Thyroid Alar Cartilage Graft
Laryngotracheal Reconstruction in Adults

Pengcheng Cui, MD¹, Pengfei Gao, MD¹, Jiasheng Luo, MD¹, and Yanyan Ruan, MD¹

Abstract
Objective. To assess the outcomes of laryngotracheal reconstruction using thyroid alar cartilage grafting in adult patients with laryngotracheal stenosis.

Study Design. Case series with chart review.

Setting. Tertiary university hospital.

Subjects and Methods. Twelve adults who underwent thyroid alar cartilage graft laryngotracheal reconstruction from April 1997 to April 2009 for laryngotracheal stenosis were analyzed. The mean age of the study population was 29 years.

Using the Myer-Cotton grading system, 3 patients had grade II stenosis, 7 had grade III, and 2 had grade IV. Seven of the 12 patients had subglottic stenosis, 3 had tracheal stenosis, and 2 had subglottic and upper tracheal stenosis.

Results. Nine of 12 (75%) patients were decannulated. Of the patients in whom laryngotracheal reconstruction failed, 2 had grade IV stenosis and 1 had severe grade III stenosis with a long segment of stenotic tissue. The postoperative complications were hematoma of the left laryngeal ventricle at the donor site in 1 patient, granulation tissues in the supraglottic and suprastomal region and at the graft site in 4 patients, and neck wound infection in 1 patient. Ossification of the thyroid alar cartilage was observed in 2 patients. A T-tube remained in situ for 6 to 18 months.

Conclusion. Laryngotracheal reconstruction with thyroid alar cartilage graft could be a viable alternative for the treatment of laryngotracheal stenosis in adults. However, it should be used only in cases of limited and minor subglottic or tracheal stenosis.

Keywords
thyroid alar cartilage, laryngotracheal reconstruction

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Surgical expansion of the stenotic laryngeal and tracheal lumen with cartilage grafting is widely accepted as one of the most effective treatments for severe laryngotracheal stenosis. Many kinds of autogenous grafts have been used in laryngotracheal reconstruction, including costal cartilage,¹ nasal septal cartilage,² hyoid bone,³ auricular cartilage,⁴ and thyroid cartilage.⁵⁻⁷ The advantages of using thyroid alar cartilage (TAC) are obvious. It is located in the same operative field, avoiding secondary morbidity and therefore reducing the operative time. Its thickness is almost the same as that of laryngotracheal cartilage, thereby reducing the possibility of intratracheal graft prolapse.

Authors have studied the outcomes with TAC techniques, but these have been limited to infants and children.⁸⁻¹⁰ In the present study, we describe our experience with laryngotracheal reconstruction using the TAC in a series of 12 adults with laryngotracheal stenosis.

Materials and Methods
This study was approved by the Institutional Review Board of the Fourth Military Medical University (Xi’an, China). Twelve adult patients (10 men) with laryngotracheal stenosis (Table 1) were treated using TAC as autogenous grafts at our hospital from April 1997 to April 2009. The mean age of the study population was 29 years (range, 18-51 years). Only 1 patient had not previously undergone a tracheotomy. Previous laryngotracheal reconstruction in other hospitals had failed in 6 patients. Stenosis was graded according to the Myer-Cotton system.¹¹ Three patients had grade II stenosis, 7 had grade III, and 2 had grade IV. The causes of stenosis were due to tracheostomy in 1 patient, trauma to the larynx or trachea (6 patients), amyloidosis of the larynx (1 patient), intubation (3 patients), and fungal laryngitis and tracheitis (1 patient). Seven of the 12 patients had subglottic stenosis, 3 had tracheal stenosis, and 2 had subglottic and upper tracheal stenosis. The mean length of stenoses was 1.6 cm (range, 1.0-4.0 cm).

The surgical technique was as described by Fayoux et al.⁹ In brief, a vertical midline incision was made over...
the larynx and upper trachea and the airway exposed. Laryngotracheofissure was carried out. The stenotic region was evaluated to determine the size of the graft required for stenosis expansion. For grade II stenoses, we did not remove scar tissue. For minor grade III stenosis, the scar tissue was removed submucosally. For severe grade III and grade IV stenoses, the scar tissue was excised as completely as possible, making the lumen larger. The TAC was exposed and removed along with the external perichondrium, leaving the internal perichondrium in situ. The graft was fashioned to be adapted for enlargement and was sutured into position with the perichondrium turned intraluminally. A 3-0 Vicryl absorbable suture was used. For patient 10, we harvested bilateral TACs for covering the laryngotracheofissure because a unilateral TAC was not long enough (Figure 1). All except 1 patient had a T-tube placed.

Results

Results are summarized in Table 2. Nine patients (75%) were successfully decannulated. The prevalence of decannulation in the 6 patients who had previous laryngotracheal reconstruction was 66.7% (4/6), whereas it was 83.3% (5/6) in the 6 subjects who had not. Of the patients in whom laryngotracheal reconstruction had failed, 2 (patients 5 and 6) were grade IV and 1 (patient 10) was severe grade III with a long segment of stenosis (4.0 cm). A collapsed lumen was observed in the 3 patients in whom laryngotracheal reconstruction had failed. Hematoma of the left laryngeal ventricle was found at the donor site in patient 11 but disappeared on the 10th postoperative day. One patient had a neck wound infection that was treated with broad-spectrum antibiotics and soon healed without graft necrosis. Granulation tissues in the supraglottic and suprastomal region and at the graft site were noted in 4 patients. Radiofrequency ablation was used to remove the granulations.

A T-tube was placed and remained in situ for 6 to 18 months (mean, 12.3 months).

The mean amount of TAC removed was $2.2 \pm 1.2$ cm. Ossification of the TAC was found in 2 patients. The mean follow-up was 12 months (range, 6-24 months). Laryngoscopy did not show subsequent pharyngolaryngeal deformation at the donor site.

Discussion

TAC grafts for subglottic stenosis in children have been proven to be successful. Fraga et al\(^8\) retrospectively studied 6 children with subglottic stenosis undergoing TAC graft laryngotracheoplasty. They found a patent subglottic airway in all patients after a mean follow-up of 26 months. Fayoux and colleagues\(^9\) reported a 92.5% success rate in a series of 27 consecutive infants treated by laryngotracheal reconstruction using a TAC graft. No patient with grade IV stenosis was included in their series. The other commonly used technique was laryngotracheal reconstruction with a costal

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**Table 1. Patient Demographic and Clinical Data**

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Sex</th>
<th>Cause</th>
<th>Location</th>
<th>Length, cm</th>
<th>Grade</th>
<th>TBR</th>
<th>Previous Therapy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24</td>
<td>M</td>
<td>Tracheostomy</td>
<td>Subglottic</td>
<td>1.0</td>
<td>III</td>
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<td>No</td>
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<td>27</td>
<td>M</td>
<td>Trauma</td>
<td>Subglottic</td>
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<td>No</td>
<td>LTR</td>
</tr>
<tr>
<td>3</td>
<td>31</td>
<td>F</td>
<td>AL</td>
<td>Subglottic</td>
<td>2.0</td>
<td>III</td>
<td>Yes</td>
<td>LTR</td>
</tr>
<tr>
<td>4</td>
<td>22</td>
<td>M</td>
<td>Trauma</td>
<td>Trachea</td>
<td>1.5</td>
<td>III</td>
<td>Yes</td>
<td>LTR</td>
</tr>
<tr>
<td>5</td>
<td>22</td>
<td>M</td>
<td>Trauma</td>
<td>Subglottic</td>
<td>1.3</td>
<td>IV</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>M</td>
<td>Postintubation</td>
<td>Subglottic + trachea</td>
<td>2.5</td>
<td>IV</td>
<td>Yes</td>
<td>LTR</td>
</tr>
<tr>
<td>7</td>
<td>51</td>
<td>M</td>
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<td>No</td>
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<td>20</td>
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<tr>
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<td>30</td>
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<td>FLT</td>
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<td>Yes</td>
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<tr>
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<td>Yes</td>
<td>LTR</td>
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<tr>
<td>12</td>
<td>40</td>
<td>F</td>
<td>Trauma</td>
<td>Trachea</td>
<td>1.5</td>
<td>III</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Abbreviations: AL, amyloidosis of the larynx; F, female; FLT, fungal laryngitis and tracheitis; LTR, laryngotracheal reconstruction; M, male; TBR, tracheostomy before referral.

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Figure 1. Intraoperative picture of the 2 thyroid alar cartilage (TAC) grafts (black and white arrows) sutured into position.
The advantage of TAC grafts for lumen augmentation is that the grafts are harvested through the same incision, so the operative time is reduced. Nguyen et al. compared the outcomes of TAC grafts and costal cartilage grafts in pediatric primary anterior laryngotracheoplasty. They found that there were no statistically significant differences in the prevalence of decannulation but that the TAC grafts required a significantly shorter operative time than costal cartilage grafts. The disadvantage of TAC grafts is its limited length for lumen augmentation. This may be overcome by harvesting bilateral TAC grafts and connecting them longitudinally. Unfortunately, the only patient in whom we tried to use 2 connected TAC grafts failed to decannulate because the stenosis was too severe. Therefore, we may need more cases to ascertain if TAC graft reconstruction is suitable for those with major grade and long segment stenoses.

In the literature, TAC grafts are used for primary laryngotracheal reconstructions. We are not sure whether the previous laryngotracheal reconstruction procedures affected the results because of the small patient samples in the present study. They did not affect the cartilage harvest because the thyroid ala had not been dissected. However, this did increase the difficulty in dissecting the cricoids and tracheal rings because of scar tissue in the neck.

A donor site complication of unilateral laryngeal ventricular hematoma was observed in 1 subject. The hematoma may have been caused by breaking the integrity of the internal perichondrium while removing the TAC. The patient showed symptoms of hoarseness and dyspnea on the first postoperative day. We removed the plug of the T-tube and inserted a tracheotomy tube through the external limb. The patient could breathe through the tracheotomy tube without experiencing dyspnea. The hematoma disappeared 10 days postoperatively, and then the tracheotomy tube was removed. The plug was inserted again so that the patient could breathe through the intraluminal portion of the T-tube. Other complications with respect to laryngeal stability such as prolapse of the supraglottic structures were not observed, even in case 10, whose bilateral TAC grafts were harvested.

There is a difference between using TAC grafts in adults and children: the thyroid cartilage in adults may be ossified. In children using a costal cartilage graft was 97% for grade II stenosis, 91% for grade III, and 72% for grade IV. In adults, the overall prevalence of decannulation was 80%. In the present study, we treated 12 adult patients using a TAC graft with a prevalence of decannulation of 75%. Three failed cases were classified as severe laryngotracheal stenosis (grade IV and severe grade III with a stenotic segment of 4 cm). For the patient with a long stenotic segment, we tried to cover the anterior defect of the lumen by connecting bilateral TAC grafts vertically, but this too proved to be unsuccessful. The augmented lumen collapsed 1 day after removal of the T-tube because of the absence of adequate support for the lateral wall cartilage. Therefore, grade IV and severe grade III stenoses might be the contraindications for laryngotracheal reconstruction using TAC grafts.

Studies in children showed that cricotracheal resection (CTR) was an optimal treatment for severe subglottic and tracheal stenosis. Cui et al. showed that the operative time is reduced. Nguyen et al. compared the outcomes of TAC grafts and costal cartilage grafts in pediatric primary anterior laryngotracheoplasty. They found that there were no statistically significant differences in the

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Table 2. Summary of Results

<table>
<thead>
<tr>
<th>Patient</th>
<th>Thyroid Alar Cartilage, Length × Width, cm</th>
<th>Ossification</th>
<th>Complication</th>
<th>Stent Duration, mo</th>
<th>Outcome (Decannulation)</th>
<th>Follow-up, mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Right, 1.5 × 1</td>
<td>No</td>
<td>Granulation</td>
<td>6</td>
<td>Yes</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>Right, 1.5 × 1</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>Right, 2.0 × 1</td>
<td>No</td>
<td>No</td>
<td>12</td>
<td>Yes</td>
<td>24</td>
</tr>
<tr>
<td>4</td>
<td>Right, 2.0 × 1</td>
<td>No</td>
<td>Granulation</td>
<td>12</td>
<td>Yes</td>
<td>12</td>
</tr>
<tr>
<td>5</td>
<td>Right, 2.5 × 2</td>
<td>No</td>
<td>Lumen collapse</td>
<td>12</td>
<td>No</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>Right, 2.5 × 1</td>
<td>No</td>
<td>Lumen collapse</td>
<td>18</td>
<td>No</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>Right, 1.3 × 1</td>
<td>Yes</td>
<td>Granulation</td>
<td>12</td>
<td>Yes</td>
<td>12</td>
</tr>
<tr>
<td>8</td>
<td>Left, 2.0 × 1.5</td>
<td>No</td>
<td>Neck wound infection</td>
<td>12</td>
<td>Yes</td>
<td>14</td>
</tr>
<tr>
<td>9</td>
<td>Left, 2.2 × 1</td>
<td>Yes</td>
<td>No</td>
<td>12</td>
<td>Yes</td>
<td>10</td>
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<tr>
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<td>Right, 2.0 × 1; left, 2.3 × 1</td>
<td>No</td>
<td>Lumen collapse</td>
<td>15</td>
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<td>Left, 1.8 × 1</td>
<td>No</td>
<td>Hematoma of left ventricle</td>
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<td>12</td>
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<td>No</td>
<td>Granulation</td>
<td>12</td>
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<td>12</td>
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</table>
undergoes ossification with increasing age. There is wide variation between the age of an individual and the stages of calcification of the laryngeal cartilage. In general, ossification of the laryngeal cartilage starts in the third decade, and the degree and extent of ossification are greater in males than in females.15,16 We found ossified TAC in 2 patients in this group, and they were all decannulated. Hence, the ossified TAC might not affect outcome. However, this would require further study with larger patient samples. Ossification of the TAC makes fixing the graft in position quite difficult. We drilled small holes with a needle on the graft first and then sutured through the holes, which reduced the possibility of graft rupture.

Stenting is important for holding grafts in position and to prevent scar contracture in laryngotracheal reconstruction. Although there is no optimal duration of stenting, a relatively long period of stenting (several months) is recommended for severe airway stenosis.17,18 In this series, all patients wore a T-tube for at least 6 months except for 1 patient with minor grade stenosis.

**Conclusion**

The TAC could be a viable alternative for laryngotracheal reconstruction in adults. However, it should be used only in cases of limited and minor subglottic or tracheal stenosis.

**Author Contributions**

Pengcheng Cui, conception and design, analysis, and interpretation of data; Pengfei Gao, acquisition of data; Jiasheng Luo, analysis and interpretation of data; Yanyan Ruan, conception and design.

**Disclosures**

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**References**


