Showkat *et al.*
Bulletin of the National Research Centre (2024) 48:56
https://doi.org/10.1186/s42269-024-01211-4

Bulletin of the National Research Centre

RESEARCH

Open Access

CO_2 laser in benign vocal fold lesions: an observational study

Showkat Ahmad Showkat[1], Aleena Shafi Jallu[1], Mohd Shafi Bhat[1] and Bashir Ahmad Malik[2*]

Abstract

Background To evaluate the clinical and functional outcome of patients having benign vocal fold lesions who were treated with carbon dioxide laser.

Methods For this Study a total of 41 Patients who had hoarseness of voice and satisfied the inclusion criteria were included. A detailed medical history and a thorough ENT examination was performed. Voice evaluation was done using (G)rade, (R)oughness, (B)reathiness, (A)sthenia….weakness (S)train (GRBAS), voice handicap index (VHI), and maximum phonation time scores.

Results All 41 patients reported hoarseness of voice as their primary complaint, and most of them developed their symptoms gradually. The following causes seem to have contributed to the presence of hoarseness of voice: LPR in 8 patients, smoking in 25 patients, voice abuse in 14 patients, and irritation exposure in 6 patients. The most frequent lesion in 25 (60.97 percent) of the subjects was a vocal polyp. This study showed majority of patients 35 (85.4%) had posterior phonatory gap and six (14.6%) had anterior gap preoperatively. All patients had incomplete glottic closure preoperatively, whereas glottic closure was complete at first follow-up postoperatively. The mean preoperative GRBAS score in study subjects was 10.972 with an SD (standard deviation) of 2.1724 and a median of 10.000. The mean postoperative GRBAS score at six months was 0.268 with an SD of 0.4486, median 0.000, Z score −5.618, and p value < 0.001 which is statistically significant.

Conclusion Precision, hemostasis, and minimal postoperative edema are benefits of using carbon dioxide laser. This research therefore supports the idea that benign vocal fold lesions might be successfully treated with the super-pulsed microspot carbon dioxide laser, which offers good voice outcomes.

Keywords Thyroarytenoid, Stroboscopy, Rhinoscopy, Hopkins rod, GRBAS, VHI, MPT

Background

The true vocal folds have a multilayered anatomy, which is the basis of Hirano's cover-body hypothesis of phonation, first forwarded in 1974 (Hirano 1974). Squamous epithelium, three layers of lamina propria, and the vocalis muscle [thyroarytenoid] make up the vocal folds' five histological layers. During vibration, these five layers function as three mechanical layers that are progressively stiffer. Stratified squamous epithelium covers the front vibratory part of the larynx, while pseudo-stratified ciliated epithelium covers the posterior glottis. The mid-membranous vocal fold, also known as the "striking zone," has the greatest amount of contact with the true vocal folds during phonation, and it is at this location that the majority of phono-traumatic lesions are discovered (Hochman et al. 1999).

Vocal polyps, vocal nodules, vocal cysts, pseudocysts, vocal fold sulcus, contact granuloma, mucosal bridge, and/or Reinke's edema are all referred to as benign 'vocal fold lesions in general. The most of the lesions on

*Correspondence:
Bashir Ahmad Malik
drbasir.orlhns18@gmail.com
[1] Department of ENT and HNS, Govt. Medical College, Srinagar, India
[2] Department of ENT and HNS, SKIMS Medical College, Bemina, Srinagar, India

the vocal folds are benign. Although many different circumstances might contribute to the formation of these lesions, the majority of them are linked to vibratory damage to the vocal cords. The most frequent risk factors include talkative extroverts and jobs that need a lot of voice. Additionally, smoking, acid reflux, untreated allergies, and infections may exacerbate vibratory harm (Smit et al. 2013). The most prevalent sign of a benign vocal fold lesion is a change in voice quality, which may range in severity from mild to severe.

The voice may be compromised when speaking, singing, or both. Hoarseness is often accompanied by greater effort while speaking, which leads to fatigue or voice fatigue over time. A history of how the voice issue first showed itself and an assessment of speaking and speech patterns are crucial elements in the diagnosis of benign vocal fold lesions. A thorough examination of the vocal folds is necessary to diagnose a benign vocal fold lesion. A stiff or flexible laryngoscope and a stroboscopic light source are commonly used for examination. Videostroboscopy is the most common method of visualizing vocal fold vibration and is an essential tool for voice assessment. Videostroboscopy can also be used to monitor disease processes as well as asses pre- and postoperative outcomes. It uses a synchronized, flashing light passed through a flexible or rigid telescope. The flashes of light from the stroboscope are synchronized to the vocal fold vibration at a slightly slower speed, allowing the examiner to observe vocal fold vibration during sound production which appears to be slow motion. Stroboscopic **e**xamination includes glottic closure pattern**,** mucosal wave**,** description of lesion, vocal fold opening pattern, supraglottic appearance, and symmetry of arytenoids (Kendall 2009).

Regardless of the kind, benign vocal fold lesions prevent the vocal folds from closing and vibrating, which results in hoarseness. It is crucial to identify the kind of vocal fold lesion(s) since some might be treated successfully with voice therapy alone, while others would need to be surgically removed.

The goal of all therapies is to help patients regain their voice's functionality. Singing voice therapy, speaking voice therapy, phono-microsurgery (surgery on the vocal folds), medicine, and voice rest are often used as treatments. When conducted with precision phono-microsurgical methods followed by specialized postoperative voice treatment, surgery for benign vocal fold lesion(s) may be very beneficial. A multitude of disorders that affect the vocal cords, such as benign nodules, vocal cord dysplasia, laryngeal papilloma, polyps, and various laryngeal malignancies, may be removed and treated with laser vocal cord surgery, an endoscopic technique.

A device that generates light using an optical amplification procedure on the basis of the stimulated emission of electromagnetic radiation is known as a laser ("Light Amplification by Stimulated Emission Of Radiation"). Since the 1960's CO_2 lasers have developed into a significant technical advancement and a crucial tool for laryngeal surgeons. With promising results, surgeons have employed lasers to treat both benign and malignant larynx lesions. The potential heat dispersion to the deeper layers of the lamina propria has decreased with the introduction of microspot CO_2 lasers with a spot size of less than 250 μm. It has been proposed that the microspot CO_2 laser is a suitable technique for the excision of superficial benign lesions of the vocal fold and may be used as a suitable alternative to microdissection (Metson 1996). The light produced by CO_2 lasers has a wavelength of 10.6 μm, which is in the center of the infrared spectrum. Water is quite effective at absorbing this energy. Water absorbs the majority of the energy; therefore, there is little penetration into the tissues. Human tissue contains between 70 and 90 percent water, hence CO_2 lasers mainly vaporize tissue to induce death (Benninger 2000). The CO2 laser's capacity to absorb water also makes it a useful tool for treating laryngeal diseases since the laryngeal tissue is mostly composed of water with just small amounts of melanin or hemoglobin.

Subjective and objective assessments of voice are critical to the analysis of outcome of surgical intervention as well as comparison between pre- and postoperative voice in patients with dysphonia. The GRBAS scale was perhaps the first widely utilized measure, and is still in use today. This includes five components: G(rade)—overall grade of hoarseness, R(oughness), B(reathiness), A(esthenia)—weakness, and S(train). Each component is rated on an integer four point scale, in which 0 is normal, 1 slight, 2 moderate, and 3 severe. This scale has been well-received because it is brief and user-friendly, making it practical for application in a clinical setting (Nemr et al. 2012). Self–assessment measures like voice handicap index (VHI) provide us with the information on the impact of dysphonia on the quality of life (Rosen et al. 2004). A simple test of glottic efficiency is maximum phonation time (MPT). MPT is the maximum time (in seconds) for which a person can sustain a vowel sound when produced on one deep breath at a relatively comfortable pitch and loudness. For maximum phonation time (MPT), the maximum length of time a patient can vocalize after taking a deep breath is measured. In general, 10 s or less is abnormal, and 5 s or less interferes with daily living (Sawaya et al. 2022).

The study was done with the aim to evaluate the clinical and functional outcomes of patients having benign vocal fold lesions who were treated with carbon dioxide laser.

Methods

This prospective observational study was conducted in the postgraduate "Department of Otorhinolaryngology, Head and Neck Surgery, Government Medical College, Srinagar" from November 2018 to April 2020 in OPD attending patients aged 16 years and above. In this study, a total of 41 individuals who had hoarseness of voice and fullfilled the inclusion criteria were included. All patients provided their written, fully informed consent. A detailed history was obtained, and a full ENT examination was performed, including anterior rhinoscopy, oral cavity examination, and an indirect laryngoscopy. Telelaryngoscopy using 70-degree rigid endoscopy and Stroboscopic examination was done preoperatively and at 1 week, 1 month and 6 months postoperatively to study the glottic closure and mucosal wave. Voice evaluation was done using GRBAS, VHI, and MPT scores.

All 41 patients underwent trans-oral laser excision (TOLE) under general anesthesia with the smallest possible endotracheal tube. The surgeon put himself in most comfortable position using a chair with articulated arm support which provided the surgeon with arms and feet supported and shoulders in an unraised neutral position. Patient was put in sniffing position to enable the use of largest luminal laryngoscope. Proper anesthetic laser-resistant tubes were used during anesthesia and wet cottonoids were kept in subglottis, over the face and eyes to prevent thermal damage, and the whole staff was made to use proper protection. Laser settings used were as 4 to 8 W, intermittent mode (0.1 s "on" and 0.5 s "off"), and patients were examined at regular intervals up to six months (one week / one month / six months after surgery).

Statistical analysis

In a Microsoft Excel spreadsheet, data were entered. Frequency and percentage were utilized to sum up categorical variables. The mean and SD were utilized to sum up continuous variables. GRABS, MPT, and VHI-10 were summarized as median and range. Paired samples "*t*" test was utilized to test the pre- and post-CO_2 laser differences in continuous measurements. Pre- and post-CO_2 laser GRABS and VHI-10 scores were compared using the Wilcoxon signed ranks test. Statistics were reported using two-sided p values, and a p value of 0.05 or below was deemed to be statistically significant.

Results

Forty-one patients who were found to have benign vocal cord lesions were included in the study. There were 14 (34.1%) female and 27 (65.9%) male patients respectively. Most of the patients in this study were aged between 31 and 50 years with mean age being 41.78 years. Eight (19.51%) of the study subjects were housewives and seven (17.07%) were government employees by profession. All (41) of the patients presented with complaint of hoarseness of voice, and the majority of them had a slow development of symptoms. The following factors seem to have contributed to the presence of hoarseness of voice: LPR in eight patients, smoking in 25 patients, voice abuse in 14 patients, and exposure to irritants in 6 patients. The most frequent lesion seen in 25 (60.97%) of the research participants was a vocal polyp. This study showed majority of patients 35 (85.4%) had posterior phonatory gap and six (14.6%) had anterior gap preoperatively. All patients had incomplete glottic closure preoperatively, whereas glottic closure was complete at first follow-up postoperatively (Table 1).

The mean preoperative GRBAS score in study subjects was 10.972 with a SD of 2.1724 and a median of 10.000. The mean postoperative GRBAS score at six months was 0.268 with an SD of 0.4486, median 0.000, Z score -5.618, and p value < 0.001 which is statistically significant. Aerodynamics maximum phonation time (MPT) preoperatively had a mean value of 12.854, with a SD of 2.8685 and a median of 13.00. Aerodynamics MPT at third postoperative follow-up had a mean value of 21.683, SD of 3.1340, median value of 22.000, Z score -5.589,

Table 1 Distribution of participants as per age, profession, and lesion

		Frequency	Percentage
Age	< 20 Years	3	7.3
	21–30 Years	5	12.2
	31–40 Years	13	31.7
	41–50 Years	11	26.8
	51–60 Years	1	2.5
	> 60 Years	8	19.5
	Total	41	100
Profession	Student	3	7.31
	Shopkeeper	3	7.31
	Laborer	5	12.19
	Housewives	8	19.51
	Imam	4	9.75
	Govt. Employee	7	17.07
	Businessmen	3	7.31
	Teacher	4	9.75
	Driver	4	9.75
	Total	41	100
VC Lesion	Nodule	14	34.1
	Polyp	25	60.97
	Cyst	02	4.87
	Total	41	100.0

Table 2 Comparison of GARBAS score preop and postoperative first, second, third by using Wilcoxson signed scale | Improvement in maximum phonation time after surgery | Voice handicap index preoperative and postoperative first, second, and third

		Mean	SD	50th Percentile	*Z* score	*P* value
GARBAS Score	Preoperative	10.927	2.1724	10.000	–	–
	1st follow-up	7.122	1.9261	7.000	−5.629	< 0.001
	2nd follow-up	2.805	1.4181	3.000	−5.600	< 0.001
	3rd follow-up	0.268	0.4486	0.000	−5.618	< 0.001
Aerodynamics MPT	Preoperative	12.854	2.8685	13.000	–	–
	MPT 1PO	14.927	2.6018	15.000	−3.429	0.001
	MPT 2 PO	18.512	3.1711	18.000	−5.382	< 0.01
	MPT 3PO	21.683	3.1340	22.000	−5.589	< 0.01
Voice Handicap Index 10 (VHI-10)	VHI-10	23.073	5.8025	22.000		
	VHI-10 1PO	15.878	5.0803	15.000	−5.610	0.001
	VHI-10 2 PO	5.610	1.9733	6.000	−5.583	0.001
	VHI-10 3PO	0.585	0.5906	1.000	−5.582	0.001

Table 3 Glottic closure comparison preoperative and postoperative

Status	Glottic Closure at Baseline	Glottic Closure at F/U 1	Glottic Closure at F/U 2	Glottic Closure at F/U 3
Incomplete	41	0	0	0
Complete	0	41	41	41
Total	41	41	41	41

All patients had incomplete glottic closure preoperatively, glottis closure was complete postoperatively at least up to 6 months

Table 4 Mucosal wave amplitude preop and postoperative first, second, and third

M	Mucosal wave amplitude at baseline	Mucosal wave amplitude at F/U 1	Mucosal wave amplitude at F/U 2	Mucosal wave amplitude at F/U 3
Reduced	39	6	0	0
Normal	2	35	41	41
Total	41	41	41	41

and p value < 0.01. The mean preoperative voice handicap index 10 was 23.073, standard deviation 5.8025, and median 22.000. Voice Handicap Index 10 at third postoperative follow-up had a mean value of 0.585, stand and deviation 0.5906, median 1.000, Z score −5.582, and P value < 0.001. (Table 2).

Stroboscopy was done for all of the study subjects. Two parameters, glottis closure and mucosal wave, were examined and recorded. Glottic closure was incomplete in all of these patients preoperatively which was complete postoperatively for all 41 (100%) patients. (Table 3).

Mucosal wave amplitude was reduced in 39 out of 41 patients preoperatively. At first follow-up 35 out of 39 patients had normal mucosal wave amplitude, and at second follow-up (1 month), all the 39 patients had normal mucosal wave amplitude (Table 4).

Discussion

The main concern for both the patient and the surgeon after micro-laryngeal surgery is the outcome of the voice. The usage of carbon dioxide laser in such surgeries has grown since it was first utilized in laryngeal procedures. We conducted this research to assess the voice quality and the vocal fold function after benign vocal fold lesions were removed using a carbon dioxide laser.

There were 41 patients in the study 27 men and 14 women with a male-to-female ratio of 1.92. With a minimum age of 20 and a highest age of 66, the study patients' average age at presentation was 41.78 years. The majority of patients, i.e., 13 (31.7%) in our study were in the fourth decade of their life followed by 11 (26.8%) patients in the fifth decade of their life, three (7.3%) patients were between 16 and 20 years, five (12.2%) patients between 21 and 30 years, one (2.5%) patient between 51 and 60 years, and eight (19%) patients above 60 years of age. Studies conducted by Pal et al. (2014) and Baitha et al. (2002) have shown similar pattern of age distribution of the subjects.

In this study, eight (19.51%) were housewives followed by seven (17.07%) government employees five (12.19%) laborers, four (9.75%) teachers, four (9.75%) preachers/imams, four (9.75%) drivers, three (7.31%) students, and three (7.31%) shopkeepers. In the studies

by Gosh et al. (2001) and Banjara et al. (2014), majority of patients were housewives.

Vocal fold polyp was the most common lesion present in 25 (60.97%) patients followed by vocal fold nodules in 14 (34.1%), and cysts in two (4.87%) patients (Figs. 1, 2 and 3). Uphaday et.al (2019) show the vocal cord polyps in 10%, vocal cord nodules in 13%, and vocal cord cysts in 14% patients.

Pre- and postoperative voice assessment was done in the form of auditory perceptual rating GRBAS (Grade, Roughness, Asthenia, Breathiness, Strain), Aerodynamic measure [MPT (Maximum Phonatory Time) in seconds], and patient self-reporting instrument voice handicap index 10 (VHI-10). There are several scoring methods for perceptual analysis of voice. GRBAS offers a simplified grading system for estimating the extent of voice modification. The mean preoperative GRBAS score of the patients in the current research was 10.972, with an SD of 2.1724 and a median of 10.000. All postoperative periods had continuous increases in GRBAS scores,

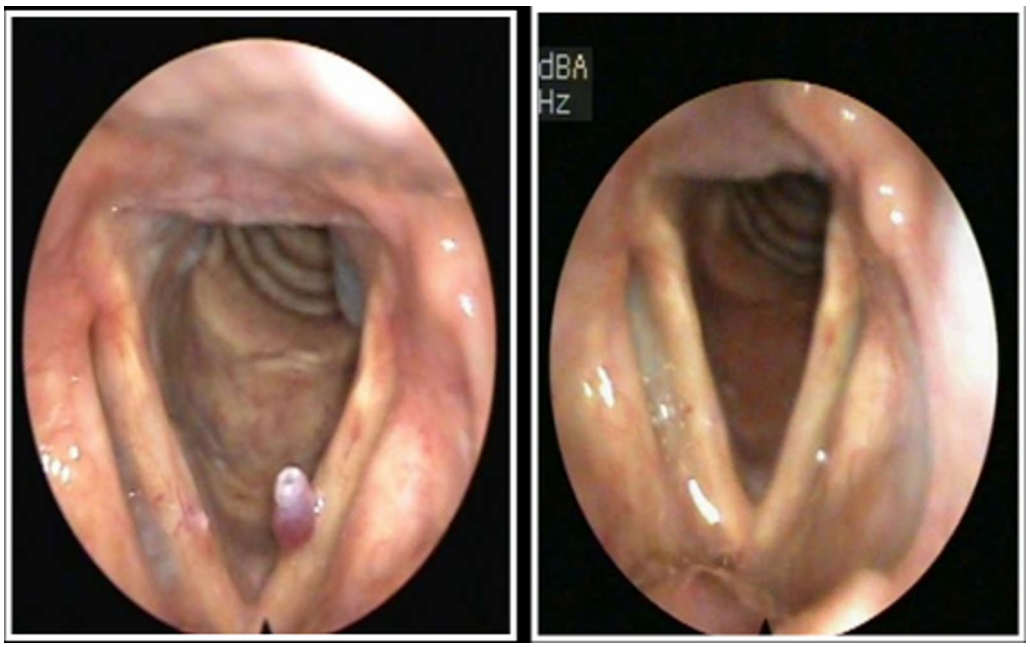

Fig. 1 Preoperative and postoperative images of left vocal cord nodule

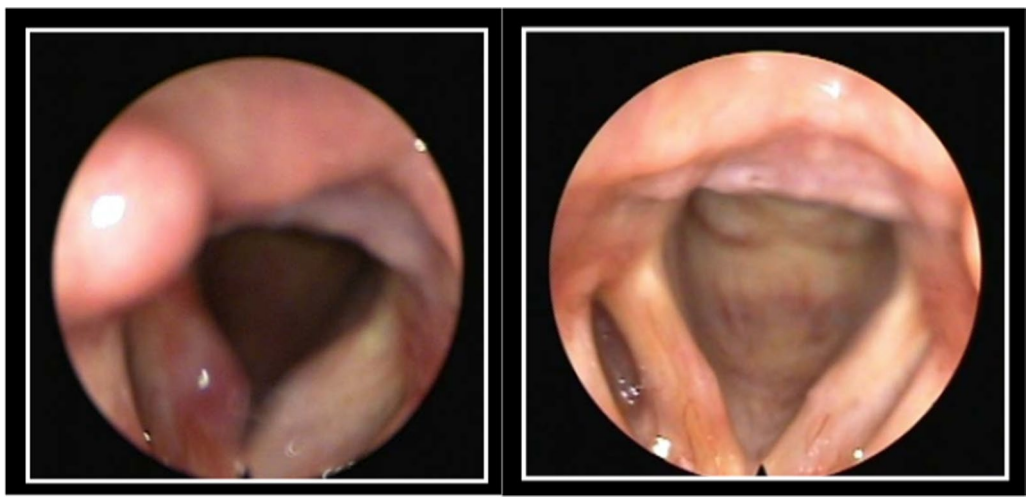

Fig. 2 Preoperative and postoperative images of right vocal cord cyst

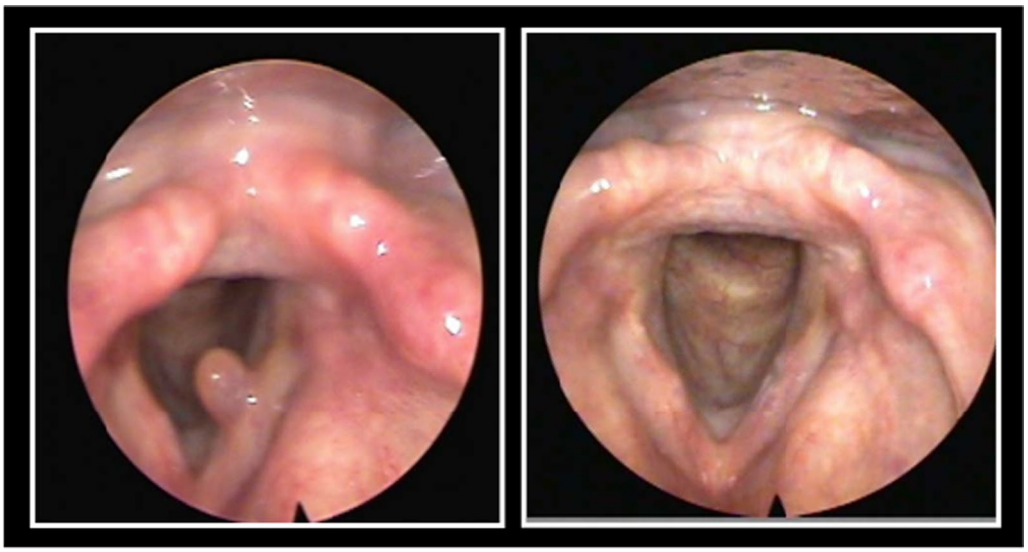

Fig. 3 Preoperative and postoperative image of left vocal cord polyp

and the mean GRBAS score at 6 months showed a major improvement with a 0.001 *p* value. Divakaran et al. (2015) in their study of Voice Outcome Following CO_2 laser-assisted microlaryngeal surgery found improvement in GRBAS scores with preoperative median GRBAS score 9 and post op median GRBAS score was 2 after 3 months.

Maximum phonation time was statistically significantly improved in our patients after surgery. The mean preoperative MPT (Maximum phonation time) was 12.854, with a standard deviation of 2. 8685 and a median of 13.000. In the third postoperative follow-up mean MPT was 21.683, standard deviation of 3.1340, median of 22.00, *Z* score −5.519, and *p* value < 0.01, which was statistically significant.

Analyzing the outcomes of patients with dysphonia requires both subjective and objective evaluations of voice. We can learn about the effects of dysphonia on quality of life using self-assessment tools like VHI. In our research, we employed the voice handicap index 10 to examine patients both subjectively and objectively. In the present study, the mean preoperative VHI-10 was 23.073 with a standard deviation of 5.8025 and a median of 22.00. Voice handicap index 10 on third postoperative follow-up had a mean value of 0.585, SD of 0.5906, median 1.00, *Z* score −5.582, and *p* value of 0.01. Significant improvement in voice handicap index and MPT has been found in patients treated with carbon dioxide laser in studies done by MARC Remacle et al. (1999) and Kumar et al. (2019).

Stroboscopy was used to examine the pre- and postoperative vocal cord morphology in all patients. Mucosal wave and glottic closure pattern were chosen as parameters since they are two significant aspects that affect voice quality. In our study of 41 patients preoperative glottic closure was incomplete in all patients (100%) with an anterior gap in six (14.6%) patients and posterior gap in 35 (85.4%) patients. We also found reduced mucosal wave amplitude in 39 (95%) patients, while mucosal wave amplitude was normal in two (4.9%) patients. Postoperatively, there was complete glottic closure in all patients at first follow-up. At their first postoperative checkup, 35 patients had normal mucosal waves, and at their second postoperative checkup, every patient had normal mucosal waves. Complete glottic closure may be described by enhanced vocal fold contact after lesion removal. As a consequence of the enhanced contact between the vocal folds and the improved creation of sub-glottic pressure, the mucosal wave also tends to become regular and normal following surgery. Divakaran et al. (2015) confirmed that after surgery, most of the patients achieve complete glottic closure and normal mucosal wave (98% each). In another study by Mobarsa et al. (2019), normal mucosal wave amplitude was present in 56.67%, and complete glottic closure was present in 80% patients at the end of tenth postop week.

The recuperation period is shortened, and the patient has less discomfort after laser procedures. There is minimal chance of significant bleeding, infection, or other consequences. With laser surgery, there is also a very low chance of scarring, which is crucial when the larynx is involved since scar tissue is thicker than normal tissue and does not vibrate as readily. In the present study, none of our patients had any complications.

Conclusions

Earlier concerns about the safety of CO_2 lasers have been allayed with the implementation of stringent laser safety measures, and scanner micromanipulators and super- and ultra-pulsed CO_2 laser advancements have made it possible to make accurate and controlled incisions of any desired form, size, or depth. Two techniques may be used to gauge voice quality and make comparisons: acoustic analysis and perceptual voice analysis. Stroboscopy, perceptual, and acoustic analyses were used to determine that the voice result in our research was outstanding.

Precision, hemostasis, and little postoperative edema are benefits of using a CO_2 laser. This research therefore supports the idea that benign vocal fold lesions may be successfully treated with the super-pulsed microspot carbon dioxide laser, which offers good voice outcomes.

Voice analysis indicated a tendency in the direction of normality, though the results did not reach statistical significance. The overall and subscale scores for the voice handicap index decreased.

Acoustic analysis, videostroboscopy, and the voice handicap index are helpful methods for evaluating the efficiency of therapy in individuals with benign vocal cord lesions from both an objective and subjective perspective. It is advised to use them often in a voice clinic.

Abbreviations

ENT	Ear nose throat
HNS	Head and neck surgery
GRBAS	Grade roughness breathiness asthenia and strain
VHI	Voice handicap index
LPR	Laryngopharyngeal reflex
SD	Standard deviation
OPD	Outpatient department

Acknowledgements

Not applicable.

Author contributions

SAS is senior author who did the surgeries and supervise the research. ASJ is senior author who performed the surgeries. MSB was major contributor in writing the manuscript. BAM is corresponding author, analyzed and compiled the patient data. All authors have read and approved the manuscript, and ensure that this is the case.

Funding

Not applicable.

Availability of data and materials

The datasets during and/or analyzed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and Consent to participate

Ethical clearance sought from the ethical committee of the institution named "Institutional Ethical Committee (IEC)" Government Medical College (GMC) Srinagar Kashmir India. Reference number: IECGMCSGR 2018/221/171, Dated—05/11/2018. Written and informed consent to participate in the study was taken from each patient (or from the legal guardians in case of children age less than 18 years) in common and understandable language "I agree to participate in the study that my labs and medical data be used for medical research."

Consent for publication

Not applicable.

Competing interests

Authors declare that there are no competing interests.

Received: 22 January 2024 Accepted: 5 May 2024
Published online: 22 May 2024

References

Baitha S, Raizada RM, Singh AKK, Puttewar MP, Chaturvedi VN (2002) Clinical profile of hoarseness of voice. Indian J Otolaryngol Head Neck Surg 54(1):14–18

Banjara H, Mungutwar V, Singh D, Gupta A (2014) Objective and subjective evaluation of larynx in smokers and nonsmokers: a comparative study. Indian J Otolaryngol Head Neck Surg 66(Suppl 1):99–109

Benninger MS (2000) Microdissection or microspot CO^2 laser for limited vocal fold benign lesions: a prospective randomized trial. Laryngoscope 110:1–17

Divakaran S, Alexander A, Vijayakumar S, Saxena SK (2015) Voice outcome following carbon dioxide laser assisted microlaryngeal surgery. Indian J Otolaryngol Head Neck Surg 67(4):361–365

Ghosh SK, Chattopadhyay S, Bora H, Mukherjee PB (2001) Microlaryngoscopic study of 100 cases of Hoarseness of voice. Indian J Otolaryngol Head Neck Surg 53(4):270–272

Hirano M (1974) Morphological structure of the vocal cord as a vibrator and its variations. Folia Phoniatr (Basel) 26(2):89–94

Hochman I, Sataloff RT, Hillman RE et al (1999) Ectasias and varices of the vocal fold: clearing the striking zone. Ann Otol Rhinol Laryngol 108(1):10–16

Kendall KA (2009) High-speed laryngeal imaging compared with videostroboscopy in healthy subjects. Arch Otolaryngol Head Neck Surg 135(3):274–281. https://doi.org/10.1001/archoto.2008.557

Kumar S, Prasad BK (2019) A comparison of surgical outcomes of carbon dioxide laser versus conventional cold instrument excision of benign vocal cord lesions. Indian J Otolaryngol Head Neck Surg 71(Suppl 1):S992–S996

Metson R (1996) Holmium:YAG laser endoscopic sinus surgery: a randomized, controlled study. Laryngoscope 106(Suppl 77):1–18

Mobarsa V, Samdani SK, Gurjar VS (2019) Outcome analysis of microlaryngeal surgery for benign lesions of vocal cord using videostroboscopy and voice handicap index. Indian J Otolaryngol Head Neck Surg 71(Suppl 1):327–332. https://doi.org/10.1007/s12070-018-1300-0

Nemr K, Simões-Zenari M, Cordeiro GF, Tsuji D, Ogawa AI, Ubrig MT, Menezes MH (2012) GRBAS and Cape-V scales: high reliability and consensus when applied at different times. J Voice. https://doi.org/10.1016/j.jvoice.2012.03.005

Pal KS, Kaushal AK, Nagpure PS, Agarwal G (2014) Etiopathological study of 100 patients of hoarseness of voice: in a rural based hospital. Indian J Otolaryngol Head Neck Surg 66(1):40–45

Remacle M, Lawson G, Watelet JB (1999) Carbon dioxide laser microsurgery of benign vocal fold lesions: indications, techniques, and results in 251 patients. Ann Otol Rhinol Laryngol 108(2):156–164

Rosen CA, Lee AS, Osborne J, Zullo T, Murry T (2004) Development and validation of the voice handicap index-10. Laryngoscope 114(9):1549–1556. https://doi.org/10.1097/00005537-200409000-00009

Sawaya Y, Sato M, Ishizaka M, Shiba T, Kubo A, Urano T (2022) Maximum phonation time is a useful assessment for older adults requiring long-term care/support. Phys Ther Res 25(1):35–40. https://doi.org/10.1298/ptr.E10152

Smit S, Underbrink M, Quinn FB, Quinn MS (2013) Benign vocal fold lesions. The University of Texas Medical Branch in Galveston, Department of Otolaryngology, Grand Round Presentation

Upadhyay A, Zaidi AK, Mundra RK (2019) A comprehensive analysis of benign vocal fold lesions causing hoarseness of voice and our experience with cold knife endolaryngeal surgery in a tertiary healthcare centre. Indian J Otolaryngol Head Neck Surg 71(Suppl 1):515–521

Publisher's Note