# Voice Profile Recovery and Quality of Life Changes After Microdirect Laryngoscopy in Three Categories of Glottis Lesions: Benign, Precancerous, and Malignant

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**Summary:** The aim of the study was comparison of voice and life quality after microdirect laryngoscopy in three patient histopathological categories: benign, precancerous, and malignant glottic lesions. A totalnof 137 patients treated with microdirect laryngoscopy were included in the study. Each patient was evaluated with a multidimensional protocol before and 3, 6, and 12 months after treatment. Final 1-year evaluations were achieved in 74.5% (102). The assessment included laryngovideostroboscopy (LVS), perceptual (GRBAS) grading, aerodynamic measures including maximum phonation time and phonation quotient and acoustic measurements (Kay Elemetrics Multi-Speech program), Voice Handicap Index (VHI), Voice-Related Quality of Life questionnaire; and World Health Organization Quality of Life Scale-Brief Version (WHOQoL-BREF). An improvement in mean value of LVS ratings was obtained in all three groups; however, only in benign lesion group was it consistently statistically significant for each time period ($P < 0.001$). Perceptual evaluation revealed significant improvement of G, R, and B parameters in benign lesions for each time period. In malignant neoplasms R and B parameters improved 3 and 6 months post microsurgery. In patients with benign lesions the maximum phonation time increased, but the improvement was significant only after 3 months. The acoustic parameters improved in all three groups. VHI significantly improved in patients with benign lesions after 3 and 12 months. VHI in the malignant neoplasm group significantly worsened on the first follow-up visit. Considering quality of life (QoL) results, only in patients with benign lesions was there a significant improvement in overall assessment of their QoL and general health.
**Key Words:** Voice quality–Quality of life–Microdirect laryngoscopy–Benign glottis lesions–Early glottis cancer.

## INTRODUCTION

The complex anatomical features and physiological capabilities of the vocal folds (VFs) provide humans with uniquely nuanced voice production. But these same complex factors also render them susceptible to injury and resulting dysphonia. Due to risk factors such as active and passive smoking, laryngopharyngeal reflux, and incorrect voice use patterns, lesions of glottic mucosa effecting phonation are very common pathologies in ENT practice.[1] These pathologies can be classified on the basis of pathological severity as benign, premalignant, or malignant. The most frequently diagnosed benign changes, for example, vocal nodules, Reinke edema, granulomas are primarily treated with medical or voice therapy.[2] Resistance to nonsurgical therapy is an indication for microsurgery. For some benign lesions such as cysts, polyps, and papillomas the initial treatment option is microsurgery. The premalignant conditions that clinically appear as leukoplakia, chronic laryngitis with hypertrophic changes of the mucosa, and erythroplakia require histopathological verification and complete resection with microsurgical methods, often with laser application. Early malignant lesions of the glottis can be curatively treated with laser cordectomies of varying extent as classified by the European Laryngological Society (ELS).[3] In most glottic lesions there is variable measurable reduction of voice quality prior to microsurgery. Surgical procedures performed on the glottis will also inevitably have an influence on voice quality. Objective voice impairment will not only depend on the location of resected mucosa, but also on the size and depth of the excision, especially as it affects Reinke space and subsequent disruption of the vibratory mechanism of the VFs. The modern approach to laryngeal microsurgery promotes soft tissue sparing to preserve the best vocal function.[4,5] This goal is surely much easier to fulfill in benign lesions. In premalignant and malignant lesions, tissue preservation must be balanced with concerns of adequate oncological resection.

We planned our study to establish a voice profile recovery and quality of life (QoL) changes after endoscopic microsurgery in patients with different laryngeal lesions. Many studies have been published about voice outcomes in select laryngeal lesions after the microsurgical procedures; however, we have not found any work comparing results between different categories of lesions. We also found very few works assessing life quality changes between various types of glottic lesions.

## MATERIALS AND METHODS

### Ethical considerations

Ethical approval was obtained from the Research Ethics Committee of Local Medical University (No. KB/267/2013). Patients gave their written informed consent to participate in the study.

## Subjects and study design

The study initially included 137 patients with different organic laryngeal pathologies. All patients were admitted to our department for microsurgical treatment. In the study protocol the voice quality and QoL for each patient was assessed before surgery and 3, 6, and 12 months postoperatively. Patients were excluded during the course of the study if initial microdirect laryngoscopy (MDL) confirmed a T2 or greater laryngeal cancer or a lesion that was not eligible for endoscopic resection. Also excluded were patients with premalignant changes or a T1 cancer developing a recurrence in the follow-up period requiring another microsurgery or radiotherapy, patients who did not complete the protocol through the 1-year follow-up. The recurrence rates in analyzed population were as follows: 12% (10 patients) in benign lesion group, 20.5% (7 patients) in precancerous changes group, and 16.7% (5 patients) in malignant lesions group. Final results were collected from 74.5% (102) of the patients—49 female, 53 male, mean age 55.8 years, age range 19–81 years. Expectedly, in benign lesion group, there was predominance of women over men (43 vs. 21), but the precancerous and malignant lesions were diagnosed in majority of male patients. The mean age in malignant and premalignant lesions group was higher than in benign lesion group (65.4 and 60.6 vs. 51.5 years, respectively). The detailed demographic characteristics of patients' groups are presented in Table 1.

The patients' lesions were grouped by final histopathological diagnosis into three groups: benign lesions, precancerous lesions, and malignant neoplasms. The cases of high-grade dysplasia and carcinoma *in situ* were classified as Tis carcinoma of VF according to laryngeal cancer staging proposed by the American Joint Committee on Cancer. Among the study group, 64 patients had benign lesions, most of which were Reinke edema, but also polyps and cysts. There were 19 patients with precancerous lesions that clinically presented as leukoplakia and/or hypertrophic chronic laryngitis with histopathology revealing mild or moderate dysplasia. The remaining 19 patients had Tis or T1 vocal carcinoma. The benign lesions were treated with minimally invasive phonosurgery with cold instruments or carbon dioxide ($CO_2$) laser microsurgery. Patients with premalignant conditions had a type I or II cordectomy operation. In malignant neoplasms, types II–V cordectomies were performed. A multidimensional voice quality assessment protocol was employed as suggested in ELS guidelines: laryngovideostroboscopy (LVS),

perceptual (GRBAS) grading, aerodynamic measures including maximum phonation time (MPT) and phonation quotient (PQ) and acoustic measurements (Kay Elemetrics Multi-Speech program, Lincoln Park, NY), and Voice Handicap Index (VHI).[4] For the evaluation of the impact of the voice impairment on the QoL the patients were asked to fill out the Voice-Related Quality of Life (V-RQoL) questionnaire and World Health Organization Quality of Life Scale-Brief Version (WHOQoL-BREF).

## Methods of voice quality evaluation

The LVS was performed by one of two otolaryngologists/phoniatricians. Both investigators did an independent interpretation of the LVS; differences in assessment were resolved with a consensus re-interpretation. For objectification of the LVS, each examination included a scored assessment of the function of both VFs: mobility (normal—0, limited—1, absent—2 points), mucosal wave (normal—0, limited—1, absent—2 points), glottal closure (longitudinal—0, dorsal—0, oval—1, hour-glass shaped—1, irregular—1), regularity and symmetry of VF vibration (symmetrical and simultaneous—0, not simultaneous—1), and the amplitude of vibration (normal—0, decreased—1, absent—2). Potential LVS ratings ranged from 0 (totally normal function) to 14 (maximal dysfunction). In cases where a laryngeal function could not be visualized (eg, compensatory supraglottic closure), a score for maximal dysfunction was assigned.

Based on the GRBAS scale proposed by Hirano, a perceptual evaluation was performed by one of the two specialists in short conversation with the patients (counting in normal voice from 1 to 20). Using a voice sample recording this evaluation was cross-checked by the other doctor. The inter-judges differences did not exceed 7% of examined parameters and the differences in assessment were resolved with a consensus re-interpretation. The recordings were made on DiVAS (XION, Berlin, Germany) with a head-worn microphone at a constant distance of 30 cm from the patient's mouth.

The aerodynamic evaluation included the MPT in seconds measured on DiVAS (XION). The patient performed three trials of maximum prolongation of a /a:/ vowel at a spontaneous, comfortable intensity and pitch level after maximal inspiration. The longest MPT was accepted for analysis. Each patient performed spirometry with a handheld spirometer (Micro Medical MICROLAB, United Kingdom) for assessment of vital capacity (VC). This measure was necessary for calculation of the PQ.

**TABLE 1.**
**Demographic Characteristics of Patients' Groups**

| Demographic Characteristics of Groups | | | | | | |
|---|---|---|---|---|---|---|
| N | | | | Age (y) | | |
| Groups | Number | Male | Female | Mean ± SD | Median | Range |
| Benign lesions | 64 | 21 | 43 | 51.5 ± 13.7 | 53 | 19–81 |
| Precancerous lesions | 19 | 14 | 5 | 60.6 ± 8.4 | 59 | 44–81 |
| Malignant neoplasms | 19 | 18 | 1 | 65.4 ± 56.3 | 65 | 52–78 |
| All patients | 102 | 53 | 49 | 55.8 ± 13.0 | 59 | 19–81 |

*Abbreviation:* SD, standard deviation.

The PQ is equivalent to VC (mL)/MPT (seconds) and is felt to reflect the average phonation airflow normalizing for gender differences in lung volume.

For the acoustic evaluation recordings of phonation of the vowel a /a:/ at comfortable frequency and intensity were performed and analyzed for each patient using the Kay Elemetrics Multi-Speech program. Voice breaks were excluded from the analysis. The classical set of acoustic parameters was chosen for further analysis including fundamental frequency in hertz (Hz) (F0), jitter percent (short-term instability of voice frequency), shimmer percent (changes of voice amplitude), and noise-to-harmonic ratio (NHR) (noise components in the voice).

For the self-assessment of voice quality we used the VHI questionnaire that has been translated and validated as a reliable method of voice evaluation in a Polish-speaking population.[6] The VHI consists of 30 items ranking voice problems in different situations of everyday life. The patient rates each item from 0—never happens, 1—rarely, 2—sometimes, 3—often, to 4—always. The total score ranges from 0 to 120. A total score lower than 30 is considered mildly handicapped. A score of 31–60 indicates moderate, 61–90 severe, and 91–120 very severe dysfunction.

### Methods of quality of life evaluation

The V-RQoL questionnaire was used in the study. The questionnaire was translated and validated as a reliable method for a Polish-speaking population.[7] The V-RQoL consists of 10 items regarding the impact of the impaired voice on different situations of everyday life. The patient rates each item from 1—the problem never occurs, 2—there is a small problem, 3—there is a moderate problem, 4—there is a big problem, to 5—it cannot be worse. The total score ranges from 10 to 50.

The QoL was also assessed with the WHOQoL-BREF that was translated, adapted, and validated for Polish native language speakers.[8] This self-reporting questionnaire contains two general categories: WHO1—regarding the overall perception of life quality and WHO2—regarding the overall perception of an individual's health using 24 items, each assigned to one of four domains of life (physical—DOM1 (seven items), psychological—DOM2 (six items), social relationships—DOM3 (three items), environment—DOM4 (eight items)). Each item is rated on a 6-point Likert scale from 0 to 5. The raw scores for each domain were converted to transformed scores ranging between 4 and 20 according to instructions, then multiplied by 4 to compare the results with the original WHOQoL-100.[9] The scores for WHO1 and WHO2 are analyzed separately and the maximum score for each is 5. The WHO1, WHO2, and domain scores are scaled in a positive direction. Higher scores reflect a better QoL.

### Statistical analysis

Statistical analysis was performed using the Statistica 12 package StatSoft (Dell Statistica Partner, Palo Alto, California, USA). Categorical variables were summarized through the calculation of frequency. Continuous variables were summarized using descriptive statistics (mean, standard deviation, median, and range). The statistical analysis was performed with nonparametric analysis of variance Friedman test (statistical significance if $P < 0.05$) and Wilcoxon paired test with Bonferroni corrections ($P = 0.017$)

## RESULTS

### Voice quality results

Functional assessment of laryngeal structures using our developed scoring system revealed improvement in the mean value of LVS ratings in all three groups of laryngeal pathologies after surgery; however, only in patients with benign lesions was it statistically significant for each follow-up time period ($P < 0.001$) (Table 2). The mean values of LVS were the highest for laryngeal malignancies compared to benign and premalignant lesions, reaching a significant level ($P < 0.01$). The perceptual evaluation revealed significant improvement of G, R, and B parameters in benign lesions for each time period ($P \leq 0.007$). In precancerous lesions and malignant neoplasms, the G, R, and B parameters improved 3 and 6 months post microsurgery, however, without statistical significance (Table 3). The aerodynamic assessment demonstrated improvement of MPT in patients with benign lesions, but the improvement was significant only after 3 months ($P = 0.016$). Changes in MPT had the effect of a significant decrease in the PQ ($P = 0.01$). Both in the premalignant lesion group and in patients with malignant neoplasms the mean value of MPT increased slightly on the first follow-up visit; however, in later periods there was a progressive deterioration in scores. At 12 months post surgery the reduction in MPT was statistically significant for premalignant changes ($P < 0.001$) and very close to significant for malignant ($P = 0.057$; Table 4). The analyzed acoustic parameters of fundamental frequency, jitter, and shimmer improved in all three groups. However, only for benign lesions did the differences in jitter and shimmer reach statistical significance for the 6 (jitter: $P = 0.013$; shimmer: $P = 0.03$) and 12 (jitter: $P = 0.008$; shimmer: $P = 0.015$) months' postsurgical groups (Table 5). The self-assessment of voice quality with VHI demonstrated moderate impairment of voice function in all three groups ($30 > VHI < 60$). An improvement in postsurgical VHI was observed for benign and precancerous lesions; however, the differences were significant only for patients with benign lesions at 3 and 12 months ($P = 0.01$ and $P = 0.003$, respectively). Only for benign lesions did the quality of voice progressively improve to a level of mild impairment (VHI <30) postoperatively. On the other hand, the VHI in the malignant neoplasm group was increased on all the follow-up visits, with the worst VHI level noted 3 months post surgery reaching statistical significance ($P = 0.015$) (Table 6).

### Quality of life postsurgical results

We did not observe significant changes of V-RQoL in any analyzed groups of pathologies. The mean level of V-RQoL was comparable for benign and premalignant lesions pre- and posttreatment. For the malignant neoplasm group, the V-RQoL rates were higher (Table 6). Considering the WHOQoL-BREF assessment, only in patients with benign lesions was there a significant improvement in WHO1—overall assessment of an individual's perception of life quality ($P = 0.01$) and in WHO2—patients' perception of general health ($P = 0.002$) at

**TABLE 2.**
**The Comparison of Functional Assessment of Laryngeal Structures on Laryngovideostroboscopy (LVS) Prior to Microsurgery (LVS 0) and in 3 Months (LVS 3 mo), 6 Months (LVS 6 mo), and 12 Months (LVS 12 mo) Postoperatively in Three Groups of Laryngeal Pathologies**

| | LVS 0 | | | LVS 3 mo | | | LVS 6 mo | | | LVS 12 mo | | | P Value |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Mean Value ± SD | Median | Range | Mean Value ± SD | Median | Range | Mean Value ± SD | Median | Range | Mean Value ± SD | Median | Range | |
| Benign lesions | 4.5 ± 2.7 | 4 | 1–10 | 3.0 ± 2.2* | 3 | 0–10 | 2.4 ± 2.2† | 2 | 0–10 | 1.6 ± 1.8‡ | 1 | 0–7 | <0.001*/†/‡ |
| Precancerous lesions | 5.8 ± 2.9 | 6 | 1–10 | 4.9 ± 2.5 | 4 | 2–10 | 4.7 ± 3.8 | 3.5 | 0–11 | 4.5 ± 3.3 | 5 | 0–10 | 0.507 |
| Malignant neoplasms | 8.1 ± 2.2 | 8 | 3–12 | 7.1 ± 2.8 | 7 | 2–12 | 5.9 ± 3.3 | 6.5 | 2–12 | 6.0 ± 2.9 | 6.0 | 2–12 | 0.229 |

* *P* value of comparison presurgical and 3 mo postoperative results.
† *P* value of comparison presurgical and 6 mo postoperative results.
‡ *P* value of comparison presurgical and 12 mo postoperative results.
*Abbreviation:* SD, standard deviation.

3 and 12 months postoperatively. However, the domain scores did not significantly change.

## DISCUSSION

There is no consensus on required tests for evaluation of voice quality in patients with laryngeal pathologies before and after MDL.[5] The only proposal for such a protocol was introduced by ELS in 2001 and includes assessment with LVS, perceptual, acoustic, aerodynamic, and self- evaluation assessments of voice quality by the patients.[4] This protocol recommends a wide range of tests actually reproduced in only a few studies. Many of the papers include the perceptual and acoustic results.[10–14] Fewer papers present solely the results of VHI evaluation.[15–17] Moreover, the majority of studies are retrospective and present only results after microsurgery without taking into account the initial voice quality. The ENT-UK Head and Neck consensus statement suggests voice evaluations be assessed before, 3 months, and 12 months post surgery.[18] However, most papers present results with no more than 3 months' follow-up. We think that such limited analyses are inadequate for predicting the relative benefits of treatment, especially when the preoperative condition is not assessed and the follow-up period is inadequate to reveal long-term outcomes. Also, nonstandardized, limited follow-up studies lead to a paucity of data for multicenter analysis and meaningful outcome assessment.

The study was designed to prospectively collect multidimensional voice and QoL assessments in benign, premalignant, and malignant laryngeal pathologies prior to MDL and at 3, 6, and 12 months following treatment. Very few studies attempt to compare results between categories of lesions. Our study is unique in prospectively comparing these three lesion categories using a comprehensive protocol including a preoperative assessment and long-term follow-up.

Modern phonosurgical methods in benign lesions aim to remove the lesions with maximum sparing of epithelium and Reinke space. Such an approach favors a significant improvement in voice parameters. Schindler et al presented a multidimensional assessment of vocal changes in benign lesions.[2] He included the results of GRBAS, MPT, acoustic evaluation, and VHI. The results of most of these measures reported similar improvements to those in our benign group. Most authors also report a recovery in perceptual rating that highly correlates with the acoustic parameter normalization after surgery.[10–12,19] Similar to our results, Stuut et al reported a significant improvement of VHI scores 3 months post microsurgery.[17] However, their VHI scores were much higher than in our patients (45.1 vs. 32.1) due to the inclusion of patients with VF paralysis. Other researchers also found statistically significant difference in pre- and postoperative VHI results for patients with benign lesions. This leads to claims of the VHI as a proven instrument for evaluating the impact of voice problems on patients and as a reliable instrument for monitoring the efficacy of therapy.[15,16] The QoL in benign laryngeal lesions has rarely been investigated. Johns et al evaluated the QoL with the Short Form 36 questionnaire and found no significant differences from the norms either before or after the operation.[19] Contrary to their study, our patients with benign laryngeal lesions demonstrated significant improve-

**TABLE 3.**
**The Results of Perception by GRBAS Scale (Mean Value ± Standard Deviation, in Italic the Median and Range) in Three Groups of Laryngeal Pathologies Prior to Microsurgery and 3 Months (3 mo), 6 Months (6 mo), and 12 Months (12 mo) Postoperatively**

| | G | R | B | A | S |
|---|---|---|---|---|---|
| **Benign Lesions** | | | | | |
| 0 | 1.4 ± 0.8 | 1.1 ± 0.8 | 0.8 ± 0.8 | 0.5 ± 0.7 | 0.6 ± 0.6 |
| | *1 (0–3)* | *1 (0–3)* | *1 (0–2)* | *0 (0–2)* | *0 (0–2)* |
| 3 mo | 0.9 ± 0.6* | 0.6 ± 0.6* | 0.5 ± 0.6 | 0.3 ± 0.5 | 0.4 ± 0.5* |
| | *1 (0–3)* | *1 (0–2)* | *0 (0–2)* | *0 (0–1)* | *0 (0–2)* |
| 6 mo | 0.8 ± 0.6† | 0.7 ± 0.6† | 0.3 ± 0.5* | 0.3 ± 0.40 | 0.5 ± 0.5 |
| | *1 (0–2)* | *1 (0–2)* | *0 (0–2)* | *0 (0–1)* | *0 (0–2)* |
| 12 mo | 0.9 ± 0.6‡ | 0.5 ± 0.5‡ | 0.2 ± 0.5† | 0.1 ± 0.3 | 0.6 ± 0.6 |
| | *1 (0–2)* | *0 (0–2)* | *0 (0–2)* | *0 (0–1)* | *1 (0–1)* |
| **P value** | **<0.001*/†** | **< 0.001*** | **0.002*/†** | | **0.01*** |
| | **0.005‡** | **0.007†** | | | |
| | | **0.004‡** | | | |
| **Precancerous Lesions** | | | | | |
| 0 | 1.5 ± 0.9 | 1.2 ± 0.7 | 1.1 ± 0.8 | 0.9 ± 0.8 | 0.8 ± 0.7 |
| | *1 (0–3)* | *1 (0–3)* | *1 (0–3)* | *1 (0–2)* | *1 (0.2)* |
| 3 mo | 1.2 ± 0.9 | 0.8 ± 0.6 | 0.8 ± 0.9 | 0.6 ± 0.9 | 0.5 ± 0.6 |
| | *1 (0–2)* | *1 (0–3)* | *1 (0–3)* | *0 (0–2)* | *0 (0–2)* |
| 6 mo | 1.4 ± 0.8 | 1.1 ± 0.5 | 0.7 ± 1.0 | 0.6 ± 0.8 | 0.7 ± 0.7 |
| | *1 (0–3)* | *1 (0–2)* | *0 (0–3)* | *0 (0–2)* | *0 (0–2)* |
| 12 mo | 1.6 ± 0.8 | 1.0 ± 0.4 | 0.7 ± 0.8 | 0.6 ± 0.8 | 1.0 ± 0.6 |
| | *1 (1–3)* | *1 (0.2)* | *0 (0–2)* | *0 (0–2)* | *1 (0–2)* |
| **P value** | **0.644** | **0.584** | **0.714** | **0.556** | **0.609** |
| **Malignant Neoplasms** | | | | | |
| 0 | 2.0 ± 0.7 | 1.4 ± 0.6 | 1.6 ± 0.8 | 1.2 ± 0.7 | 1.0 ± 0.8 |
| | *2 (1–3)* | *1 (1–3)* | *2 (0–2)* | *1 (0–2)* | *1 (0–3)* |
| 3 mo | 1.9 ± 0.6 | 1.1 ± 0.6 | 1.5 ± 0.9 | 1.1 ± 0.9 | 0.9 ± 0.6 |
| | *2 (1–3)* | *1 (0–2)* | *2 (0–3)* | *1 (0–3)* | *1 (0–2)* |
| 6 mo | 1.5 ± 0.5 | 0.9 ± 0.5 | 1.2 ± 0.8 | 1.1 ± 0.7 | 0.7 ± 0.7 |
| | *1.5 (1–2)* | *1 (0–2)* | *1 (0–2)* | *1 (0–2)* | *1 (0–2)* |
| 12 mo | 1.6 ± 0.7 | 1.1 ± 0.5 | 0.9 ± 1.0 | 0.7 ± 0.8 | 1.0 ± 0.5 |
| | *1 (1–3)* | *1 (0–2)* | *1 (0–3)* | *0.5 (0–2)* | *1 (0–2)* |
| **P value** | **0.08** | **0.429** | **0.151** | **0.155** | **0.504** |

\* *P* value of comparison presurgical and 3 mo postoperative results.
† *P* value of comparison presurgical and 6 mo postoperative results.
‡ *P* value of comparison presurgical and 12 mo postoperative results.

ment in overall assessment of life quality and general perception of health after MDL.

Regarding the changes of voice and QoL in patients with premalignant laryngeal lesions, there are very few studies. Precancerous lesions of leukoplakia or chronic laryngitis often occur in the setting of risk factors like smoking or gastroesophageal reflux. These lesions often affect large areas of laryngeal mucosa and the hypertrophic changes disturb the cover of the VF. Due to the extent of these lesions, voice assessments typically reveal significant disturbances. Treatment is aimed at the complete removal of the leukoplakia, often compromising epithelial sparing. Zhang et al reported a comparison of voice quality in patients with leukoplakia after laser and cold instrument MDL.[12] He evaluated patients prior to and 1 week, 1 month, and 3 months posttreatment. For both methods he found statistically signifi-

cant improvement not only in GRBAS rating but also for all analyzed acoustic parameters and VHI score. Surprisingly, the authors noted significant improvement of all parameters within 1 month postoperatively. Also of interest, the 3-month interval results for his patients were much better than for our patients. VHI scores reduced to a very mild dysphonia level—9.4 and 10.4, respectively. In comparison, our patients' VHI score for this follow-up period was 32.3. Compared to Zhang's group, the only measure we noted superior results for was in MPT (16.2 seconds compared to 15.5 seconds and 13.7 seconds). Bahannan et al considered the effectiveness of treatment for precancerous laryngeal lesions with laser microsurgery focusing on voice outcomes comparing types I–III versus types IV–V cordectomies.[14] Unfortunately, they lumped premalignant with early glottic cancers in their analysis of types I–III

**TABLE 4.**
**The Results of Aerodynamic Parameters: Maximal Phonation Time (MPT) in Seconds, Vital Capacity (VC) of Lungs in Milliliters, and Phonation Quotient (PQ) in Three Groups of Laryngeal Pathologies Prior to Microsurgery and 3 Months (3 mo), 6 Months (6 mo), and 12 Months (12 mo) Postoperatively**

| | MPT | | VC | | PQ | |
|---|---|---|---|---|---|---|
| | Mean ± SD | Median Range | Mean ± SD | Median Range | Mean ± SD | Median Range |
| **Benign Lesions** | | | | | | |
| **0** | 14.0 ± 7.0 | 12. 4 (4.1–34) | 3730 ± 1073 | 3640 (1510–6450) | 328.4 ± 210.7 | 276. 8 (113.0–1259) |
| **3 mo** | 16.6 ± 7.9* | 15.2* (3.2–40.0) | 3604 ± 1079 | 3485 (1540–6010) | 270.3 ± 160.7 | 260 (95–1169)* |
| **6 mo** | 14.1 ± 5.9 | 12.9 (3.1–30.1) | 3538 ± 829 | 3450 (1730–5780) | 285.0 ± 156.8 | 216.9 (124.9–1210) |
| **12 mo** | 15.6 ± 7.9 | 15.2 (2.3–39.4) | 3629 ± 1132 | 3665 (414–6420) | 303.2 ± 250.3 | 231.3 (40.6–1630.4) |
| *P* value | **0.016*** | | **0.067** | | **0.01*** | |
| **Precancerous Lesions** | | | | | | |
| **0** | 17.1 ± 8.3 | 16.3 (3–34) | 3581 ± 9609 | 3805 (2160–4920) | 312.2 ± 348.0 | 195.4 (75.9–1640) |
| **3 mo** | 17.1 ± 8.8 | 16.2 (6.4–35.2) | 3523 ± 944 | 3595 (1810–5190) | 276.6 ± 201.1 | 173.2 (100.7–811) |
| **6 mo** | 14.9 ± 5.1 | 15.3 (8.1–22.5) | 3612 ± 1014 | 3740 (2040–5230) | 274.4 ± 143.1 | 225.5 (126.7–587.6) |
| **12 mo** | 13.4 ± 5.72 | 12.6*** (7.3–22.1) | 3365 ± 877 | 3800 (1970–4990) | 290.3 ± 132.4 | 222 (156.3–534.2) |
| *P* value | **< 0.001*** | | **0.318** | | **0.391** | |
| **Malignant Neoplasms** | | | | | | |
| **0** | 15.1 ± 8.7 | 12.8 (3.2–36.6) | 3827 ± 887 | 3520 (2350–5170) | 385.9 ± 207.3 | 375 (112–1200) |
| **3 mo** | 16.0 ± 7.9 | 15.9 (2.4 ± 32.9) | 3829 ± 992 | 3590 (1810–4440) | 333.9 ± 299.9 | 219 (129–1296) |
| **6 mo** | 13.6 ± 7.9 | 12.6 (2.1–32.5) | 3644 ± 562 | 3755 (2470–4170) | 404.2 ± 380.3 | 278.9 (100–1629) |
| **12 mo** | 10.3 ± 5.2 | 9.1*** (2.9–21.5) | 3865 ± 875 | 3740 (2160–5250) | 495.0 ± 297.2 | 376.7 (208–1252) |
| *P* value | **0.057*** | | **0.118** | | **0.014** | |

*Abbreviation:* SD, standard deviation.
\* *P* value of comparison presurgical and 3 mo postoperative results.
\*\*\* *P* value of comparison presurgical and 12 mo postoperative results.

cordectomies. Therefore, a straightforward comparison to our results is not possible. However, the results of acoustic parameters measured were comparable to our results. Counterintuitively, Reiters et al reported patients with precancerous laryngeal lesions considered their voices as only very mildly handicapped (VHI lower than 15).[20] We did not find any studies about QoL in patients with premalignant lesions.

In contrast, the results of voice function and QoL assessments in patients with early glottic cancers are fairly well documented in the literature. However, most of the studies concentrate on a comparison between MDL and radiotherapy results. Spielmann et al in his systematic review of studies on this topic found considerable methodological heterogeneity among analyzed works, which resulted in an inability to draw unequivocal results.[18] He pleads for a consensus on analytic methods to develop

comparable results. Sjögren et al published the results of aerodynamic (MT, VC, PQ), acoustic (F0, jitter, shimmer) parameters and VHI scores, with a mean 45-month follow-up after laser microsurgery.[21] All their reported measures are better than for our patients (eg, MPT 16.17 seconds vs. 10.3; jitter 0.45 vs. 4.4; VHI 19.2 vs. 44.6). However, their study includes only T1a cancers located in the mid-portion of the VFs. Likely their results would have been negatively impacted if it had included T1b cancers and tumors infiltrating the anterior commissure. Núñez Batalla et al presented a 6-month follow-up for laser resection of early glottic cancers with comparable results to ours with a mean MPT (11.8 seconds vs. 14.9 seconds) and F0 (173.4 Hz vs. 163.7 Hz). However, jitter (0.4 vs. 3.9), shimmer (5.8 vs. 8.7), and VHI (28.8 vs. 48.3) are all lower in their study group.[22] The result of acoustics parameters presented by Tamura et al are

**TABLE 5.**
**The Results of Acoustic Parameters: Fundamental Frequency (F0) in Hz, Jitter (%), Shimmer (%), Noise-to-Harmonic Ratio (NHR) in Three Groups of Laryngeal Pathologies Prior to Microsurgery and 3 Months (3 mo), 6 Months (6 mo), and 12 Months (12 mo) Postoperatively**

| | F0 | | | Jitter | | | Shimmer | | | NHR | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean ± SD | Median | Range | Mean ± SD | Median | Range | Mean ± SD | Median | Range | Mean ± SD | Median | Range |
| **Benign Lesions** | | | | | | | | | | | | |
| 0 | 165.3 ± 54.9 | 157.9 | 72.0–405.8 | 2.3 ± 1.6 | 2.2 | 0.3–10.1 | 5.5 ± 3.0 | 4.8 | 1.8–15.7 | 0.16 ± 0.06 | 0.14 | 0.08–0.41 |
| 3 mo | 165.3 ± 44.5 | 170.4 | 87.6–293.3 | 2.0 ± 1.8 | 1.5 | 0.4–8.3 | 5.3 ± 4.6 | 4.0 | 1.8–22.9 | 0.14 ± 0.07 | 0.14 | 0.06–0.45 |
| 6 mo | 169.2 ± 45.4 | 176.1 | 94.4–308.9 | 1.8 ± 2.3 | 1.0† | 0.3–13.0 | 4.7 + 4.2 | 3.3† | 1.7–21.0 | 0.15 ± 0.09 | 0.14 | 0.07–0.65 |
| 12 mo | 178.2 ± 53.9 | 176.2‡ | 95.8–309.4 | 1.6 ± 1.3 | 1.2‡ | 0.4–7.5 | 4.0 ± 2.5 | 3.4‡ | 1.4–14.4 | 0.16 ± 0.16 | 0.13 | 0.07–1.14 |
| *P* value | | 0.015‡ | | | 0.013†<br>0.008‡<br>0.03 | | | 0.03†<br>0.015‡<br>0.034 | | | 0.408 | |
| **Precancerous Lesions** | | | | | | | | | | | | |
| 0 | 161.9 ± 49.6 | 150.3 | 93.5–263.4 | 2.8 ± 1.9 | 2.4 | 0.4–7.0 | 6.3 ± 3.6 | 5.7 | 2.2–14.3 | 0.18 ± 0.09 | 0.15 | 0.08–0.39 |
| 3 mo | 147.9 ± 46.7 | 128.7 | 81.8–222.3 | 2.9 ± 35 | 1.6 | 0.4–14.7 | 6.4 ± 5.7 | 4.2 | 2.3–22.2 | 0.20 ± 0.19 | 0.13 | 0.07–0.84 |
| 6 mo | 157.6 ± 56.2 | 134.2 | 82.9–253.5 | 2.5 ± 2.9 | 1.0 | 0.3–8.4 | 6.0 + 4.0 | 4.4 | 2.0–13.5 | 0.20 ± 0.20 | 0.14 | 0.08–0.84 |
| 12 mo | 175.5 ± 76.2 | 143.5 | 100.3–301.6 | 2.3 ± 1.5 | 2.3 | 0.7–5.3 | 4.9 ± 3.1 | 4.1 | 1.6–11.1 | 0.73 ± 1.61 | 0.14 | 0.11–5.51 |
| *P* value | | 0.224 | | | 0.318 | | | 0.856 | | | 0.285 | |
| **Malignant Neoplasms** | | | | | | | | | | | | |
| 0 | 186.6 ± 88.1 | 159.8 | 98.3–454.9 | 4.8 ± 3.5 | 3.5 | 0.6–9.9 | 12.2 ± 8.4 | 8.5 | 3.4–26.8 | 0.3 ± 0.2 | 0.2 | 0.1–0.8 |
| 3 mo | 148.9 ± 32.4 | 151.1 | 99.5–190.2 | 3.4 ± 2.2 | 2.7 | 0.7–8.6 | 8.1 ± 4.2 | 6.8 | 2.8–17.5 | 0.2 ± 0.1 | 0.2 | 0.1–0.7 |
| 6 mo | 163.7 ± 45.6 | 157.8 | 99.3–248.1 | 3.9 ± 3.0 | 2.4 | 0.8–12.2 | 8.7 ± 4.9 | 8.0 | 2.9–19.5 | 0.3 ± 0.2 | 0.2 | 0.1–0.6 |
| 12 mo | 149.2 ± 44.4 | 138.2 | 103.8–282.1 | 4.4 ± 4.9 | 1.8 | 0.6–19.3 | 8.9 ± 6.8 | 5.9 | 0.3–22.1 | 0.3 ± 0.3 | 0.2 | 0.1–1.1 |
| *P* value | | 0.457 | | | 0.477 | | | 0.652 | | | 0.773 | |

*P value of comparison presurgical and 3 mo postoperative results.
† P value of comparison presurgical and 6 mo postoperative results.
‡ P value of comparison presurgical and 12 mo postoperative results.
*Abbreviation:* SD, standard deviation.

**TABLE 6.**
**The Results of Self-assessed Voice Quality With the Voice Handicap Index (VHI) and the Quality of Life With the Voice-Related Quality of Life (VRQoL) and the World Health Organization Quality of Life Scale-Brief Version (WHOQoL-BREF) in Three Groups of Laryngeal Pathologies Prior to Microsurgery and 3 Months (3 mo), 6 Months (6 mo), and 12 Months (12 mo) Postoperatively**

| | VHI | | VRQoL | | Q1 | | Q2 | | Domain1 | | Domain2 | | Domain3 | | Domain4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean ± SD | Median | Mean ± SD | Median | Mean ± SD | Median | Mean ± SD | Median | Mean ± SD | Median Range | Mean ± SD | Median Range | Mean ± SD | Median Range | Mean ± SD | Median Range |
| **Benign Lesions** | | | | | | | | | | | | | | | | |
| 0 | 32.1 ± 19.6 | 30 (0–80) | 17.4 ± 6.7 | 15.0 (10–38) | 3.1 ± 0.8 | 4 (2–5) | 3.1 ± 0.9 | 3 (2–5) | 54.8 ± 11.2 | 56 (31–81) | 66.4 ± 11.1 | 69 (31–88) | 66.8 ± 19.2 | 72 (19–100) | 68.2 ± 12.9 | 69 (44–100) |
| 3 mo | 24.7 ± 22.3* | 18* (0–95) | 15.6 ± 6.5 | 13 (10–35) | 3.8 ± 0.8 | 4* (1–5) | 3.4 ± 0.8 | 4 (1–5) | 53.2 ± 10.0 | 56 (31–69) | 62.3 ± 10.7 | 63 (38–88) | 67.2 ± 15.7 | 75 (31–100) | 66.3 ± 12.2 | 57 (31–100) |
| 6 mo | 24.0 ± 21.3 | 17 (0–84) | 15.8 ± 6.6 | 13 (10–37) | 3.8 ± 0.6 | 4 (2–5) | 3.4 ± 0.9 | 4 (1–5) | 55.4 ± 9.9 | 56 (31–69) | 63.5 ± 12.7 | 69 (25–88) | 69.4 ± 17.3 | 72 (31–100) | 68.7 ± 14.1 | 69 (25–100) |
| 12 mo | 21.0 ± 18.0 | 20‡ (0–66) | 17.2 ± 13.7 | 12 (10–88) | 3.7 ± 0.7 | 4‡ (2–5) | 3.5 ± 0.8 | 4‡ (2–5) | 54.8 ± 11.3 | 56 (25–68) | 64.3 ± 13.6 | 69 (19–81) | 68.1 ± 16.7 | 45 (19–94) | 68.8 ± 14.8 | 69 (13–94) |
| *P* value | **0.01*** **0.003‡** | | **0.12** | | **0.01*/‡** | | **0.002‡** | | **0.293** | | **0.581** | | **0.148** | | **0.905** | |
| **Precancerous Lesions** | | | | | | | | | | | | | | | | |
| 0 | 36.2 ± 26.8 | 29.5 (0–97) | 18.4 ± 9.3 | 14 (10–38) | 3.6 ± 0.7 | 4 (2–5) | 2.8 ± 1.2 | 3 (1–4) | 53.6 ± 29.9 | 56 (25–69) | 62.2 ± 13.5 | 69 (31–81) | 67.3 ± 16.8 | 69 (31–100) | 65.7 ± 10.1 | 69 (50–81) |
| 3 mo | 32.3 ± 29.7 | 22 (0–101) | 17.9 ± 9.5 | 13.5 (10–45) | 3.3 ± 0.7 | 3 (2–4) | 3.0 ± 0.7 | 3 (2–4) | 59.9 ± 14.7 | 59.5* (31–88) | 57.9 ± 12.9 | 56 (38–88) | 71.5 ± 17.2 | 75 (25–100) | 65.4 ± 18.7 | 66 (25–94) |
| 6 mo | 24.9 ± 22.9 | 22.5 (0–86) | 15.3 ± 7.8 | 13.5 (2–32) | 3.4 ± 0.6 | 3.5 (2–4) | 3.1 ± 0.9 | 3 (1–4) | 48.9 ± 7.6 | 47 (38–63) | 59.1 ± 12.6 | 59.5 (38–81) | 65.9 ± 17.8 | 69 (25–100) | 67.4 ± 13.3 | 72 (44–88) |
| 12 mo | 33.4 ± 28.5 | 27 (2–91) | 16.5 ± 9.9 | 15 (3–37) | 3.3 ± 0.5 | 3 (3–4) | 3.2 ± 0.5 | 3.5 (1–4) | 49.5 ± 11.9 | 44‡ (31–75) | 49.0 ± 21.6 | 50 (19–81) | 70.8 ± 19.8 | 75 (31–100) | 68.2 ± 7.9 | 69 (50–75) |
| *P* value | **0.477** | | **0.479** | | **0.467** | | **0.144** | | **0.012*** **0.03‡** | | **0.309** | | **0.271** | | **0.732** | |
| **Malignant Neoplasms** | | | | | | | | | | | | | | | | |
| 0 | 35.3 ± 19.7 | 35 | 18.6 ± 6.9 | 17 (10–32) | 3.4 ± 0.8 | 3.0 (2–5) | 3.1 ± 0.9 | 3 (2–5) | 51.8 ± 13.1 | 50 (31–81) | 61.5 ± 9.7 | 56 (50–81) | 66.4 ± 14.5 | 69 (44–100) | 65.5 ± 11.9 | 69 (50–88) |
| 3 mo | 49.5 ± 22.8 | 54.0 (0–78) | 22.4 ± 7.6 | 23 (0–35) | 3.3 ± 0.7 | 3 (2–4) | 2.9 ± 0.9 | 3 (1–4) | 55.5 ± 9.4 | 56 (38–75) | 59.3 ± 10.6 | 56 (44–75) | 64.1 ± 11.2 | 69 (44–81) | 65.9 ± 12.6 | 63 (50–88) |
| 6 mo | 48.3 ± 25.4 | 33.5 (0–83) | 21.9 ± 9.1 | 19 (10–28) | 3.4 ± 0.9 | 4 (1–4) | 2.7 ± 1.1 | 2 (1–4) | 52.2 ± 9.7 | 56 (38–63) | 62.6 ± 8.6 | 63† (50–75) | 65.1 ± 15.3 | 65.5 (44–94) | 67.0 ± 14.8 | 63 (38–94) |
| 12 mo | 44.6 ± 30.4 | 48 (0–99) | 23.1 ± 9.8 | 22 (10–39) | 3.5 ± 0.5 | 4 (3–4) | 3 ± 1 | 3 (1–4) | 52.5 ± 10.6 | 56 (44–69) | 57.9 ± 8.4 | 56 (44–69) | 61.7 ± 12.9 | 56 (44–75) | 66.7 ± 13.4 | 69 (44–81) |
| *P* value | **0.074** | | **0.214** | | **0.808** | | **0.977** | | **0.431** | | **0.038†** | | **0.091** | | **0.675** | |

\* *P* value of comparison presurgical and 3 mo postoperative results.
† *P* value of comparison presurgical and 6 mo postoperative results.
‡ *P* value of comparison presurgical and 12 mo postoperative results.
*Abbreviation:* SD, standard deviation.

similar in F0 to ours, but their jitter and shimmer values are again lower—reported at a longer follow-up period of over 24 months.[23] The already mentioned work of Bahannan et al compared acoustics parameters for types I–III versus types IV–V laser cordectomies.[14] The presented findings after cordectomies of types IV–V are similar to those achieved in our group (jitter 6.5 vs. 4.4; shimmer 11.1 vs. 8.9, NHR 0.28 vs. 0.3). Chu et al also presented voice parameters 6 months after extended laser cordectomies (types III–V), which are comparable with our findings.[24] Regarding QoL measure after surgery for early laryngeal carcinoma, Loughran et al reported decreased QoL following treatment.[25] Our findings of significantly worse VHI results at 3 months postoperatively may be explained by prolonged healing associated with more radical endoscopic surgery coupled with initial patient anxiety and depression associated with a cancer diagnosis. However, this VHI deterioration was not reflected in poorer VRQoL or WHO-BREF scores. Fortunately, 12 months after laser MDL the VHI results were again comparable to those estimated prior to treatment. Similar to our observation, Vilaseca et al using different QoL questionnaires demonstrated improvement of global QoL in patients with early glottis cancer 1 year after the laser treatment.[26] However, the comparison of scores values is impossible due to limited data reporting and because of the variety of questionnaires used by authors.

A cautionary and attention demanding is the observation that the voice quality results, especially MPT and VHI, during the 1-year follow-up are not constant over the time in patients with premalignant and malignant changes compared to benign lesions. On the basis of these results we implemented additional voice rehabilitation approximately 6 months after surgery in these two groups of patients, to verify whether or not it can maintain the initial results of voice quality. The other aspects demanding further analysis are smoking habits and comorbidities, especially chronic obstructive pulmonary disease in those two groups of patients.

## CONCLUSIONS

- The microsurgical treatment of benign laryngeal lesions resulted in superior postoperative results when compared to the preoperative state, and compared to precancerous and malignant lesions. Benign lesions demonstrated significant improvement in both objective and subjective measures. Most of the parameters improved in a short interval after surgery but were even better at 1-year follow-up.
- The treatment of premalignant lesions of VFs resulted in mixed results of some nonsignificant improvements and deterioration in voice quality measurements with subjective and objective methods. These mixed results are likely due to more extensive surgery overall than is associated with benign lesions. This group of laryngeal lesions is the least studied, making the comparison of results from other studies difficult.
- Treatment of early glottic cancers with laser cordectomies also resulted in mixed results of some nonsignificant improvements and deterioration in voice quality measurements with subjective and objective methods. Results in this group are affected by the extent, and in particular, the depth of resection. The extent of surgery and psychological factors mentioned previously likely explains the significant deterioration in self-assessed voice quality in the first postoperative assessment. This deterioration almost recovered to preoperative status at 1-year follow-up. This information should be considered when counseling patients.
- Future studies employing this comprehensive evaluatory protocol with at least 1-year follow-up would generate better data fit for comparison and better define treatment outcomes for various laryngeal pathologies.

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