Vocal Fold Medialization in Children

Injection Laryngoplasty, Thyroplasty, or Nerve Reinnervation?

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Objective: To review surgical interventions for pediatric unilateral vocal fold immobility (UVFI).

Design: Retrospective medical chart review.

Setting: Two tertiary academic centers.

Patients: All children who underwent vocal fold medialization for dysphonia, with or without aspiration, from January 2004 to September 2006.

Interventions: Injection laryngoplasty, ansa cervicalis–recurrent laryngeal nerve anastomosis, or thyroplasty.

Main Outcome Measures: Age, sex, intervention, etiology, time from onset of UVFI to surgery, subjective success in improving voice, subjective duration of improvement, and complications.

Results: Twenty-seven procedures were performed in 15 patients (mean age, 10.6 years). Nineteen injection laryngoplasties, 3 thyroplasties (1 bilateral), 2 ansa cervicalis–recurrent laryngeal nerve reinnervation procedures, 1 adduction arytenoidopexy, and 1 cricothyroid joint subluxation were performed. Causes of UVFI included thoracic surgery in 6 cases (40%), prolonged intubation in 4 (26%), central nervous system neoplasm in 3 (20%), unknown etiology in 1 (7%), and anoxic brain injury in 1 (7%). The mean duration from onset of symptoms to treatment was 47 months. There was 1 surgical complication (postoperative aspiration pneumonia following thyroplasty while the patient was under local anesthesia). Parents reported a satisfactory outcome in all cases.

Conclusions: Injection laryngoplasty, thyroplasty, and nerve reinnervation can be performed in pediatric patients with good outcomes and an acceptable safety profile. This article describes the experiences of 2 institutions with phonosurgery for UVFI in children and provides insight into the advantages and disadvantages of each procedure. Prospective studies, with validated quality-of-life measurements, are needed to greater clarify the role of different types of phonosurgery in children with UVFI.


Unilateral vocal fold immobility (UVFI) in neonates is associated with stridor, poor feeding, or symptoms associated with an incompetent larynx. Dysphonia, with or without aspiration, is found in older children with UVFI. Speech therapy is useful in patients with UVFI and may be adequate treatment in some cases; however, others require surgery for greater degrees of medialization. Most research concerning vocal fold medialization has been conducted in adult populations. A PubMed search of English language articles published since 1966 using the phrase “vocal fold medialization” identified 167 articles, whereas using “pediatric vocal fold medialization” yielded 3. Published work investigating surgical intervention and UVFI in children describes treatment specifically for aspiration or does not distinguish which patients were treated primarily for voice. To our knowledge, there are no published articles that explore the advantages or disadvantages of each type of vocal fold medialization in the pediatric patient.

There is a degree of trepidation toward surgical intervention in the pediatric larynx. Many children are not able to undergo phonosurgery under local anesthesia, a condition necessary for delivering optimal results with thyroplasty and adduction arytenoidopexy. The anatomic alterations that result from most phonosurgical interventions are static, whereas the size, thickness, and composition of the larynx change as a person progresses from childhood to adulthood. Good results obtained at a young age may be lost during maturation. Spontaneous recovery of vo-

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cal fold movement has been reported at 18 months in an adult and as late as 4 years in a child. Patients with congenital bilateral vocal fold immobility have recovered movement as late as 11 years after onset. Because poor voice quality is not a life-threatening condition, it may be prudent in some cases to wait for spontaneous recovery of vocal fold movement or to abstain from phonosurgical intervention until after a child has gone through puberty to get the best result.

Although these concerns are valid, vocal performance does affect how a child interacts with peers and adults. Pediatric patients at our clinic have reported experiencing emotional disturbance and even suicidal ideation related to poor voice quality. Improvement in voice-related quality of life has been demonstrated after vocal fold medialization in adults but not in children. Delaying phonosurgical intervention may be the appropriate choice for some patients; however, other children deserve consideration for this procedure.

Thyroplasty, arytenoid adduction, injection laryngoplasty, and laryngeal reinnervation have their own unique influences on the larynx, the ramifications of which need to be investigated in the pediatric patient. Over the past several years, the senior authors (J.E.K. and C.J.H.) have begun to perform vocal fold medialization in patients who have not responded to speech therapy. To review the safety and general effectiveness of each type of intervention and to lay a framework for future prospective studies, we describe the clinical experience (at 2 institutions) of pediatric patients who underwent vocal fold medialization with voice quality, with or without aspiration, as the chief concern.

### METHODS

The medical records of patients seen at the Massachusetts Eye and Ear Infirmary Airway and Swallowing Disorders Clinic, Boston, and the University of Wisconsin–Milwaukee Pediatric Otolaryngology Clinic, Milwaukee, were searched for patients aged 2 to 18 years who had undergone phonosurgical intervention for vocal fold medialization with voice quality as the primary indication. The type of intervention, age at intervention, time from onset of vocal fold immobility to phonosurgical intervention, duration of improvement, and parent satisfaction were recorded for each patient. Duration of improvement was a subjective consensus determined by the parents, physicians, and speech pathologists who cared for each patient. Complications were defined as prolonged hospitalization, emergency department visit, or unplanned clinic visits related to unintended events associated with the procedure. Approval by the institutional review board was obtained at each institution. Each patient was evaluated and treated with speech therapy both before and after surgery.

### RESULTS

A total of 15 patients had 27 interventions. There were 19 injection laryngoplasties, 3 thyroplasties (1 bilateral), 1 adduction arytenoidopexy, 1 cricothyroid joint subluxation, and 2 laryngeal reinnervation procedures. The mean age at initial intervention was 10.6 years (range, 2.5-18 years). There was a mean time delay of 47 months from onset of symptoms to phonosurgical intervention (range, 4-162 months). There were 8 females and 7 males. Causes of vocal fold immobility included thoracic surgery in 6 cases (40%), prolonged intubation in 4 (26%), neurologic origin in 4 (27%), and unknown etiology in 1 (7%). Parents were pleased that their child underwent the medialization procedure in all cases.

Nineteen injection laryngoplasties were performed in 12 patients (Table 1). No patients in this series experienced a spontaneous recovery of vocal fold movement. The injections were performed while the patients were under general anesthesia, 10 with an endotracheal tube in place and 9 without intubation using total intravenous anesthesia, topical lidocaine, and spontaneous respiration.

### Table 1. Characteristics of Patients Treated With Injection Laryngoplasty

<table>
<thead>
<tr>
<th>Patient No./Age, y</th>
<th>Etiology</th>
<th>Duration of Follow-up, mo</th>
<th>Injection Material</th>
<th>Duration of Effect, mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2,5</td>
<td>Thoracic surgery</td>
<td>3</td>
<td>Cadaveric dermis</td>
<td>3</td>
</tr>
<tr>
<td>2/7</td>
<td>Thoracic surgery</td>
<td>5</td>
<td>Cadaveric dermis</td>
<td>5</td>
</tr>
<tr>
<td>3/8</td>
<td>Prolonged intubation</td>
<td>24</td>
<td>Cadaveric dermis</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cadaveric dermis</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cadaveric dermis</td>
<td>4</td>
</tr>
<tr>
<td>4/11</td>
<td>Thoracic surgery</td>
<td>24</td>
<td>Cadaveric dermis</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cadaveric dermis</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cadaveric dermis</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cadaveric dermis</td>
<td>4</td>
</tr>
<tr>
<td>5/5</td>
<td>Prolonged intubation</td>
<td>28</td>
<td>Bovine collagen</td>
<td>Unknown</td>
</tr>
<tr>
<td>6/11</td>
<td>Prolonged intubation</td>
<td>LF</td>
<td>Calcium hydroxylapatite voice gel</td>
<td>Unknown</td>
</tr>
<tr>
<td>7/11</td>
<td>Neurologic origin</td>
<td>LF</td>
<td>Hydrated porcine gelatin powder</td>
<td>EPTW</td>
</tr>
<tr>
<td>8/14</td>
<td>Prolonged intubation</td>
<td>1</td>
<td>Hydrated porcine gelatin powder</td>
<td>EPTW</td>
</tr>
<tr>
<td>9/18</td>
<td>Neurologic origin</td>
<td>1</td>
<td>Hydrated porcine gelatin powder</td>
<td>EPTW</td>
</tr>
<tr>
<td>10/13</td>
<td>Thoracic surgery</td>
<td>15</td>
<td>Autologous fat</td>
<td>6</td>
</tr>
<tr>
<td>11/13</td>
<td>Neurologic origin</td>
<td>4</td>
<td>Calcium hydroxylapatite</td>
<td>EPTW</td>
</tr>
<tr>
<td>12/17</td>
<td>Thoracic surgery</td>
<td>18</td>
<td>Autologous fat</td>
<td>1</td>
</tr>
</tbody>
</table>

Abbreviations: EPTW, effect present at time of writing; LF, lost to follow-up.

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In many ways, vocal fold medialization in children has the same considerations as in adults. Spontaneous recovery of vocal fold movement is observed in both groups but has been reported much later, up to 4 years after onset, in children.1 An adult’s voice may alter with age, but presbyphonic changes are more gradual than those associated with the metamorphosis of puberty. The success of performing a procedure while patients are under local anesthesia is dependent on whether the patients can be cooperative and protect their airway and whether they are adults or children. The decision to intervene phono-surgically for lateralized vocal folds is made for aspiration, or as discussed herein, when poor voice quality has a considerable impact on quality of life. The type of modality used for medialization is collectively decided based on the unique qualities of each procedure and patient.

Injection laryngoplasty using Teflon (DuPont, Wilmington, Delaware) and later micronized, acellular, cadaveric dermis (Cymetra; LifeCell, Branchburg, New Jersey) has been reported in treating children for aspiration.1,2,5,6 Injection laryngoplasty is advantageous in the early window when spontaneous recovery of vocal fold movement is possible. Major complications in treating pediatric patients with injection laryngoplasty were found in the literature and our case series. However, vocal cord hematoma, vocal cord inclusion cyst, laryngeal abscess, and tracheotomy have been reported in adults.1,2,13 The

gelatin powder) at the time of reinnervation. Each patient was discharged in good condition on the first postoperative day. The patient injected with autologous fat reported a good result for 1 month and then gradual deterioration in vocal quality. However, at 3 months after the procedure, she reported a rapid improvement in her voice quality. At 18 months after the procedure, she had a 2-octave range and had been accepted into a baccalaureate program majoring in vocal performance. To date, her immobilized vocal cord has assumed a more median position, has a strong mucosal wave, and has less vocal fold atrophy on stroboscopic examination. The second patient had a good voice result with injection of hydrated porcine gelatin powder for 4 weeks, but then his voice quality returned to baseline. Five months after his procedure, he was able to attain full vocal cord closure and had a 2-octave range that he has maintained for more than 1 year postoperatively.

### Table 2. Characteristics of Patients Who Underwent Thyroplasty

<table>
<thead>
<tr>
<th>Patient No./Age, y</th>
<th>Etiology</th>
<th>Surgical Procedure</th>
<th>Duration of Follow-up, mo</th>
<th>Type of Anesthesia</th>
<th>Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/13.5</td>
<td>Neurologic origin</td>
<td>Bilateral thyroplasty</td>
<td>26</td>
<td>LMA</td>
<td>None</td>
</tr>
<tr>
<td>2/5.5</td>
<td>Thoracic surgery</td>
<td>Left thyroplasty</td>
<td>19</td>
<td>LMA</td>
<td>None</td>
</tr>
<tr>
<td>3/18</td>
<td>Neurologic origin</td>
<td>Left thyroplasty, adduction arytenoidopexy, cricothyroid joint subluxation</td>
<td>19</td>
<td>Local</td>
<td>Aspiration pneumonia</td>
</tr>
</tbody>
</table>

Abbreviation: LMA, laryngeal mask airway.
smaller size of a pediatric airway should be considered when performing medialization.

There are a myriad of choices for materials in injection laryngoplasty. Micronized, acellular, cadaveric dermis and bovine collagen produced subjective effects for 4 to 6 months. We did not observe good results at 1 year as reported in other studies.14,15 Calcium hydroxyapatite is purported to last 1 year, but we did not identify published work reporting a follow-up longer than 6 months.16,17 We are still following 1 patient who had a good result 4 months after calcium hydroxyapatite injection. Recently, foreign body reaction has been reported after injection with calcium hydroxyapatite.18 Autologous fat was used on 2 occasions with inconsistent results, which is similar to the experience reported in the literature.19 Hydrated porcine gelatin powder lasted 4 months in 2 patients, which is longer than the 4 to 6 weeks described in the literature.20

There are 20 cases of pediatric thyroplasty reported prior to this series of patients.21-22 It has been performed on children as young as 2 years for aspiration.23 The pediatric larynx dictates a more inferior placement of implantation material.24 The only major complication in our series was an aspiration pneumonia acquired after thyroplasty. Laryngeal mask airway with flexible fiberoptic laryngoscopy is the appropriate method of anesthesia for an uncooperative patient or a patient with impaired airway protection, but this method is inferior for obtaining optimum voice quality. To our knowledge, the long-term voice results for children who have undergone thyroplasty prior to puberty have not been reported. Revision thyroplasty could be performed after puberty but is technically difficult.25 Thyroplasty could be considered for prepubescent children with aspiration in addition to voice concerns or older adolescents with good airway protection who may tolerate a procedure under local anesthesia. Adduction arytenoidopexy and cricothyroid joint subluxation should be restricted to a role of “fine tuning” procedures to be performed with thyroplasty in older adolescents who have completed their laryngeal growth cycle.

Reinnervation with ANSA-RLN anastomosis provides an attractive alternative for treating UVFI in children. The procedure is performed optimally while the patient is under general anesthesia and is not dependent on the cooperation of the child. A reinnervation procedure does not alter the laryngeal skeleton and would not complicate additional phonosurgery if needed later in life. The procedure, however, negates any chance of spontaneous recovery of vocal fold movement. Success with laryngeal reinnervation has been reported in adults, but the procedure has not been widely adopted.24,25 This may be due in part to the excellent, immediate results obtained with thyroplasty. We had 1 excellent outcome and a second satisfactory outcome with ANSA-RLN anastomosis, but studies involving more subjects are needed to determine if a consistent result can be delivered.

The patients, parents, and physicians involved in this study felt that the interventions were a success. However, this opinion is highly subjective and is not backed by the accumulated systematic objective data. This article describes the experiences of 2 institutions with phonosurgery for UVFI in children and provides insight into the advantages and disadvantages of each procedure. A prospective study, with clearly defined outcomes and systematic data collection, would provide more detailed results.

In conclusion, injection laryngoplasty, thyroplasty, and nerve reinnervation can be performed in children with good outcomes and with an acceptable safety profile. Injection laryngoplasty can be repeated until a child reaches an age where a definitive thyroplasty, with or without arytenoids procedures, can be performed under local anesthesia. Injection laryngoplasty is also a good choice in patients who may experience a spontaneous recovery of vocal fold movement. Thyroplasty can be considered for prepubescent children with aspiration concerns in addition to voice concerns or older adolescents with good airway protection who can tolerate a procedure under local anesthesia. In addition, ANSA-RLN anastomosis is appropriate for younger children with UVFI with voice concerns or older adolescents who are unable to protect their airway under local anesthesia. Prospective studies are needed to greater clarify the appropriate role for each method of vocal fold medialization.

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Author Contributions: Drs Sipp, Kerschner, and Hartnick and Ms Braune 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: Sipp and Hartnick. Acquisition of data: Sipp, Kerschner, Braune, and Hartnick. Analysis and interpretation of data: Sipp, Kerschner, and Hartnick. Drafting of the manuscript: Sipp and Hartnick. Critical revision of the manuscript for important intellectual content: Sipp, Kerschner, Braune, and Hartnick. Administrative, technical, and material support: Braune. Study supervision: Kerschner and Hartnick.

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REFERENCES