CO2 Laser in Benign Vocal Fold Lesions - An Observational Study

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Research Article

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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 research, a total of 41 individuals who had hoarseness of voice and satisfied the inclusion criteria were included. A thorough medical history was obtained, and a thorough ENT examination was performed, including an anterior rhinoscopy, an oral cavity examination, an indirect laryngoscopy, a 70-degree Hopkins rod examination, and a stroboscopy. 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 (MPT) 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 research participants was a vocal polyp. This study showed majority of patients 35 (85.4%) had posterior phonatory gap and 6 (14.6%) had anterior gap preoperatively. All patients had incomplete glottic closure preoperatively whereas glottic closure was complete at 1st follow-up postoperatively. The mean pre-operative 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 oedema 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 micro-spot carbon dioxide laser, which offers good voice outcomes.


BACKGROUND

The true vocal folds have a multilayered anatomy, which is the basis of Hirano's cover-body hypothesis of phonation, first forward in 1974 [1]. 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 [2].

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 lesions on 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 [3]. 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 assess pre- and post-operative 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 examination includes glottic closure pattern, mucosal wave, description of lesion, vocal fold opening pattern, supraglottic appearance and symmetry of arytenoids[4].

Regardless of the kind, benign vocal fold lesions prevent the vocal folds from closing and vibrating, which results in hoarseness. It's 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 post-operative 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 1960s, CO\textsubscript{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\textsubscript{2} lasers with a spot size of less than 250 µm. It has been proposed that the microspot CO\textsubscript{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 [5]. The light produced by CO\textsubscript{2} lasers has a wavelength of 10.6 µm, which is in the center of the infrared spectra. 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\textsubscript{2} lasers mainly vaporize tissue to induce death [6]. The CO\textsubscript{2} 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 post-operative voice in patients with dysphonia. The GRBAS scale was perhaps the first widely utilized measure, and is still in use today. This includes 5 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.[7]. Self –assessment measures like voice handicap index (VHI) provide us with the information on the impact of dysphonia on the quality of life [8]. 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 seconds or less is abnormal, and 5 seconds or less interferes with daily living [9].

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 satisfied 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 an anterior rhinoscopy, an oral cavity examination, an indirect laryngoscopy. Telelaryngoscopy using 70-degree rigid endoscopy and Stroboscopic examination was
done pre operatively 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. This improves the microsurgical motor control and reduces the complications. 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 & post- CO\(_2\) laser GRABS and VHI-10 scores were compared using the Wilcoxon Signed Ranks test. Statistics were reported using 2-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 31–50 years with mean age being 41.78 years. Eight (19.51%) of the study subjects were housewives and 7 (17.07%) were government employees by profession. All 41 (100%) of the patients’ presenting complaint was hoarseness of voice, and the majority of them had a slow development of symptoms. 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 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 6 (14.6%) had anterior gap preoperatively. All patients had incomplete glottic closure preoperatively whereas glottic closure was complete at 1st follow-up postoperatively. (Table 1)
The mean pre-operative 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 3rd post-operative follow-up had a mean value of 21.683, SD of 3.1340, median value of 22.000, Z score −5.589, 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 3rd
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 post operatively for all 41(100%) patients. (Table 3)
All patients had incomplete glottic closure pre operatively, glottis closure was complete post operatively at least up to 6 months.

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 2nd follow-up (1 month) all the 39 patients had normal mucosal wave amplitude (Table 4).

<table>
<thead>
<tr>
<th></th>
<th>Mucosal Wave Amplitude at Baseline</th>
<th>Mucosal Wave Amplitude at F/U 1</th>
<th>Mucosal Wave Amplitude at F/U 2</th>
<th>Mucosal Wave Amplitude at F/U 3</th>
</tr>
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<td>Reduced</td>
<td>39</td>
<td>6</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Normal</td>
<td>2</td>
<td>35</td>
<td>41</td>
<td>41</td>
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<td>Total</td>
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DISCUSSION

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

There were 41 patients in the trial, with a male-to-female ratio of 1.92 and 27 men and 14 women. 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 4th decade of their life followed by 11 (26.8%) patients in their 5th decade of life, 3 (7.3%) patients were between 16 to 20 years, 5 (12.2%) patients between 21 to 30 years, 1 (2.5%) patient between 51 to 60 years and 8 (19%) patients above 60 years of age. Studies conducted by Pal KS et al[10] and Baitha S et al[11] have shown similar results.

In this study, most of the patients 8 (19.51%) were housewives followed by government employees 7 (17.07%) followed by laborers 5 (12.19%), teachers 4 (9.75%), preachers/imams 4 (9.75%), drivers 4 (9.75%), students 3 (7.31%), shopkeepers 3 (7.31%). In the studies by Gosh SK et al[12] and Banjara H et al[13] majority of patients were housewives.

Vocal fold polyps were the most common lesion 25 (60.97%) in our study subjects followed by vocal fold nodules in 14 (34.1%), and cysts in 2 (4.87%) patients. (Fig. 1, 2 &3). In a study by uphaday A et.al [14] vocal cord polyps in 10%, vocal cord nodules in 13% and vocal cord cysts in 14% patients.

Pre and post-operative 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 post-operative periods had continuous increases in GRBAS scores, and the mean GRBAS score at 6 months showed a major improvement with a 0.001 p-value. Divakaran S et al[15] in their study of Voice Outcome Following CO₂ Laser Assisted Microlaryngeal Surgery found improvement in GRBAS scores with pre-operative median GRBAS score 9 and by the last follow-up visit, namely, in the 3rd month, the median GRBAS score was 2.

Maximum phonation time was statistically significantly improved in our patients after surgery. The mean pre-operative 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 3rd 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[16] and Kumar S et al[17].

Stroboscopy was used to examine the vocal folds' pre- and post-operative morphology in all patients. Mucosal wave and Glottic closure pattern were chosen as parameters since they are 2 significant aspects that affect voice quality. In our study of 41 patients preoperatively, we found glottic closure was incomplete in all patients (100%) with an anterior gap in 6 (14.6%) patients' 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 2 (4.9%) patients. Postoperatively there was complete glottic closure in all patients at 1st 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 S et al [15] confirmed that after surgery most of the patients achieve complete glottic closure and normal mucosal wave (98% each). In another study by Mobarsa V (2019) normal mucosal wave amplitude was present in 56.67% and complete glottic closure was present in 80% patients at the end of 10th post op 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 since the laser surgery often takes place in a doctor's office. 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**

In fact, the development of the carbon dioxide laser marks a significant turning point in the treatment of benign vocal fold lesions. With the implementation of stringent laser safety measures, earlier concerns about the safety of CO₂ lasers have been allayed. Scanner micromanipulators and super- and ultra-pulsed CO₂ 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 oedema are benefits of using a CO₂ laser. This research therefore supports the idea that benign vocal fold lesions may be successfully treated with the super-pulsed micro-spot carbon dioxide laser, which offers good voice outcomes.

Voice analysis indicated a tendency in the direction of normality, but 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 : out patient department

**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: IECGMCGR 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

**Availability of data and material:** The datasets during and/or analysed during the current study available from the corresponding author on reasonable request.

**Competing interests:** authors declare that there are no competing interests.

**Funding:** not applicable

Author’s 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, analyze and compile the patient data. All authors have read and approved the manuscript, and ensure that this is the case.

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**References**

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


Figures
Figure 1

Preoperative and postoperative images of left vocal cord nodule
Figure 2

Preoperative and postoperative images of right vocal cord cyst

![Preoperative and postoperative images of right vocal cord cyst](image)

Figure 3

Preoperative and postoperative image of left vocal cord polyp

**Supplementary Files**

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- [STROBEchecklistv4combined.docx](STROBEchecklistv4combined.docx)