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What is This?
Voice Quality after Recurrent Laryngeal Nerve Resection and Immediate Reconstruction

Sarah L. Rohde, MD¹, Charles T. Wright, MD, MBA¹, Jennifer C. Muckala, MA, CCC-SLP¹, Jamie Wiggleton, ANP-BC¹, Bernard Rousseau, PhD, CCC-SLP¹, and James L. Netterville, MD¹

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Abstract

**Objective.** To evaluate clinician perception of voice quality, patient self-reported psychosocial impact of dysphonia, and glottic closure in patients who have undergone resection of the recurrent laryngeal nerve (RLN) and immediate operative reconstruction during thyroid surgery.

**Study Design.** Prospective observational study.

**Setting.** Single tertiary care hospital.

**Subjects and Methods.** Nine patients underwent immediate operative reconstruction of the RLN by the senior author from 2002 to present. Outcome measures included (1) perceptual voice ratings assessed using the GRBAS (Grade, Roughness, Breathiness, Asthenia, Strain) scale, (2) psychosocial impact of dysphonia assessed using the Voice Handicap Index (VHI), and (3) assessment of glottic closure from laryngeal videostroboscopy.

**Results.** The RLN was reconstructed with primary anastomosis (4), free nerve graft (3), or vagus-RLN anastomosis (2). Seven patients had voice samples and videostroboscopy examinations obtained at a minimum of 9 months from surgery. Six were judged to have slight disturbance of voice based on overall Grade scoring (G = 1). Five rated their voice as normal or mild on the VHI instrument (score range 8-29). Laryngeal analysis revealed the immobile vocal fold in the median, physiologic phonating position with preserved bulk, recovered tension, and glottic closure during phonation. Three patients less than 9 months from surgery had an expected severe self-reported rating of dysphonia.

**Conclusion.** Primary anastomosis, free nerve grafting, and vagus-RLN anastomosis are viable options for RLN reconstruction. Patients who undergo resection and immediate reconstruction of the RLN are able to regain self-perceived functional voices.

**Keywords**
thyroid, recurrent laryngeal nerve, voice quality

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Injury to the recurrent laryngeal nerve (RLN) is a known complication of thyroid surgery. Thyroid cancer can invade the RLN, necessitating its resection even in patients with normal preoperative vocal fold mobility. Loss of intrinsic laryngeal muscle innervation leads to loss of motion, flaccidity, and muscle atrophy. Patients experience incomplete glottic closure, which manifests itself as dysphonia and even aspiration. Vocal fold paralysis (VFP) negatively affects patient quality of life.

Treatment options include injection laryngoplasty, medialization laryngoplasty, arytenoid adduction, and laryngeal reinnervation. The majority of the literature focuses on postoperative treatment of VFP and not immediate reconstruction of the cut or resected RLN. Vocal fold injection, arytenoid adduction, and medialization thyroplasty are effective in improving voice quality but cannot prevent muscle atrophy. Previous studies have shown that after RLN neurorrhaphy, regeneration occurs in a misdirected fashion among adductor and abductor fibers, restoring tension during phonation and fixing the cord in the median position.

Recurrent laryngeal nerve reinnervation remains a well-established technique in cases of recognized RLN injury or resection, but voice quality outcomes remain largely undescribed. Immediate reconstruction techniques, including primary neurorrhaphy, ansa cervicalis to RLN anastomosis, vagus to RLN anastomosis, and free nerve grafting have been described. Recent reports in the literature have focused on

¹Department of Otolaryngology–Head and Neck Surgery, Vanderbilt University Medical Center, Nashville, Tennessee, USA

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**Corresponding Author:**
Sarah L. Rohde, MD, Department of Otolaryngology–Head and Neck Surgery, Vanderbilt University Medical Center, 2125 21st Ave South, 7209 Medical Center East, Nashville, TN 37232, USA
Email: sarah.rohde@vanderbilt.edu
bridging procedure (Table 1). Nine patients underwent immediate operative reconstruction between 2002 and 2010. Six of 9 patients were more than 12 months from immediate nerve reconstruction had results comparable to thyroplasty on the VHI (Table 3). Additional studies comparing RLN reinnervation results to patients with known RLN resection could provide additional evidence of patient benefit. Patients may require interim injection laryngoplasty to bridge their speech and swallowing as reinnervation occurs. Patients at 5, 8, and 11 months postoperatively with continued severe disturbance in voice may have continued improvements in dysphonia vs failed reinnervation. Videostroboscopy on the patient 11 months out from surgery showed intermediate tone suggesting slow recovery. Further studies will be needed to determine at what time point a reinnervation procedure should be considered a failure. It is important to note that immediate reconstruction of the RLN does not preclude

### Materials and Methods

This study was approved by the Vanderbilt University Institutional Review Board. We performed a prospective observational study of consecutive patients who underwent immediate operative repair of the RLN anastomosis by the senior author from 2002 to present. Assessment of the severity of dysphonia was carried out by a single speech pathologist using the GRBAS (Grade, Roughness, Breathiness, Asthenia, Strain) scale. The GRBAS ratings were performed using recorded voice samples. Further visual analysis was performed using videostroboscopic images obtained at routine clinic visits. Evaluation of videostroboscopic images was performed by a single, senior speech pathologist. Patient self-assessment of the psychosocial impact of dysphonia was assessed using the Voice Handicap Index (VHI).

### Results

Nine patients underwent immediate operative reconstruction of the RLN between 2002 and 2010. Six of 9 patients were being treated for malignant thyroid disease. Four patients underwent primary RLN anastomosis, 2 patients underwent vagus nerve to RLN anastomosis, and 3 patients required nerve grafting. The technique chosen for reinnervation was based on the extent of resection or injury. Primary anastomosis was used in cases of recognized injury without resection or short-segment resection of the RLN. Vagus nerve to RLN anastomosis and nerve grafting were used in cases requiring long-segment resection of the RLN. Only 3 of the 9 patients required an injection laryngoplasty as a temporary bridging procedure (Table 1).

Seven of 9 patients were evaluated with videostroboscopy. In all cases, the immobile vocal fold was observed to be in the median, physiologic phonating position. The immobile vocal fold recovered tension, mucosal wave, and glottic closure during phonation (Figure 1). Although normal vocal fold movement was not restored, there was no paradoxical motion observed.

The GRBAS scale findings are shown in Table 2. Results were obtained at 9 to 30 months from the date of surgery. Six patients were perceived to have only slight disturbance of voice on Grade, Roughness, and Breathness scoring. All patients were perceived to have moderate to severe disturbance of voice on Strain scoring. High strain values may be secondary to maladaptive behaviors learned during recovery of RLN tone given recovered glottis closure during phonation seen on stroboscopy. Additional studies evaluating the effect of speech therapy on strain scoring could be performed.

All patients more than 12 months out from surgery reported a mild psychosocial impact of dysphonia as assessed using the Voice Handicap Index. Importantly, this effect was maintained, with retained self-reported mild psychosocial impact of dysphonia in 2 patients at 6 and 8 years from surgery. As expected, the 3 patients less than 1 year from surgery had a severe self-reported rating of dysphonia.

### Discussion

When comparing RLN reinnervation with previously reported thyroplasty results from our own institution, patients more than 12 months from immediate nerve reconstruction had results comparable to thyroplasty on the VHI (Table 3). Additional studies comparing RLN reinnervation results to patients with known RLN resection could provide additional evidence of patient benefit. Patients may require interim injection laryngoplasty to bridge their speech and swallowing as reinnervation occurs. Patients at 5, 8, and 11 months postoperatively with continued severe disturbance in voice may have continued improvements in dysphonia vs failed reinnervation. Videostroboscopy on the patient 11 months out from surgery showed intermediate tone suggesting slow recovery. Further studies will be needed to determine at what time point a reinnervation procedure should be considered a failure. It is important to note that immediate reconstruction of the RLN does not preclude

### Table 1. Patient Characteristics

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age, y</th>
<th>Sex</th>
<th>Diagnosis</th>
<th>Operation</th>
<th>Type of Repair</th>
<th>Injection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>51</td>
<td>F</td>
<td>Thyroid nodule</td>
<td>L thyroid lobectomy</td>
<td>Primary anastomosis</td>
<td>Yes (1 month)</td>
</tr>
<tr>
<td>2</td>
<td>38</td>
<td>F</td>
<td>Symptomatic MNG</td>
<td>R thyroid lobectomy</td>
<td>Primary anastomosis</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>70</td>
<td>F</td>
<td>Papillary thyroid cancer</td>
<td>TT, CND, L ND</td>
<td>Nerve graft</td>
<td>Yes (POD 4)</td>
</tr>
<tr>
<td>4</td>
<td>86</td>
<td>F</td>
<td>Symptomatic MNG</td>
<td>L thyroid lobectomy</td>
<td>Primary anastomosis</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>49</td>
<td>M</td>
<td>Papillary thyroid cancer</td>
<td>TT, CND, BND</td>
<td>Nerve graft</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>37</td>
<td>F</td>
<td>Papillary thyroid cancer</td>
<td>R CND, R ND</td>
<td>Vagus to RLN anastomosis</td>
<td>No</td>
</tr>
<tr>
<td>7</td>
<td>60</td>
<td>M</td>
<td>Medullary thyroid cancer</td>
<td>L CND, L ND</td>
<td>Vagus to RLN anastomosis</td>
<td>No</td>
</tr>
<tr>
<td>8</td>
<td>57</td>
<td>M</td>
<td>Papillary thyroid cancer</td>
<td>L CND, L ND</td>
<td>Nerve graft</td>
<td>Yes (3 months)</td>
</tr>
<tr>
<td>9</td>
<td>58</td>
<td>F</td>
<td>Papillary thyroid cancer</td>
<td>TT, CND, B ND</td>
<td>Primary anastomosis</td>
<td>No</td>
</tr>
</tbody>
</table>

Abbreviations: B, bilateral; CND, central compartment nodal dissection; F, female; L, left; M, male; MNG, multinodular goiter; ND, neck dissection; POD, postoperative day; R, right; RLN, recurrent laryngeal nerve; TT, total thyroidectomy.
future thyroplasty should a patient fail to attain the desired voice improvement.

In this series of patients, each technique used for immediate reconstruction resulted in videostroboscopic findings consistent with reinnervation. A retrospective study of 237 patients who underwent ansa cervicalis reinnervation of the RLN, by Wang et al, found similar results. When compared with normal controls, these patients had no statistical difference in acoustic maximum phonation time, perceptual evaluation, or acoustic analysis. A similar study has been performed using the contralateral ansa cervicalis. That multiple techniques result in comparable stroboscopy findings and mild psychosocial impact of dysphonia is important given the varying extent of resection and neck dissection necessary when treating thyroid carcinoma. Additional studies will be necessary to determine whether a particular nerve donor or nerve graft yields the best phonation results.

Multiple authors have demonstrated the benefits of reinnervation of the RLN. Reinnervation prevents muscle atrophy and fixes the cord in the midline. Recurrent laryngeal nerve reinnervation should be used when surgery requires resection of the RLN or when an RLN injury is identified at the time of surgery.

**Conclusion**

Primary anastomosis, free nerve grafting, and vagus-RLN anastomosis are viable options for RLN reconstruction and subsequent reinnervation. Patient VHI scores are comparable to the VHI scores of patients who have undergone slastic medialization laryngoplasty. Patients who undergo

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**Table 2. GRBAS (Grade, Roughness, Breathiness, Astenia, Strain) Score Summary**

<table>
<thead>
<tr>
<th>Patient</th>
<th>Time from Surgery, mo</th>
<th>Grade</th>
<th>Roughness</th>
<th>Breathiness</th>
<th>Astenia</th>
<th>Strain</th>
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<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td>1</td>
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</tr>
<tr>
<td>3</td>
<td>20</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>11</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
resection and immediate reconstruction of the RLN are able to regain self-perceived functional voices.

**Author Contributions**

Sarah L. Rohde, substantial contributions to conception and design and analysis and interpretation of data, drafting the article, final approval of the version to be published; Charles T. Wright, substantial contributions to acquisition of data, drafting the article, final approval of the version to be published; Jennifer C. Muckala, substantial contributions to acquisition of data and analysis and interpretation of data, final approval of the version to be published; Jamie Wiggleton, substantial contributions to acquisition of data, final approval of the version to be published; Bernard Rousseau, substantial contributions to conception and design and analysis and interpretation of data, revising the article critically for important intellectual content, final approval of the version to be published; James L. Netterville, substantial contributions to conception and design, revising the article critically for important intellectual content, final approval of the version to be published.

**Disclosures**

**Competing interests:** None.

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**References**


**Table 3. Voice Handicap Index Scores after Recurrent Laryngeal Nerve Reinnervation**

<table>
<thead>
<tr>
<th>Patient</th>
<th>Time from Surgery</th>
<th>Total Score</th>
<th>Physical</th>
<th>Functional</th>
<th>Emotional</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8 y</td>
<td>26</td>
<td>11</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>6 y</td>
<td>8</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>4.5 y</td>
<td>26</td>
<td>14</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>2.5 y</td>
<td>29</td>
<td>16</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>14 mo</td>
<td>17</td>
<td>11</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>11 mo</td>
<td>82</td>
<td>30</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>8</td>
<td>8 mo</td>
<td>88</td>
<td>40</td>
<td>30</td>
<td>18</td>
</tr>
<tr>
<td>9</td>
<td>5 mo</td>
<td>89</td>
<td>33</td>
<td>33</td>
<td>23</td>
</tr>
<tr>
<td>After thyroplasty, mean (SD)</td>
<td>3.8 mo</td>
<td>28.7 (19.5)</td>
<td>12.4 (7.5)</td>
<td>9.3 (6.8)</td>
<td>6.7 (6.2)</td>
</tr>
</tbody>
</table>