ORIGINAL ARTICLE

The Use of the Mobile Voice Laboratory in the Operating Room During Type I Thyroplasty With Gore-Tex®

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KEYWORDS
Spectrogram; Mobile voice laboratory; Unilateral vocal fold paralysis; Type I thyroplasty

Abstract

Introduction and objective: The purposes of this study are to demonstrate the use of the mobile voice lab in type I thyroplasty with Gore-Tex® using analysis of spectrogram and fundamental frequency in the operating room, and also to show how to do this procedure.

Methods: Voice samples were recorded in the operating room immediately before and during type I thyroplasty. Six-week postoperative samples were also taken in the voice laboratory. Fundamental frequency and spectral analysis were analyzed. Spectrograms were evaluated by a blind panel of 4 judges on a 100 mm visual analogue scale. All three time points were compared and statistical analysis performed. Pre and postoperative V-RQOL scores were also compared.

Results: Significant improvement in spectrogram ratings were seen between before and during (P < .001), and before and after voice samples (P < .017). There was no significant difference between during and after scores, suggesting the persistence of the intraoperative improvement in this measure. Changes in fundamental frequency were not statistically significant, although fundamental frequency tended to increase in women and decrease in men after type I thyroplasty. Mean V-RQOL scores improved from 48.08 to 85.08 (P < .001).

Conclusions: The mobile voice laboratory may be useful during type I thyroplasty with Gore-Tex®. It offers an opportunity for the surgeon and voice pathologist to continue to collaborate in the treatment of patients with unilateral vocal fold paralysis.

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Uso del laboratorio móvil de voz en la sala de operaciones durante tiroplastia tipo I con Gore-Tex®

Resumen

Introducción y objetivos: Los objetivos de este estudio fueron la demostración del uso del laboratorio móvil de voz durante la tiroplastia tipo I con Gore-Tex®, utilizando análisis de espectrograma y frecuencia fundamental en el quirófano, además de mostrar el modo de realización de este procedimiento.

Métodos: Las muestras de voz fueron grabadas en la sala de operaciones inmediatamente antes, y durante la tiroplastia tipo I. También se tomaron muestras 6 semanas después de la cirugía. Se realizó un análisis de la frecuencia fundamental, y un análisis espectral de la voz. Los espectrogramas fueron evaluados por 4 jueces externos, utilizando una escala visual de 100 mm. Se compararon los 3 puntos temporales (antes, durante y después), y posteriormente se realizó un análisis estadístico. Adicionalmente se realizó una comparación de las puntuaciones del cuestionario V-RQOL pre y poscirugía.

Resultados: Se obtuvo una mejoría significativa de los valores de los espectrogramas tomados antes y durante la cirugía (p < 0,001), y antes y después de la cirugía (p < 0,017). No hubo diferencia entre las muestras tomadas durante y después, resaltando la importancia de la mejoría intraoperatoria de esta medición. Los cambios en la frecuencia fundamental no fueron estadísticamente significativos, aunque este parámetro mostró una tendencia al incremento en mujeres y una disminución en varones tras la tiroplastia. El promedio del cuestionario V-RQOL experimentó un incremento de 48,08 a 85,08 (p < 0,001).

Conclusiones: Los resultados muestran que el laboratorio móvil de voz puede ser útil durante la tiroplastia tipo I con Gore-Tex®. Esta herramienta ofrece una oportunidad de colaboración conjunta entre el cirujano y el logopedista en el tratamiento de pacientes con parálisis unilateral de cuerda vocal.

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Introduction

Unilateral vocal fold paralysis (UVFP) usually presents as a breathy voice due to failure of the vocal folds to approximate during adduction.1 A patient with UVFP may also present with reduced phonatory duration, diplopia, restricted pitch range, reduced loudness, air hunger, dysphagia, and even aspiration.2-4 The goals of treatment for UVFP are to improve voice and swallowing function by improving glottic closure.

Treatment options for UVFP include voice therapy, injection laryngoplasty, laryngeal framework surgery, and reinnervation procedures. Type I thyroplasty is probably the most frequently used permanent surgical intervention and should be performed only once it has been determined that the vocal fold will not regain function. It is typically performed when the patient is awake, so that he or she may perform phonatory tasks to help the surgeon design the optimal implant. The surgeon must work quickly, as intraoperative edema will affect the voice and make it difficult to determine when the ideal implant has been fashioned.

A number of implant materials have been described for type I thyroplasty, including silastic,5 Gore-Tex®,6,7 hydroxylapatite,8 and others. An advantage of Gore-Tex® is that subtle alterations may be made to the implanted Gore-Tex® during the procedure without removing it or needing to recarve a more solid implant. This allows for quicker fine-tuning of the voice.

The success of the surgery is dependent on the ability of the surgeon to fashion and position an implant to create the ideal glottic configuration to yield the strongest voice. The surgeon’s ear and ability to perceptually analyze the voice are critical.

Some have suggested, however, that fewer than 50% of surgeons’ expected outcomes based on perceptual judgments are predictable due to the complexity of voice production.9 Therefore, having the ability to obtain intraoperative objective voice measures could help in the decision-making process. Certainly the surgeon’s ear is the primary determinant, but using the mobile voice laboratory provides additional data that may facilitate the surgeon’s decision to alter the implant.

Objective voice analysis, assessment, and treatment by the voice pathologist are valuable in the care of the patient with UVFP. In some cases, voice therapy alone may provide significant improvement in voice quality and obviate the need for surgery.9 In all cases, the voice pathologist can provide detailed preoperative and postoperative assessment.10 Objective voice data are obtained through computerized voice analysis. Such data are useful for evaluating efficacy of treatment. Computerized voice analysis can also be performed on recordings of patients’ voices prior to their injury (e.g. from an answering machine recording, home video, or professional recording) and in the operating room. This additional data may help the surgeon design an implant to try to recover the patient’s pre-injury voice.

The purposes of this study are to demonstrate the use of the mobile voice lab in type I thyroplasty with Gore-Tex® using analysis of spectrogram and fundamental frequency in the operating room, and also to show how to do this procedure.
Methods

An exemption was obtained from the institutional review board for the publication of this study. This retrospective study included 8 male and 7 female patients with UVFP who were selected from Lakeshore Professional Voice Center, Lakeshore Ear, Nose, and Throat Center. Initial diagnosis of UVFP was made with dynamic voice evaluation and videostroboscopy by a laryngologist (ADR). A formal computerized voice evaluation was then performed by a voice pathologist (CJM). The evaluation includes a complete detailed objective and perceptual analysis of the patient’s digitally DAT recorded with a Professional Voice Recorder Marantz (PMD670) and the recording analyzed with the Kay CSL 4400. A perceptual voice analysis (GRBAS scale) and V-RQOL questionnaire (voice-related quality of life) are also performed during the initial voice evaluation. The V-RQOL is a validated, patient-completed, 10 item, five-point instrument that measures the physical and social/emotional impact of dysphonia. A standard algorithm is used to calculate domain or overall score from 0 to 100, with higher scores indicating better V-RQOL.11-13

During type I thyroplasty in operating room, objective measures using fundamental frequency and narrow band spectrogram are taken immediately before the procedure and as the implant is fashioned until the optimal subjective voice quality is achieved and judged by the laryngologist and voice pathologist. The spectrographic analysis and fundamental frequency obtained help to compare the voice before and during the procedure. The fundamental frequency and spectral analysis are obtained using a real-time spectrogram with a narrow band filter, sample rate recording at 44.1 kHz, and a view cut spectrogram at 4 kHz. To test the voice, the patient is asked to produce the following phonatory tasks: sustained vowel /a/, days of the week, months, sing “Happy Birthday”, and perform a glissando in a supine position. The narrow-band analysis is preferred because the goal is to display frequency resolution, as in the analysis of harmonics for a human’s voice.

The mobile voice laboratory consists of a laptop computer with Windows XP, a pre-amplifier M-Audio, a condenser professional microphone Shure 16-A, and real-time spectrogram software (WaveSurfer® version 1.5.8 and Audio® version 1.0) (Fig. 1). These programs can be opened in multiple windows, so multiple samples can be analyzed simultaneously. Therefore, precious time is not wasted during the procedure. The patient’s new voice, with the Gore-Tex® in place, is compared to the recordings and voice parameters of the pre-paralyzed vocal fold voice. It is important that the patient is not sedated during this part of the procedure.

Fundamental frequency and spectrograms were compared in every patient from recordings from preoperative assessment, during the procedure, and six weeks postoperatively (Fig. 2). Spectrogram prints without sound were evaluated by a blind panel of four judges on a 100 mm visual analogue scale, where 0=no harmonics are present in the spectrogram, only noise, and 100=there are only harmonics from the bottom to the top of the spectrogram. No noise is present. Using external judges with expertise in reading spectrograms without using perceptual analysis of the same phonatory tasks before, during and after surgery allows us to know if the mobile voice laboratory in the operating room helps the laryngologist to have another tool besides the perceptual voice judgment to decide how much implant the patient needs. Raters were asked to mark with an “x” the point of the visual analogue scale which best describes the spectrogram. All three time points were compared and statistical analysis performed. The four judges were voice pathologists with more than 10 years of experience in voice disorders and acoustical analysis of voice.

Raters were given written instructions with forty-five spectrogram pictures; fifteen before surgery, fifteen during surgery, and fifteen postoperative. All spectrograms were ordered randomly to avoid pattern recognition. Raters were allowed to see every spectrogram as many times as needed to make their assessments.

The statistical analysis was performed using SPSS® v.18.0 for Windows. Reliability analysis and the inter-class correlation coefficient (ICC) were applied to measure the inter-rater agreement in the spectrogram rates. Repeated measures analysis of variance (ANOVA) also was applied to test for differences over time (preoperative versus postoperative). P value < .05 was considered statistically significant.

Results

Fifteen patients (eight male and seven female) with UVFP were included in this study. Fundamental frequency and spectrograms were compared in every patient via recordings from the preoperative assessment, during the procedure, and six weeks postoperatively. The mean ratings and standard deviations for the spectrogram judgment on a 100 mm visual analogue scale are presented in Table 1. Mean values for preoperative spectrograms were rated at 24.65, intraoperative spectrograms at 56.40, and six-week postoperative spectrograms at 43.62. These results show a significant change in the judges’ ratings over the three times points (before, during, and after). The mean differences of before, during and after are listed in Table 2. Significant statistical differences were observed between before/during, and before/after. No significant difference was observed between during and after scores.

The reliability analysis and the ICC measured the inter-rater agreement in the spectrogram rates, considering the three time points (before, during and after). The overall ICC value was 0.546 (P < .001). This data shows consistency between the judges’ evaluation of the spectrograms.

The average and standard deviations for fundamental frequency (F0) are presented in Table 3. Even though there is a trend in F0 change (male F0 decreases, female F0 increases), the time–gender interaction is not statistically significant.

The pre-thyroplasty median V-RQOL score was 48.08, whereas the post-thyroplasty median score was 85.08. The average difference from initial to final V-RQOL measurement was an increase of 44 units. The final V-RQOL measurements were significantly higher than the initial VRQOL measurements (P < .001).

Discussion

The primary goal of a type-I thyroplasty is to improve glottic closure; thus improving patient voice and swallowing
The "ideal" glottic configuration is the one that yields the optimal voice quality. The patient should be kept awake during thyroplasty, so that his or her voice may be tested and heard. Thus, the shape and placement of the implant may be altered to improve vocal quality. The surgeon's ability to perceptually analyze the voice during the procedure in an expedient fashion is critical. This ability will vary amongst even technically gifted surgeons. Having the ability to obtain intra-operative objective voice measures may assist the surgeon in the decision-making process.

The spectrogram demonstrates the strength of the harmonics in a voice sample. Improvement in spectral pattern can be monitored in the operating room and is a useful measure of the improvement in vocal quality. As the voice becomes clearer, the spectrogram demonstrates less "noise", and the harmonics extend into higher frequencies. The judges in the study demonstrated a significant

<table>
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<th>Measure</th>
<th>Measure 2</th>
<th>Mean Difference</th>
<th>Significance</th>
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<tbody>
<tr>
<td>Before</td>
<td>During</td>
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<td>0.001</td>
</tr>
<tr>
<td>Before</td>
<td>After</td>
<td>18.96</td>
<td>0.017</td>
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<tr>
<td>During</td>
<td>After</td>
<td>12.78</td>
<td>0.197</td>
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improvement in the intraoperative spectrograms compared to preoperative ratings. Although the ratings 6-weeks postoperatively were slightly worse, there was no significant difference from the intraoperative scores. The 6-week scores were significantly better than the preoperative ratings. This suggests that the improvement seen in spectral pattern intraoperatively is maintained even when postoperative swelling resolves.

One criticism of the study is that it is difficult to rate spectrograms. We used a visual analogue scale to try to obtain a numerical score for each spectrogram. Although this is not a validated outcome measure, inter-rater reliability was fairly good.

Although the F0 ANOVA pair-wise comparisons were not statistically significant, the trend of the F0 makes sense. Male voices with UVFP tend to start out higher in frequency, as they strain to obtain stronger voice. As the glottic insufficiency is corrected, the male F0 should be lower. The fundamental frequency of a woman’s voice tends to drop with a vocal fold paralysis. However, once glottic closure is improved, the F0 should rise.

Harries and Morrison\textsuperscript{15} wrote, “the degree of patient satisfaction is one of the most important parameters of the success of surgical treatment, perhaps more than any objective changes”. The V-RQOL is a validated voice outcome measure. The statistical significance of the student t-test analysis performed upon the V-RQOL data indicates a high patient satisfaction rating six weeks after surgery (P.<0.001). Hogikyan et al.\textsuperscript{12} performed a similar V-RQOL analysis upon post-thyroplasty patients at the University of Michigan in 2000. The improvement demonstrated in our study is consistent with their findings. The study does not prove that using the mobile voice laboratory yields better voice results during thyroplasty than using only the surgeon’s ear. However, it does demonstrate that the improvement seen in these patients’ spectrogram scores is consistent with improvement in their own perceptions of their voice quality.

The UVFP patient’s best chance of achieving an optimal voice is with the first thyroplasty. Revision surgeries tend to be difficult and risky.\textsuperscript{16,17} Intraoperative vocal fold edema will affect the patient’s voice and may compromise the ultimate result of the surgery. The surgeon must proceed in a timely manner to get the truest assessment of vocal quality. The use of Gore-Tex\textsuperscript{8} allows the surgeon to make millimeter adjustments without taking the time to remove and recarve a traditional silastic implant. Using the mobile voice laboratory provides additional data that can facilitate the surgeon’s decisions to alter the implant.

Other problems with this study include a small sample size and the fact that it is a retrospective study. Unfortunately, only a fraction of the patients on whom we performed thyroplasty completed a postoperative voice evaluation. Furthermore, a prospective study comparing thyroplasty results when and when not using the mobile voice laboratory might better demonstrate its usefulness. Such a study could be considered in the future. However, the purpose of this study was not to suggest that the mobile voice laboratory is required to perform this surgery well. Rather, we are suggesting that it may be a useful tool to assist the surgeon. Furthermore, by bringing the voice pathologist into the operating room, a collaborative, team approach to the voice patient is continued.

### Conclusions

Intra-operative objective voice measures can be useful in the decision making process during type I thyroplasty with Gore-Tex\textsuperscript{8}. Although subjective assessment of voice quality is critical while fashioning an implant, the mobile voice laboratory provides additional objective data which may help the surgeon make timely decisions. The real time spectrogram and fundamental frequency can be analyzed in the operating room despite the background noise of the operating equipment, unlike many other voice parameters. Improvement in spectrogram persists at the 6-week postoperative evaluation. The mobile voice laboratory also provides an opportunity for the surgeon and voice pathologist to continue to collaborate in the treatment of the patient with UVFP.

### Conflict of Interest

The authors declare no conflict of interest.

### References


