-time dedicated super-specialty residency program in lingual orthodontics will have the aim and objective to train orthodontists to acquire knowledge, skills, aptitude, and attitudes to be able to function as an independent clinician/consultant in lingual orthodontics and a teacher acquainted with research methodology. It may be suggested that M.Ch. in lingual orthodontics would be an appropriate degree to be awarded as the eligibility criteria for applicants would be after completion of Master in Dental Surgery in orthodontics. It will be practical and feasible to introduce this super specialty branch in the institutes and universities that have already running orthodontics postgraduation programs. In the beginning, 2 years duration of the course may look more feasible as we need teachers and guides for subsequent batches. Initially, visiting faculties would help to start the courses in universities/institutes where there is a shortage of teaching faculties, and online teaching (seminars and webinars) could be utilized. Once adequately trained manpower is available, full-time faculties can be recruited.

There is a country-to-country variation in the duration of educational systems for dentists and orthodontic specialists.[19] Thus, it is important to discuss the duration of this program. The ideal duration of the lingual super specialty program should be at least 3 years. The first 6 months of the curriculum must include preclinical works such as customization of lingual brackets, transfer tray making, arch wire template making, and full complement of lingual treatment sequences performed in the metal typodont. During this period, the student should orient himself to lingual orthodontics by differentiating all aspects in comparison to labial conventional orthodontics. From the 3rd month onward, clinical cases should be taken up for compiling the records and case discussion (diagnosis and treatment planning) so that immediately after 6 months he or she can start up the cases. Thus, the candidate has two and half years of comprehensive clinical training including finishing and detailing on lingual orthodontics. Minimum of thirty extraction cases should be addressed and completed by the candidate to complete the course. These 3 years of dedicated training in lingual orthodontics will complete the learning curve of an orthodontist. Eventually, at the end of this course, the chair-side time will reduce, proper posture with ligation by indirect vision would be attained, diagnostic and clinical skills will be sharpened, and laboratory dependency will be revert.

Apart from clinical training, compulsory original research work (both clinical and nonclinical) and preparation of the manuscript for publication must be included as a part of the curriculum. The topic of the thesis should be finalized within the first 6 months so that the candidate has sufficient time to work on it. Independent research work will not only help in learning research methodology but also strengthen the evidence-based database on lingual orthodontics. This will help in further refinement and evolution of the technique.

Syllabus for this program may include basic sciences such as head and neck anatomy, bone and muscle physiology, cellular biology, and genetics and the clinical portion of these programs include courses such as growth and development, biomechanics, biology of tooth movement, biostatistics, functional oral and dental anatomy, dentofacial orthopedics, multidisciplinary care, functional appliances, developmental biology, connective tissue biology, biomaterials, craniofacial anomalies, cephalometrics, TMJ and occlusion, functional considerations, and surgical orthodontics with special relevance to lingual orthodontics. Integrating of practice management in the curriculum will enable the clinician to excel in this field along with professional skills.[20] Table 4 enlists the presently available books on lingual orthodontics. Seminars, case discussions, and journal presentations will help in establishing this branch. A candidate has to undergo theory; practical and viva voce exams with case presentations to be declared successfully completing the course. The course design is summarized in Table 5.

Table 4: Lingual orthodontics books

Name of the book	Name of the author	Name of the publisher	Year of publication
Contemporary Lingual Orthodontics	Kurz C	Specialty Appliances	1997
Lingual Orthodontics	Romano R	Canada: B.C. Decker Inc., 1998	1998
Invisible Orthodontics, Current Concepts and Solutions in Lingual Orthodontics	Takemoto K, Scuzzo G	Berlin: Quintessenz Verlag Publication	2003
Lingual Orthodontic Treatment, Mushroom Archwire Technique, and the Lingual Bracket	Hong RK, Kyung HM	Seoul: Dentos	2009
Lingual Orthodontics, A New Approach Using Light Lingual System and Lingual Straight Wire	Scuzzo G, Takemoto K	London: Quintessence Publication	2010
Lingual and Esthetic Orthodontics	Romano R	United Kingdom: Quintessence Publishing	2011
Lingual Orthodontics, TAM with FLB and straight CLB	Choi YB	Seoul: Myung Mun Publishing	2014
Achieving Clinical success in Lingual Orthodontics	Hartin J, Augusto U	Switzerland: Springer International Publishing	2015
Atlas of Bracketless Fixed Lingual Orthodontics, Basic Concept	Mariniello A, Cuzzaolino F	Italy: Quintessence Publication	2015
Beyond Lingual Orthodontics	Lapenta, Roberto	Quintessence Publishing	2016

Table 5: Summarization of the design of the proposed super-specialization course in lingual orthodontics

Aim and objective	Degree	Eligibility	Course type	Course duration	Curriculum
To produce independent clinicians/ consultants and teachers with in-depth knowledge, skills, aptitude, and attitude in the field of lingual orthodontics	M.Ch. in lingual orthodontics	After completion of postgraduate course in orthodontics	Full-time residency program	3 years	Preclinical (6 months) Clinical (2½ years - minimum of 30 completed extraction cases) Thesis with manuscript for publication Seminars Theory (basic sciences, clinical science with relevance to lingual orthodontics and practice management) Case discussions (diagnosis and treatment planning before starting case and progress of the case every 6 months) Examination at the end of each session (theory, practical and viva including case presentation)

FINAL REMARKS

It is true that increased chair-side time, difficulty in working posture, and poor treatment outcome are the issues for rejection of lingual orthodontic technique by many orthodontists. But as with any specialty, learning curve takes its own time to master the technique and it is the most important phase for the orthodontist to either accept or reject lingual orthodontics. There are many short duration courses running worldwide to train orthodontists to take up lingual practice. These courses help in orientation and start-ups, but the real learning curve begins with the ongoing clinical cases, mid-treatment complications and their solutions. Lingual orthodontics is not about change in bracket system or mechanics. It is a completely different concept in all aspects. It differs from the labial technique in relation to patient counseling, treatment planning, anchorage considerations, applied dental anatomy, bracket system (positioning, bonding, rebonding, and debonding procedures), biomechanics, ergonomics, treatment duration, etc., Thus, it is not feasible in short duration courses or module-based part-time programs to acquire comprehensive training in lingual orthodontic education. Full-time residency program as discussed above is the future for this field. It will produce competent clinicians, teachers, and help in compiling the research database for the growth of this branch.

This goal can be achieved by a collective effort by the orthodontists, different orthodontic associations, universities, government regulatory bodies, and the lawmakers. Collective effort, systematic, and practical approach would help the cause in nurturing the first super specialty branch in dentistry:Lingual Orthodontics!

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There are no conflicts of interest.

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Critical Review

Rapid maxillary expansion in contemporary orthodontic literature

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Abstract

We have reviewed our retrospective research about rapid maxillary expansion performed in the early mixed dentition to summarize the results of different studies regarding maxillary dental arch width variation and crowding improvement in light of contemporary literature. The aim is to define the effects of treatments followed until the end of dental arch growth. In all studies, a Haas expander anchored to the deciduous dentition was used. The samples consisted of treated patients with and without a lateral crossbite and homogeneous untreated individuals as controls. Two additional control groups of adolescents and adults in dental Class 1 were also compared. As a result of the analysis, rapid maxillary expansion with anchorage to the deciduous dentition was found to be effective in increasing transverse width in intermolar and intercanine areas, and the change was preserved until the full permanent dentition stage. When performed before maxillary lateral incisors have fully erupted, this procedure allows for a rapid increase in the arch length in the anterior area and consequently, in the space available for permanent incisors with a stable reduction in crowding over time.

Key words: Anchorage, anterior crowding, arch dimension, cross-bite, rapid maxillary expansion

INTRODUCTION

The rapid maxillary expansion is a procedure used for midpalatal suture opening by means of fixed orthodontic appliances, during growth. The aim is to increase the transverse width of the maxillary arch as the result of dental and skeletal expansion.

The bibliography on this topic is extensive, with the first report by Angell.[1] Over the years, many papers have been published, especially after 1961, when Haas[2] described his expander design and appliance effects.

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Clinical indications for rapid maxillary expansion are a lateral crossbite or a constricted maxillary arch. In addition, the increase in arch length allows for reducing the lack of space for crowded teeth.

Over the years, we have retrospectively analyzed the effects of a Haas expander anchored to the deciduous dentition to improve a lateral crossbite and anterior crowding.[3-7] Some evidence has already been reported about the effectiveness of this anchorage design in the correction of transverse discrepancy.[8]

The uniqueness of this procedure lies in the appliance anchorage. The traditional rapid maxillary expander (Hyrax or Haas) anchors to first permanent molars and bicuspids. The replacement of permanent with deciduous

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dentition as anchorage aims to reduce the risk of negative side-effects on permanent teeth produced by the expansion force[9-14] and/or by plaque accumulation around bands.[15]

In this paper, we review our research about rapid maxillary expansion performed in the early mixed dentition to describe and summarize the effect of early treatment with a Haas expander anchored to deciduous dentition on maxillary dental arch dimensions and anterior crowding and to evaluate its long-term stability until adolescence.

SUTURE STRAIN TIMING AND RESPONSE TO RAPID MAXILLARY EXPANSION

Midpalatal sutures can be orthodontically opened during the period of skeletal growth, before the contact among the maxilla, the palatine bone, and the pterygoid process has become close. More specifically, Melsen and Melsen[16] described changes in the tightness of surface junctions in four stages infantile, juvenile, adolescent, and adult. The older the individual, the more interdigitated the suture and the more difficult its reopening. In particular, fractures were always present on disarticulated bones from dry skulls of adolescents, and suture separation was impossible in adulthood.

For disarticulation of the midpalatal suture with a rapid maxillary expander, a force of 4–9 kg is utilized. The screw is activated daily, and the force is transmitted from the screw across the anchoring anatomical structures (teeth and in the case of the Haas design, the palatal vault) to palatal bones and the cranial base. The suture opens when the load produced by the screw exceeds the resistance of the facial skeleton.[9] However, the decrease in load does not follow a linear trend. From 30% to 50% of the load dissipates within the first 15 min and the last 50–70% over a 24-h period. After this interval, the persistence of a residual load is classified as an increase in skeletal resistance.

Maxillary suture opening is not parallel in the anterior and occlusal views.[17] In the anterior plane, it is triangular, with the vertex at the level of the frontomaxillary suture and the base in the alveolar bone. On each side, the zygomatic arch provides resistance and prevents parallel displacement of the two maxillary halves.

In the palatal view, the opening is also triangular with a greater gain in width in the anterior than in the molar area at a ratio of 3:2.[8] Resistance in the posterior area is produced by the pterygoid process,[17] which is already heavily interdigitated with the maxilla[16] in late childhood. For rigidity, especially, in the area close to the cranial base, the pterygoid plates bend only laterally during expansion.[18]

Holberg and Rudzki-Janson[19] studied stresses occurring in cranial bones (sphenoid, frontal, occipital, and temporal bones), particularly near the foramina, when the pterygoid process bends. The greater the bending, the stronger the stress on the cranial base and the higher the risk of bone fractures. Consequently, microfractures can injure the vulnerable structures passing through cranial foramina (round foramen, maxillary nerve, oval foramen, mandibular nerve; superior orbital fissure, accessory meningeal artery, superior ophthalmic vein, inferior ophthalmic vein, oculomotor nerve, trochlear nerve, three branches of the ophthalmic nerve, and abducent nerve). However, bone elasticity protects against stress and fractures and decreases with patients' skeletal age. At the juvenile cranial base, with a lateral bend of 2.5 mm in the pterygoid process, the stress was between 61.3 and 186.3 MPa. In contrast, it amounted to 210.2–426.8 MPa at the adult cranial base. Therefore, rapid maxillary expansion not surgically assisted is a high-risk procedure in adult individuals.

Conversely, there is a lower age limit for beginning the treatment. Following the results published by Thilander *et al.*,[20] the right timing for rapid maxillary expansion corresponds to early mixed dentition after first permanent molars have fully erupted. An early expansion for cross-bite, during the deciduous dentition stage, is contraindicated because a lateral crossbite in the deciduous dentition cannot necessarily be associated with a crossbite in the mixed dentition. Therefore, at this stage of development, rapid maxillary expansion has been classified as over-treatment. The only treatment proposed is an occlusal modification by tooth grinding or by bite-blocks on the deciduous dentition.

During this period, between the early mixed and full permanent dentitions, the pubertal peak in skeletal maturation was analyzed as a cut-off, which could influence the response to expansion. Relative to the long-term, Baccetti *et al.*[21] reported a greater orthopedic effect (increased maxillary skeletal width, lateronasal width, and latero-orbitale width) in patients with expansion before the peak than in those treated subsequent to the peak.

We focused our analysis on changes in the dental arch after maxillary expansion.[5] A treatment performed in the early mixed dentition was identified as one of the favorable conditions for dental arch width stability, especially in intercanine and intermolar areas, in patients treated for a lateral crossbite. In other words, male children with a lateral cross-bite that expanded in the first transitional period,[22]

that is, before maxillary lateral incisors had fully erupted, showed no relapse in dental arch dimension and form 2 years and 4 months after the end of treatment and the cessation of retention. On the contrary, a later expansion together with female gender and the absence of a lateral crossbite were classified as negative exposures for dental arch form stability over time.

In addition, another important aspect of the treatment procedure is retention time. After disarticulation, it is necessary to wait for suture ossification before removing the expander. As previously reported, the opening is triangular, with a greater gain in width in the anterior area than in the molar area.[8] Therefore, the time needed for ossification can vary from the anterior to the posterior area. Vardimon *et al.*[10] estimated 5 months for the molar area and 10 months for the anterior area. On the other hand, in a previous paper, Ekström *et al.*[23] indicated 3 months as retention time after expansion. However, they analyzed patient responses only by means of radioisotopes. More recently, Lione *et al.*[24] defined 6 months as the global time needed for bone deposition in all parts of the suture.

EXPANSION APPLIANCE DESIGN AND ANCHORAGE

In 2013, Zuccati *et al.*[25] reviewed randomized clinical trials focusing on the effectiveness of different types of expander designs. In general, at 6-month follow-up, the expansion effect was similar in patients treated by means of rapid maxillary expanders with different anchorage designs (tooth-borne anchorage, tooth tissue-borne anchorage, skeletal anchorage, acrylic bonded anchorage, two- vs. four-band anchorage) and the quad helix. The only condition for equivalence in results was an equal expansion force generated by the screws. However, a meta-analysis was not performed because data reported in the reviewed papers were heterogeneous with a high risk of bias. Therefore, the authors did not reach a definitive conclusion.

Many of the papers published about maxillary expansion were aimed at identification of a better expander that allowed for opening the midpalatal suture without the side-effect of dentoalveolar proclination.

For example, Oliveira *et al.*[26] compared the Hyrax with the Haas expander. They concluded that the combined tissue-borne anchorage provided by the Haas expander increased the orthopedic effect. On the contrary, the expansion produced by the Hyrax appliance, with an exclusively tooth-borne anchorage, resulted from a combination of alveolar bone and molar tipping and not from a predominant effect on the midpalatal suture.

Lagravère *et al.*[27] evaluated the effectiveness of skeletal anchorage by two screws inserted into the bicuspid-molar area, replacing the traditional dental anchorage provided by the Hyrax design. No significant difference was observed 6 months after the end of treatment. However, the most relevant negative result was the presence of dentoalveolar proclination in the patients treated with the expander anchored exclusively by means of screws. The degree of molar tipping was equal in both groups. However, when Mosleh *et al.*[28] modified the anchorage design by adding dental anchorage to first molars with skeletal anchorage by screws in the bicuspid region (bone-borne maxillary Hyrax expander), the dental and alveolar proclination was reduced and reached the highest level in patients treated only with the traditional Hyrax (tooth-borne maxillary Hyrax expander). Therefore, the clinical option of skeletal anchorage is not based on sound scientific evidence and as reported by Lagravère *et al.* in his editorial in the American Journal of Orthodontics and Dentofacial Orthopedics,[27] is the second choice after traditional appliance design only when available dental anchorage is not adequate.

With regard to dental anchorage, some authors have confirmed the effectiveness of expanders bonded to deciduous molars instead of permanent molars.[3-8,24,29] In particular, the stability of expansion was checked during a follow-up longer than that of treatments with the expander skeletally anchored.

A comparison between expanders anchored to deciduous versus permanent dentition was performed by Ugolini *et al.*[30] in a randomized clinical trial. The three-dimensional (3D) analysis of dental casts showed a significant increase in transverse widths in both groups. However, it must be noted that the highest net amount of expansion was reached in the group with the expander anchored to deciduous dentition, especially in intercanine area. Moreover, molar tipping was more pronounced in the group with anchorage to first permanent molars.

In addition, the clinical choice of this alternative deciduous anchorage can be supported by the evidence for reduced risk of side-effects in the permanent dentition and periodontal tissues as a consequence of the high forces exerted by the expander screw[9] and/or by plaque accumulation:

1. Root resorption;[10-12]
2. Bone loss;[13,14] and
3. White-spot lesions.[15]

With regard to the side-effects on alveolar bone, however, there is no clear evidence, because data published in the literature are not always consistent. In fact, Lione *et al.*[31] published a literature review in which they concluded that

the thesis of bone loss as a side-effect after rapid maxillary expansion cannot be accepted.

In conclusion, anchorage to deciduous dentition is motivated by the effectiveness of dental arch widening, and its stability is preserved in the middle and long-term.[3-8] Second, it can reduce the negative side-effects produced by expansion on permanent dentition because the anchoring deciduous teeth will be lost.

Conversely, analysis of the recently reported data about equivalence in the effectiveness of anchorage to deciduous dentition and gold standard anchorage to permanent molars[30] could induce clinicians to prefer the new option for reduced risks.

DENTAL EFFECT OF A RAPID MAXILLARY EXPANDER ANCHORED TO DECIDUOUS TEETH

Intermolar width

The primary aim of rapid maxillary expansion is the increase of intermolar width to correct a lateral crossbite. A secondary aim is the widening of a constricted maxillary arch.[8,32]

We have estimated the changes in intermolar width measured at first permanent molars in a group of patients after expansion performed with a Haas expander anchored exclusively to deciduous teeth.[5] The amounts of variation differed between patients with and those without a lateral crossbite. Two years and 4 months after the end of treatment, and the cessation of retention, the patients with a previous lateral crossbite kept 3.9 mm of 4.9 mm initial expansion. On the contrary, in the group of patients without a lateral crossbite, the initial expansion of 2.6 mm was reduced to 1.5 mm in the same time interval.

When we compared our results with those of a 3D analysis performed by Ugolini *et al.*[30] in patients treated for a lateral crossbite with an expander anchored to deciduous teeth, we found that the intermolar width showed a similar change, with an increase of 4.4 mm maintained in the short-term.

However, the most relevant question relates to the stability of expansion until the stage of permanent dentition is achieved in comparison with the change produced by growth in the absence of treatment for a lateral crossbite. Moreover, in the final analysis of estimated intermolar width of treated patients, the increase produced by growth must be differentiated from treatment effects. From a theoretical point of view, we can hypothesize, at the end of growth, an increment of intermolar width resulting from the sum of treatment expansion and growth.

As reported by Sillman,[33] the increase in intermolar width during mixed dentition is not as pronounced, because it occurs mainly in the deciduous dentition.

Hesby *et al.*[34] reported an increase of 2.8 mm in children between the ages of 7.6 and 12.9 years. They used as reference points the most gingival point on the contour of the distal margin ridge of the maxillary permanent first molars. As the same authors reported in a previous paper,[35] maxillary molars erupt with a buccal torque and then move lingually with age. The opposite movement occurs in the mandibular arch. Over this period of time, maxillary and mandibular intermolar widths increase. In particular, in the maxillary arch, the movement of the molar apex is greater than that of the crown, which explains why intermolar distance widens.

To check the effect of expansion preserved in the stage of permanent dentition, we followed, retrospectively for 4.1 years, a group patients treated exclusively with a Haas expander in early mixed dentition[7] for a lateral crossbite [Figure 1]. The relapse was nonsignificant (0.5 mm), and the net increase amounted to 4.6 mm. A similar result was obtained by Lima *et al.*[36] in patients treated at the age of 8 years and 2 months with a traditional expander anchored to permanent molars. A final increase of 4.5 mm was measured 4 years after the end of treatment.

In the same study, we compared the patients treated early for cross-bite at the follow-up in permanent dentition with two groups of untreated adolescents and adults in dental Class 1 and without a lateral crossbite and one group of adolescents with a lateral crossbite and a dental class homogenous with that of the treated patients before treatment. The aim was to establish whether the treatment had modified the dental arch dimension toward the value of untreated "ideal" patients and in cases of absence of treatment if the intermolar width remained constricted.

Results confirmed treatment effectiveness: The patients with expansion reached intermolar width equal to that of untreated adolescents and adults with normal occlusion. Moreover, it must be noted that relapse after treatment was so minimal that treated patients just at the end of treatment in mixed dentition presented an intermolar width not different from that of older control individuals in normal occlusion measured at the end of growth. Therefore, we can hypothesize that growth in intermolar width was not relevant after the end of treatment. On the contrary, the untreated individuals with a lateral

Figure 1: Case report. Female patient treated for a lateral cross-bite at age 8 years and 2 months with a rapid maxillary expander anchored exclusively to deciduous dentition and followed until the permanent dentition stage. (a) Pretreatment (age, 8 years and 2 months). (b) End of expansion after 25 days' screw activation (0.2 mm/day). (c) Appliance removal, after 13 months. (d) Follow-up at 4 years and 3 months after debonding and the cessation of retention

crossbite maintained a reduced intermolar diameter, narrower than that of treated patients and individuals in normal occlusion. Conversely, the control individuals without a lateral crossbite and with the same dental class as treated patients before treatment showed intermolar width slightly more narrow than that of treated patients and untreated persons in dental Class 1.

To evaluate the intermediate change at the late mixed dentition stage, we performed the same study design,[6] comparing a similar group of treated patients in early mixed dentition at the follow-up in late mixed dentition with two groups of untreated individuals with and without a lateral crossbite and a canine dental class homogeneous with that of treated patients before treatment and a group of adolescents in dental Class 1 without a lateral crossbite. We reached the same conclusions as reported in the previous paper.

Therefore, the persistence of a lateral crossbite was obstacle in the physiological development of intermolar width, and the patients treated early achieved a diameter equal to that of individuals with normal dental occlusion. The increase produced showed no relapse until the end of dental arch growth.

In conclusion, rapid maxillary expansion with anchorage to deciduous dentition is effective for the correction of a lateral crossbite and to achieve physiological intermolar width.

Intercanine width and anterior crowding

Early rapid maxillary expansion also modifies intercanine width in patients with a lateral crossbite. Patients treated in the first period of transition, that is before lateral incisors had fully erupted, showed, at the follow-up in permanent dentition, a diameter equal in dimension to those of adolescents and adults in dental Class 1 without a lateral crossbite.[7] In contrast, control groups of individuals with a lateral crossbite preserved a significant reduction in intercanine width both in late mixed[6] and in permanent dentition.[7]

Therefore, rapid maxillary expansion corrects an intercanine transverse deficiency in patients with a lateral crossbite and re-establishes a normal growth trend with responses similar to those recorded in the intermolar area.

However, when we evaluated the net increase in intercanine width, it was influenced not by the presence of a lateral crossbite but by treatment timing. In a short time, at the 2- and 4-month follow-ups, we measured a significant increase in intercanine width in patients with (mean, 3.3 mm) and without (2.7 mm) a lateral crossbite.[5]

Favorable exposure was identified in the young dental age. The patients treated with expanders before lateral incisors had fully erupted (first period of transition)[22] showed increased intercanine width of 3.5 mm compared with 1.6 mm in patients treated after the eruption of lateral incisors (inter-transitional period). It must be

noted, however, that the intercanine width reached the same length in both groups and showed the same degree of relapse. In fact, the difference in net increase resulted from the narrower diameter in the youngest patients before treatment relative to that of older patients: 28.6 mm of intercanine width in the first group versus 31.3 mm in the second.

The initial difference can be explained as the result of growth occurring during the eruption of maxillary incisors. As reported by Moorrees *et al.*,[37] the intercanine widths grow mainly during the eruption of incisors and to a lesser degree during the eruption of cuspids. They estimated an increase of 3.8 mm in the period between the ages of 7 and 12 years. Sillman[33] described growth in the intercanine diameter up to 13 years of age. However, he identified a spurt during deciduous dentition (0–4 years).

Consequently, the increased intercanine width measured in the youngest patients was no greater than that normally recorded during dental arch growth. It was the same increment as that obtained in a shorter period than usual by means of the rapid opening of the suture produced with the treatment.

Moreover, following the results published by Ugolini *et al.*,[30] the anchorage to deciduous dentition produced a more stable expansion, specifically in the anterior area, relative to that produced by the traditional anchorage design on permanent molars.

The rapid increase in intercanine width is favorable because, in only 1 month of screw activation, the diameter widened, and new space was made available for crowded teeth.

In fact, in our analysis[6] of the anterior irregularity index,[38] the patients receiving expansion treatment in the early mixed dentition (first transitional period) showed, in follow-up at 9 years of age, an irregularity index (median, 2.4 mm) lower than that of untreated individuals with (median, 3.2 mm) and without (median, 4.0) a lateral crossbite.

The same comparison performed at the follow-up in the permanent dentition[7] showed that the advantage of early expansion was still present: 56% of untreated adolescents with a lateral crossbite had an anterior irregularity index higher than 5 mm versus 11% of patients treated early for a lateral crossbite. In addition, the individuals without a lateral crossbite, homologous for canine dental Class with treated patients before expansion, had a prevalence of 33% of an irregularity index higher than 5 mm. Those patients fell between the two groups of treated and untreated individuals for lateral crossbite, and the difference did not reach the level of significance in each of two-by-two comparisons.

The improvement in anterior crowding should be evaluated as a positive effect, even when it is not a complete resolution. In fact, as reported by Surbeck *et al.*,[39] severe crowding is a negative risk factor for relapse after orthodontic treatment.

The reduction in the irregularity index can be explained as the effect of the rapid increase in intercanine arch length produced by the expansion (mean value, 6.8 mm), a consequent eruption of better-aligned incisors, and an insertion of transseptal fibers in less-rotated teeth.[40] This conclusion confirms the results of Canuto *et al.*[41] about the ineffectiveness of rapid maxillary expansion performed in permanent dentition for improving stability in anterior alignment after fixed orthodontic treatment.

In addition, in the specific clinical condition of permanent incisor cross-bite, a spontaneous correction was recorded in 84% of cases after early rapid maxillary expansion with anchorage to deciduous dentition.[29]

Furthermore, the transverse increase in molar area cannot be included in estimations of dental arch length increase.

Hnat *et al.*[42] had forecast the arch length change for different increments in width, using a model based on combined beta and hyperbolic cosine functions. Assuming a triangular suture opening and, therefore, a ratio of expansion between canine and molar area of 1.25:1 and 1.5:1, increased arch length occurs in the anterior area only. In the posterior area distal from cuspids, the curve becomes flatter and shorter than before expansion. If we assume an equal expansion in anterior and posterior areas, the increase in arch length is 95% in the anterior area and only 5% in the posterior area.

In the model Germane *et al.*[43] applied to the mandibular arch, molar expansion higher than 5 mm is needed to solve 2 mm crowding. In contrast, an increase of 2 mm in arch length can be produced by 2 mm of incisor or 2.5 mm of cuspid proclination.

Those mathematical details, together with the results published by Ugolini *et al.*,[30] provide further justification for the use of an expander anchored to deciduous dentition, which allows for modification of the anterior area in a greater and more stable way than that provided by the traditional expander anchored to permanent molars.

CONCLUSIONS

1. Rapid maxillary expansion aiming to correct a lateral crossbite must be performed during skeletal growth,

after the eruption of first permanent molars and before the end of adolescence
2. Rapid maxillary expansion with anchorage to deciduous dentition is effective in increasing transverse width in intermolar and intercanine areas, and the change is preserved until the full permanent dentition stage
3. An early expansion, before maxillary lateral incisors have fully erupted, allows for rapid increase in the arch length in the anterior area and consequently, in the space available, with a concomitant reduction in crowding
4. Anchorage to deciduous teeth produces a more pronounced and stable expansion in the anterior area, with a reduction in the risk of negative side-effects on the dentition, than the traditional expander anchored to permanent molars.

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Conflicts of interest
There are no conflicts of interest.

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