Combination of Autologous Fascia Lata and Fat Injection Into the Vocal Fold via the Cricothyroid Gap for Unilateral Vocal Fold Paralysis

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Objectives: To apply the technique of injection of a combination of autologous fascia lata and fat into the vocal fold via the cricothyroid gap for unilateral vocal fold paralysis and to evaluate the therapeutic effect in 12 patients who underwent the procedure.

Design: Retrospective analysis of 12 patients.

Setting: Academic research.

Patients: A mixture of autologous fascia lata and fat was injected into the thyroarytenoid muscle of the paralyzed vocal fold in 12 patients.

Main Outcome Measures: Videolaryngostroboscopy was performed to observe the changes to the vocal fold. The patients’ phonatory function before and after surgery was assessed by computerized acoustic analysis and by blinded perceptual evaluation.

Results: Videolaryngostroboscopy demonstrated that the paralyzed vocal folds in these patients were pushed medially after the procedure. Statistically significant improvements were found in the perturbation measurements (jitter and shimmer), harmonics to noise ratio, and maximum phonation time. Ratings by a panel of voice experts also showed each voice to be statistically significantly improved after the procedure. No complications were noted.

Conclusion: A combination of autologous fascia lata and fat injected into the vocal fold for unilateral vocal fold paralysis is a safe and effective therapy.


Peripheral unilateral vocal fold paralysis can lead to glottal insufficiency, influence effective vibration of the vocal fold, and cause pararhria. Injection into the vocal fold can effectively remedy the glottal insufficiency, with improvement in voice quality. Autologous fascia lata and fat are considered ideal materials for injection because of good tissue compatibility,1-10 and maturation of autologous fascia lata is characterized by active collagen remodeling for up to 12 months.11 In recent years, we have treated peripheral unilateral vocal fold paralysis by injecting a combination of autologous fascia lata and fat into the vocal fold through the cricothyroid gap. To objectively evaluate the long-term therapeutic effect of this injection procedure, we undertook a retrospective study of 12 patients.

PERIPHERAL UNILATERAL VOCAL FOLD PARALYSIS can lead to glottal insufficiency, influence effective vibration of the vocal fold, and cause pararhria. Injection into the vocal fold can effectively remedy the glottal insufficiency, with improvement in voice quality. Autologous fascia lata and fat are considered ideal materials for injection because of good tissue compatibility,1-10 and maturation of autologous fascia lata is characterized by active collagen remodeling for up to 12 months.11 In recent years, we have treated peripheral unilateral vocal fold paralysis by injecting a combination of autologous fascia lata and fat into the vocal fold through the cricothyroid gap. To objectively evaluate the long-term therapeutic effect of this injection procedure, we undertook a retrospective study of 12 patients.

METHODS

PATIENTS

Eighteen patients with peripheral unilateral vocal fold paralysis were operated on. To evaluate the effect of the surgery on voice quality, the selection criteria of patients were defined as follows: age 18 to 75 years, disease duration longer than 6 months, and evidence of clinical symptoms and need for surgery. The exclusion criteria for the study included patients with ongoing malignant tumor, those previously treated with other augmented or medialized surgical procedures, and those with incomplete clinical data. Based on these criteria, 3 patients were excluded from the study, 1 for each of the following reasons: age younger than 18 years, disease duration shorter than 6 months, and no acoustic variable analysis before surgery because of machine malfunction. Two patients were unavailable for follow-up, and 1 patient died of lung cancer. Therefore, 6 patients were excluded, and the study in-
included 12 patients (8 men and 4 women ranging in age from 21-68 years [mean age, 44.3 years]). The disease duration ranged from 0.5 to 18 years, and the vocal fold paralysis included 4 cases on the right side and 8 cases on the left side (9 median, 2 paramedian, and 1 lateral). The causes of vocal fold paralysis included thyroid surgery (n=5), idiopathic neuritis (n=3), other surgical procedures of the neck (n=2), surgery of the mediastinum thoraces (n=1), and trauma of the neck (n=1). Preoperative electromyographic testing confirmed that all patients included in the study had a lesion of the recurrent laryngeal nerve of neurogenic origin. Hoarseness and severe dysphonia were present in all patients; 5 patients reported shortness of breath when vocalizing, 5 patients had dizziness, and 2 patients experienced bucking in hydropisia. Videolaryngostroboscopy using a 70° rigid telescope (model 8702D; Karl Storz, Tuttlingen, Germany) showed that 10 patients had no contact of the paralyzed vocal fold inward. After confirming the pathway, a sufficient amount of paste mixture of fascia lata and fat for the anterior median (one third), middle, and posterior median (one third) of the thyroarytenoid muscle was injected to equally raise the medial edge of the paralyzed vocal fold inward (Figure 2). The medial margin of the vocal fold was then gently stroked with a suction tip to make the contour even. The degree of augmentation was based on the location of the medial edge of the paralyzed vocal fold; to achieve overcorrection, it was necessary to inject 2.0 to 2.5 mL to move the fold slightly (1.0-1.5 mm) beyond the normal physiologic location of the vocal fold. Patients with atrophy of the paralyzed vocal fold received a greater injection volume.

After surgery, the patients remained silent and inhaled an atomized budesonide suspension for 5 days. Patients were instructed to begin to phonate 5 days after surgery.

**SURGICAL PROCEDURES**

Five milliliters of fat and 3 × 4 cm of fascia lata were harvested from an incision on the lateral aspect of the thigh. The fascia was minced into tiny 0.5-mm pieces with scissors. The fat was minced into a volume of about 1.0 to 1.5 mm³ and then placed on rayon gauze and thoroughly rinsed with lactated Ringer solution to separate the remaining blood, free fatty acids, and cellular debris. The fascia lata and globular fat were blended in a ratio of 2:1 and were then poured into an injection syringe connected to an extradural puncture needle without a stylet.

Using general anesthesia and endotracheal intubation, a suspension laryngoscope was set to expose the laryngeal lumen and vocal fold for microsurgery (Figure 1). To achieve satisfactory adduction of the arytenoid cartilage, we intubated the patient using a small-diameter tube of 6 mm. At the beginning of surgery, the cricoarytenoid joint was noted to be mobile by palpation. With monitoring by a camcorder system and microscopic control, starting from 3 mm to the side of the anterocervical median line, the extradural puncture needle was inserted into the arch of the superior border of the cricoid cartilage. For this procedure, the needle head should be inclined back toward the mucosa, moved through the cricothyroid membrane, and soon inserted medially and superiorly toward the vocal fold of the same side, passing directly into the vocal fold without entering the laryngeal lumen, while avoiding piercing the mucosa.

Videolaryngostroboscopy was performed to observe changes to the vocal fold. To assess changes in phonatory function caused by the injection, computerized acoustic analysis and blinded perceptual evaluation were performed and were compared before surgery and 12 months after surgery. Patients were followed up for 12 to 24 months after surgery (mean follow-up, 16.6 months). During evaluation, the patients were instructed to sustain the vowel sound /iː/ for 2 seconds. A 2-second data sample was used for analysis with computer speech laboratory software (Dr Speech, version 4; Tiger DRS Inc, Shanghai, China). Acoustic variables were analyzed for jitter, shimmer, normalized noise energy, and harmonics-to-noise ratio. Each patient had several rehearsals of the maximum phonation time test during voice training. Of 2 consecutive recordings as already described, the longer-lasting performance was used for the evaluation. The severity of disorder for each variable in the blinded perceptual evaluation, including grade, roughness, breathiness, and ashenia as described by De Bodt et al, was categorized as normal (score of 0), mild (score of 1), moderate (score of 2), or severe (score of 3). Voice quality was assessed by a panel of 4 voice experts comprising 2 phoniatrists and 2 speech-
language pathologists; each expert had a minimum of 10 years’ experience in clinical voice pathologic analysis.

Scores were compared for each variable, and the mean values were determined before and after surgery. Differences were analyzed by paired t test using commercially available statistical software (SPSS version 10.0; SPSS Inc, Chicago, Illinois). Statistical significance was defined as P < .05.

RESULTS

SYMPTOMS AFTER SURGERY

Eleven of 12 patients showed improvement after surgery: conscious phonatory capability and voice quality were improved, and symptoms of fatigue and sore throat were relieved or eliminated. One patient underwent re-injection 3 months after the first operation, and symptom improvement was satisfactory. All patients with severe dysphonia had no symptoms of dysphonia after surgery. Shortness of breath when vocalizing, dizziness, and bucking in hydropopsia also disappeared or were relieved. No dyspnea occurred after injection.

VIDEO-LARYNGOSTROBOSCOPY

The injected side of the vocal fold demonstrated notable hyperemia and swelling, which gradually subsided after 1 week (Figure 3) and disappeared by 1 month after surgery. The volume of the injected vocal fold was slightly reduced, and the medial edge of the paralyzed vocal fold, which had exceeded the median line, had returned to the median line by 3 months after surgery. The volume of the vocal folds remained stable at 3 months after surgery, the paralyzed vocal folds in our patients were pushed medially, and the glottis closed well on phonation (Figure 4). The results of follow-up evaluations at 6, 12, and 24 months after surgery showed no notable volume decreases of the injected vocal folds compared with those at 3 months after surgery. Videolaryngostroboscopy revealed significant improvements in vocal fold vibration amplitude and mucosal wave excursion. Mucosal wave amplitude symmetry and phase synchrony were present in most patients, with partial closure and phase synchrony in all patients with proper glottal closure. No signs of hampered mucosal waves were noted.

ACOUSTIC ANALYSIS AND PERCEPTUAL EVALUATION AFTER SURGERY

Acoustic analysis showed that voice quality improved markedly by 12 months after surgery (Table 1). The mean maximum phonation time increased from 4.76 seconds before surgery to 9.26 seconds at 2 weeks after surgery and to 11.89 seconds at 12 months after surgery and remained stable after 12 months. There was significant improvement (P < .001) in all acoustic variables measured, including jitter, shimmer, harmonics-to-noise ratio, and maximum phonation time. Blinded perceptual evaluation of voice quality by a panel of voice experts demonstrated that postoperative voices were significantly better than preoperative voices in terms of grade, roughness, breathiness, and asthenia (P < .001 for all) (Table 2). Phonatory function improved gradually and continually with increasing follow-up time. No complications were noted after 12 to 24 months.

COMMENT

The following 3 types of surgical techniques are used for the treatment of unilateral vocal fold paralysis: vocal fold augmentation by injection of various substances, laryngeal framework surgery (medialization thyroplasty or arytenoid adduction), and laryngeal reinnervation. Among these techniques, injection into the vocal fold to increase the volume and to provide closure of the glottis is simple and practical. Substances for injection include abiotic materials (such as polytetrafluoroethylene [Teflon], hydroxyapatite, liquid silica gel, glycerin, saxol, and polyethylene) and biomaterials (such as collagen, autologous fat, autologous fascia lata, and hyaluronic acid). Ideally, the injected biomaterial should have good hist-

Figure 3. One week after surgery (right-hand side). The injected side of the vocal fold demonstrated notable hyperemia and swelling.

Figure 4. Three months after surgery (right-hand side). The vocal fold volume remained stable 3 months after surgery. The paralyzed vocal folds in our patients were pushed medially, and the glottis closed well on phonation.
tocompatibility without any associated rejection and should cause no tissue irritation, laryngeal edema, granuloma, hyperplastic nodes, or allergic reactions. In addition, the material must have sufficient flexibility and be able to maintain the vibrating quality and elasticity of the vocal fold without being resorbed so that it can remain in the tissue. Autologous fascia lata, collagen, and fat fit these criteria and are recommended for this use. In 1998, Rihkanen\textsuperscript{15} first reported the method of augmenting the vocal fold with autologous fascia lata in 11 patients with unilateral vocal fold paralysis, and small globules of fat had been previously used in an autologous implant to soften vocal fold scars.\textsuperscript{10} As reported in 2001, fascia transplantation in the thyroarytenoid muscle led to regeneration of the vocal fold, analogous to transplantation of stem cells to regenerate other organs.\textsuperscript{17} Therefore, we hypothesized that injection of a combination of autologous fascia lata and fat into the vocal fold would effectively regenerate a pliable mucosal wave. Our study results show that the combination of autologous fascia lata and fat was not antigenic, had sufficient flexibility to maintain the vibration quality of the vocal folds, and remained for a long time within the vocal folds. Injection of a mixture of autologous fascia lata and fat increased the vocal fold volume and moved the medial edge of the paralyzed vocal fold inward so that both sides of the vocal fold closed well during vocalization, generating subglottic pressure. The subglottic pressure could push aside the closed glottis, allowing its edge to vibrate and produce the voice.

In contrast to a paste made from fascia lata alone, mixed fascia lata and fat is easily and smoothly expelled from the syringe needle, enabling more accurate control of the injection process. Removal of fat from the same incision as that used to harvest fascia lata facilitates preparation of the mixture. In the absence of a customized long syringe such as a Brunning syringe, an extradural puncture needle without a stylet can be used to inject via the cricothyroid gap. Using camcorder system monitoring and microscopic control, the mixture can be accurately injected into the vocal fold via the cricothyroid gap. The mucosal surface of the vocal folds remains intact. The injection volume can be precisely measured to 0.1 mL. To maintain the surface tension, it is better not to pierce the mucosal surface of the vocal folds during injection; there was no report in our series of material being expelled from the injection site. In our study, the surgical procedures were performed using general anesthesia with a suspension laryngoscope to accurately control the injection position and volume and to maintain the mucosal surface of the vocal folds intact.

An additional innovation in this study was the injection of 2.0 to 2.5 mL of mixture into the thyroarytenoid muscle. Mikus et al\textsuperscript{18} reported absorption ratios of fat injected into the vocal folds of canines of up to 70%. To compensate for this, we administered 2.0 to 2.5 mL of injection mixture, which was much more than the 0.2 to 0.4 mL injected by Rihkanen,\textsuperscript{15} to obtain sufficient residual volume of the vocal fold to maintain effective closure of the glottis after any postoperative absorption. Although some volume was absorbed in our patients, the increased vocal fold volume stabilized by 3 months after surgery, and glottal closure did not notably change.

In conclusion, we treated unilateral vocal fold paralysis by injecting a combination of autologous fascia lata and fat into the vocal fold through the cricothyroid gap to gain better mucosal wave amplitude symmetry and phase synchrony. As a result, the symptoms of dysphonia and bucking in hydroposia were improved for these patients, and a satisfactory therapeutic effect was eventually achieved. The procedure was a comparatively simple, safe, and effective therapy for unilateral vocal fold paralysis. If the injection volume is properly controlled, we suggest that this mixture of autologous fascia lata and fat may be an ideal material for vocal fold injection to remedy peripheral unilateral vocal fold paralysis. Although further studies are needed comparing the performance of this mixture with that of other injectable or

### Table 1. Comparison of Computerized Acoustic Analysis Among 12 Patients Before and After Injection Using Paired $t$ Test

<table>
<thead>
<tr>
<th>Variable</th>
<th>Before injection, mean (SD)</th>
<th>12 mo After injection, mean (SD)</th>
<th>$t$ Statistic</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jitter, %</td>
<td>1.89 (0.60)</td>
<td>0.60 (0.17)</td>
<td>9.735</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Shimmer, %</td>
<td>8.86 (2.06)</td>
<td>4.23 (1.53)</td>
<td>15.283</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Normalized Noise Energy, dB</td>
<td>-4.79 (1.35)</td>
<td>-9.74 (3.63)</td>
<td>-23.351</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Harmonics-to-Noise Ratio, dB</td>
<td>10.53 (3.19)</td>
<td>17.04 (3.73)</td>
<td>-11.367</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Maximum Phonation Time, s</td>
<td>4.76 (1.72)</td>
<td>11.89 (3.59)</td>
<td>-11.367</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

### Table 2. Comparison of Blinded Perceptual Evaluation of Voice Quality Among 12 Patients Before and After Injection Using Paired $t$ Test\textsuperscript{a}

<table>
<thead>
<tr>
<th>Variable</th>
<th>Before injection, mean (SD)</th>
<th>12 mo After injection, mean (SD)</th>
<th>$t$ Statistic</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
<td>2.6 (0.4)</td>
<td>1.3 (0.4)</td>
<td>24.697</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Roughness</td>
<td>1.2 (0.3)</td>
<td>0.9 (0.2)</td>
<td>7.241</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Breathiness</td>
<td>2.4 (0.6)</td>
<td>1.0 (0.3)</td>
<td>-23.351</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Asthenia</td>
<td>1.0 (0.3)</td>
<td>0.1 (0.0)</td>
<td>10.53</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

\textsuperscript{a}The severity of disorder for each variable in the blinded perceptual evaluation, including grade, roughness, breathiness, and asthenia was categorized as normal (score of 0), mild (score of 1), moderate (score of 2), or severe (score of 3).
implanted materials, we believe that a wide clinical application of this method is worthy of consideration.

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Author Contributions: Drs Cheng, Li, Huang, Xue, and Wang had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Cheng, Li, Huang, and Wang. Acquisition of data: Xue, Jiang, and Wu. Analysis and interpretation of data: Xue, Jiang, and Wu. Drafting of the manuscript: Cheng, Li, Huang, and Wang. Critical revision of the manuscript for important intellectual content: Xue, Jiang, and Wu. Statistical analysis: Cheng, Li, Xue, Jiang, and Wang. Obtained funding: Cheng, Li, and Wang. Administrative, technical, and material support: Cheng, Li, Huang, Xue, Jiang, and Wang. Study supervision: Huang and Jiang.

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