Window Anterior Commissure Relaxation Laryngoplasty in the Management of High-Pitched Voice Disorders

Ismail Kocak, MD, MSc; Muzeyyen Dogan, MD; Elcin Tadihan, MSc; Zeynep Alkan Cakir, MD; Serkan Bengisu, MSc; Meltem Akpinar, MD

Objective: To present the success rate of a less invasive modification of Isshiki type III anterior commissure relaxation laryngoplasty technique in patients with high-pitched voice disorders.

Design: Prospective case series.

Setting: KBB Major Private Clinic of Istanbul Surgery Hospital and the University of Yeditepe Hospital.

Patients: Twenty-one adult patients who believed that their high-pitched voices conflicted with their body image and/or gender identity.

Intervention: Type III thyroplasty for pitch alteration.

Main Outcome Measures: Comparison of preoperative and postoperative (>6 months) fundamental frequency levels, diplophonia, perception of body image and pitch, and subjective ratings of comfort during vocalization.

Results: The patients were mostly male (mean age, 30.5 years). The most frequent cause of high-pitched voice was sulcus vocalis (n=14), followed by constitutional causes (n=5), mutational falsetto (n=1), and severe glottic scarring secondary to childhood diphtheria (n=1). After surgery, the fundamental frequency dropped significantly from a mean of 213.81 Hz to 149.86 Hz (P<.001), equaling a mean postoperative semitone drop of 6.23. Misperception leading to an abnormal body image was reduced by 86%. Fourteen patients who originally had feelings of tension and fatigue during phonation and vocalization gained comfort postoperatively. Diplophonia with subharmonic signals observed in 11 cases preoperatively was reduced or disappeared in 6 cases. No complications or failures were observed during the follow-up period.

Conclusion: Window anterior commissure relaxation laryngoplasty is an efficient, easy, less invasive, and safe procedure in the surgical management of organic and functional high-pitched voice disorders.

The habitual vocal pitch is a major factor characterizing the vocal quality, and it has a role in defining one's body image. It is correlated with the patient's sex, age, airway size, and laryngeal morphometry.1,5 Atrophic vocal folds, functional problems, and even normal-looking vocal folds may produce inappropriately high-pitched levels that may lead to a feminine or childlike voice and perception of body image when the patient talks on the telephone or communicates in other nonvisual manners.6 Surgical correction or reduction of pitch was first defined by Isshiki et al7 as the type III thyroplasty technique. This technique aims to shift the anterior portion of the thyroid cartilage with its anterior commissure attachment to obtain relaxed vocal folds.7 The technique is often used to manage atrophic vocal fold abnormalities and mutational falsetto.8-10 The results are consistent, and good functional outcomes in terms of vibration quality have been reported.11 However, instability is still a potential problem of this technique and can interfere with the fine adjustments made during surgery and result in postoperative complications related to displacement.12 This report presents a less invasive modification of the standard Isshiki technique that provides better stability and ease of adjustability.

METHODS

PATIENT SELECTION

Between February 10, 1999, and November 16, 2006, 21 patients underwent window anterior commissure relaxation laryngoplasty at the KBB Major Private Clinic of Istanbul Surgery Hospital and the University of Yeditepe Hosp-
Table 1. Data on Patients Treated With the WACRL Technique

<table>
<thead>
<tr>
<th>Patient No./Sex/Age, y</th>
<th>Pathological Condition</th>
<th>Pathological Type</th>
<th>Surgical History</th>
<th>Implant</th>
<th>Mediализation</th>
<th>Follow-up, mo</th>
<th>FF, Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/M/29</td>
<td>Sulcus vocalis</td>
<td>Vergeture</td>
<td>Bilateral hyaluronic acid injection</td>
<td>...</td>
<td>...</td>
<td>72</td>
<td>196</td>
</tr>
<tr>
<td>2/M/30</td>
<td>Sulcus vocalis</td>
<td>Vergeture</td>
<td>...</td>
<td>Silicone</td>
<td>...</td>
<td>80</td>
<td>173</td>
</tr>
<tr>
<td>3/M/28</td>
<td>Sulcus vocalis</td>
<td>Pocket</td>
<td>Sulcus removal</td>
<td>...</td>
<td>...</td>
<td>62</td>
<td>216</td>
</tr>
<tr>
<td>4/M/34</td>
<td>Sulcus vocalis</td>
<td>Pocket</td>
<td>Sulcus removal</td>
<td>...</td>
<td>...</td>
<td>57</td>
<td>210</td>
</tr>
<tr>
<td>5/M/32</td>
<td>Sulcus vocalis</td>
<td>Vergeture</td>
<td>Microweb excision</td>
<td>PTFE</td>
<td>...</td>
<td>22</td>
<td>192</td>
</tr>
<tr>
<td>6/F/24</td>
<td>Constitutional</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>6</td>
<td>245</td>
</tr>
<tr>
<td>7/M/34</td>
<td>Sulcus vocalis</td>
<td>Vergeture</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>29</td>
<td>187</td>
</tr>
<tr>
<td>8/M/26</td>
<td>Constitutional</td>
<td>...</td>
<td>...</td>
<td>Silicone</td>
<td>...</td>
<td>38</td>
<td>243</td>
</tr>
<tr>
<td>9/M/27</td>
<td>Constitutional</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>53</td>
<td>208</td>
</tr>
<tr>
<td>10/M/29</td>
<td>Constitutional</td>
<td>...</td>
<td>...</td>
<td>Silicone</td>
<td>...</td>
<td>46</td>
<td>224</td>
</tr>
<tr>
<td>11/M/23</td>
<td>Sulcus vocalis</td>
<td>Vergeture</td>
<td>Temporalis fascia implant</td>
<td>PTFE Left</td>
<td>...</td>
<td>18</td>
<td>243</td>
</tr>
<tr>
<td>12/M/32</td>
<td>Constitutional</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>10</td>
<td>173</td>
</tr>
<tr>
<td>13/M/36</td>
<td>Sulcus vocalis</td>
<td>Vergeture</td>
<td>...</td>
<td>Silicone</td>
<td>...</td>
<td>27</td>
<td>162</td>
</tr>
<tr>
<td>14/F/28</td>
<td>Sulcus vocalis</td>
<td>Vergeture</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>37</td>
<td>263</td>
</tr>
<tr>
<td>15/M/33</td>
<td>Sulcus vocalis</td>
<td>Vergeture</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>28</td>
<td>165</td>
</tr>
<tr>
<td>16/M/27</td>
<td>Sulcus vocalis</td>
<td>Vergeture</td>
<td>...</td>
<td>PTFE</td>
<td>...</td>
<td>11</td>
<td>187</td>
</tr>
<tr>
<td>17/M/28</td>
<td>Sulcus vocalis</td>
<td>Vergeture</td>
<td>Sulcus removal</td>
<td>PTFE Left</td>
<td>...</td>
<td>10</td>
<td>234</td>
</tr>
<tr>
<td>18/M/27</td>
<td>Sulcus vocalis</td>
<td>Vergeture</td>
<td>...</td>
<td>PTFE</td>
<td>...</td>
<td>8</td>
<td>228</td>
</tr>
<tr>
<td>19/M/42</td>
<td>Mutational falsetto</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>6</td>
<td>241</td>
</tr>
<tr>
<td>20/M/37</td>
<td>Glottic scarring</td>
<td>...</td>
<td>Hyaluronic acid injection + fascia</td>
<td>Silicone Right</td>
<td>...</td>
<td>44</td>
<td>276</td>
</tr>
<tr>
<td>21/M/34</td>
<td>Sulcus vocalis</td>
<td>Vergeture</td>
<td>...</td>
<td>PTFE</td>
<td>Bilateral</td>
<td>21</td>
<td>222</td>
</tr>
</tbody>
</table>

Abbreviations: FF, fundamental frequency; PTFE, polytetrafluoroethylene (GORE-TEX; W. L. Gore & Associates, Flagstaff, Arizona); WACRL, window anterior commissure relaxation laryngoplasty; ellipses, not applicable.

Rationale of the Surgical Technique

This technique is a modification of Ishikini type III thyroplasty. Instead of separating the thyroid cartilage into 3 pieces, only the anterior commissure—thyroid cartilage complex (ACTC) is separated. This spares the thyroid cartilage to increase stability and allow additional procedures, such as medialization arytenoid adduction. The shape of the cartilage is rhomboid to facilitate surgical manipulation through a small anterior midline incision. The ACTC alone can be moved in coronal and sagittal directions as a composite tissue block. Coronal displacement provides symmetric tension or relaxation, while sagittal displacement provides asymmetric tension or relaxation.

Surgical Technique

Anesthesia

The surgery was performed using local sedation anesthesia. Patients were sedated with intravenous fentanyl citrate and midazolam hydrochloride under the control of an experienced anesthesiologist. The tissue overlying the anterior thyroid region was infiltrated with 2% lidocaine containing 1:200,000 epinephrine. Oxygen was supplied via a nasal cannula throughout the procedure.

Intraoperative Monitoring

During the operation, computerized voice analysis systems were available and the patients were monitored during the tuning process and positional changes. The fundamental frequency levels in phonation and speech tasks (sustained vowel and counting from 1 to 12) were analyzed. When a medialization procedure was added, the patients were monitored by fiberoptic nasolaryngoscopy to determine the exact location and to pre-
vent undesired augmentation volume and sites, such as the supraglottis and anterior glottis.

Incision

The patients were placed in the supine position with the head extended to expose the thyroid cartilage. A 2-cm horizontal incision was made anterior to the midthyroid level inside a skin crease. The sternohyoid muscles were separated and retracted laterally to expose the anterior thyroid cartilage. The external perichondrium of the thyroid cartilage was incised vertically with the superior and inferior margins of the thyroid cartilage in the shape of a vertically rotated $H$. The anterior commissure was localized by either measuring the midpoint or finding the red point of the anterior glottic vessels.

Preparing the Rhomboid Window

A rhomboid-shaped cartilage window was prepared, while keeping the anterior commissure centered in the operative field. The superior and inferior corners were not less than 3 mm from the inferior and superior margins of the thyroid cartilage to maintain the stability of the entire thyroid cartilage framework. The lateral corners were extended laterally not less than 10 mm in the direction of the glottic line parallel to the inferior border of the inferior thyroid cartilage border (Figure 1). The cartilage window was incised with a No. 15 scalpel or by drilling with 2- to 3-mm diamond burrs (Figure 2). After the internal perichondrium was reached, the window was partially mobilized by circumferential elevation of the thyroid lamina away from the internal perichondrium, while keeping the ACTC window and its internal perichondrium attachments intact (Figure 3). The lateral cartilage borders of the flanges were removed further by drilling or cutting. Care was taken to preserve the internal perichondrium. The lateral corners were reduced while following the glottic line for symmetry. Each reduction resulted in passive posterior displacement of the window ACTC, resulting in a drop in the fundamental frequency (Figure 4).
After displacement of 4 to 5 mm was obtained, the lateral contact between the cartilage window and thyroid cartilage frame was lost, but further relaxation was allowed until a certain stable and balanced tension was reached and no further fundamental frequency change was measured. The cartilage window was grasped gently and moved in sagittal and coronal directions to obtain better voice quality. Coronal movements resulted in symmetric tension, while sagittal movements resulted in asymmetric tension. If the passive relaxation was insufficient, a force was applied to displace the ACTC, which was then stabilized. After the desired or optimal pitch levels were reached, the quality of the voice was reevaluated. In the presence of breathiness and diplophonia, sagittal positioning and medialization procedures were planned. In the case of bowed, atrophic, or incompetent vocal fold or folds, a medialization pocket was undermined through the inferior border of the frame. The frame corner was the upper limit of the augmentation pocket. The pocket was extended through the midglottic level, which usually did not need to be exceeded for atrophic abnormalities.

A silicone or polytetrafluoroethylene (PTFE) (GORE-TEX; W. L. Gore & Associates, Flagstaff, Arizona) stripe was introduced into the medialization pocket and used to stabilize the ACTC. After any bleeding was controlled, the strap muscles and skin flaps were approximated with 3-0 polyglactin and the skin was closed with 4-0 nylon sutures. A Penrose drain was left in the neck for 1 or 2 days. The sutures were removed on the sixth postoperative day.

In the postoperative period, the patients were instructed not to make any vocal effort or participate in sports activities. Antireflux medication was added for 3 weeks. Vocal fold edema and voice quality were checked between 4 and 10 days postoperatively, in the sixth postoperative week, and more than 6 months postoperatively.

**VOICE EVALUATION**

Voice analysis was performed with the Multi-Dimensional Voice Program developed by Kay Elemetrics (Lincoln Park, New Jersey). Each voice sample was recorded in a quiet room (noise level, <40 dB) with the use of a unidirectional (cardioid) mi-

### Table 2. Changes in FF and Semitones According to Pathological Condition

<table>
<thead>
<tr>
<th>Pathological Condition</th>
<th>FF, Hz</th>
<th>Preoperative</th>
<th>Postoperative</th>
<th>Decrease</th>
<th>Pitch Drop, Semitones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulcus vocalis (n=14)</td>
<td>205.71</td>
<td>146.43</td>
<td>59.28</td>
<td>6.00</td>
<td></td>
</tr>
<tr>
<td>Constitutional (n=5)</td>
<td>218.60</td>
<td>158.60</td>
<td>60.00</td>
<td>5.56</td>
<td></td>
</tr>
<tr>
<td>Mutational falsetto (n=1)</td>
<td>241.00</td>
<td>119.00</td>
<td>122.00</td>
<td>12.22</td>
<td></td>
</tr>
<tr>
<td>Glottic scarring (n=1)</td>
<td>276.00</td>
<td>185.00</td>
<td>91.00</td>
<td>6.93</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: FF, fundamental frequency.

---

**Figure 4** Lateral views of the cartilage window before (A) and after (B) relaxation.

**Figure 5.** Pitch drops according to use and type of implant in patients undergoing window anterior commissure relaxation laryngoplasty. PTFE indicates polytetrafluoroethylene.
crophone (SM58; Shure, Niles, Illinois) placed 10 cm from the lips. The subjects were instructed to sound the vowel a at a comfortable level for 3 seconds. The first and last 200 milliseconds of the sustained phonation were discarded and the fundamental frequency was measured. Each trial was captured digitally at 16-bit resolution with a sampling rate of 44 100 Hz. A narrow-band spectrogram (Real-Time Spectrogram, Model 5129, Version 2.4; Kay Elemetrics) was used to evaluate the subharmonics and diplodia in the voice. Semitones were calculated from the corresponding notes that represent the frequency value. A narrow-band spectrogram was used to measure the degree of subharmonic type 2 signals.

**QUESTIONNAIRES**

Routine questionnaires were used to evaluate 3 main points in the preoperative and postoperative periods (more than 6 months): (1) self-perceived pitch as high, normal, or low; (2) caller response on routine telephone communications as “Mr.,” “Mrs.,” “Miss,” or “Get your Mommy or Daddy”; and (3) the comfort level in speech as bad or good.

**STATISTICAL ANALYSIS**

All computations and statistical analyses were performed with SPSS 8.0.0 (SPSS Inc, Chicago, Illinois). Paired t tests were used to compare differences between the preoperative and postoperative values of the voice analysis. Statistical significance was set at P < .05.

**RESULTS**

**MEAN FUNDAMENTAL FREQUENCY**

The overall preoperative mean (SD) fundamental frequency was 213.81 (32.48) Hz, and it decreased postoperatively to 149.86 (27.36) Hz, which was highly significant (P < .001). The mean decrease was 63.95 (20.35) Hz, corresponding to a mean of 6.23 (1.98) semitones. The greatest decrease (12.22 semitones) was seen in the patients with mutational falsetto, followed by the patients with the scarred vocal fold with 6.93 semitones, the sulcus vocalis cases with 6.00 semitones, and the constitutional cases with 5.56 semitones (Table 2). Without implants, a considerable decrease in the fundamental frequency was obtained. For further relaxation, PTFE was used in 6 cases and silicone blocks in 7 cases for ACTC compression and stabilization. Although the best relaxation results were achieved with silicone, there was no significant difference between the implant and nonimplant groups (Figure 5).

**PERCEPTION OF PITCH AND BODY IMAGE**

A subjective pitch drop was noted by all patients in the constitutional (n = 5), mutational falsetto (n = 1), and glottic scarring (n = 1) groups. In the sulcus group (n = 14), 3 patients reported no improvement in their voice quality postoperatively despite changes in the fundamental frequency (Table 3). The overall change in high-pitched voice perception was 86% (in 18 of the 21 patients), which was statistically significant (P < .05).

**COMFORT**

On the questionnaires, a feeling of tension or fatigue was noted by 12 patients in the sulcus group, the patient with a mutational falsetto disorder, and the patient with glottic scarring secondary to a laryngeal diphtheria infection in childhood. It was not a problem for the patients in the constitutional group. All of the patients who experienced the feeling of tension or fatigue gained a cer-
sired values are still controversial. Putting the funda-
ment of the sex or age of the speaker in the listener's mind.

The most common disorders leading to a high funda-
mental frequency within the normal range of a desired
population or group often results in success in terms of
the correct perception and identification of sex, while
levels outside these normal ranges are often misperceived.

Window anterior commissure relaxation laryngopla-
asty is less invasive than the standard technique for
pitch-lowering surgery. However, the change and relax-
ation have limits. After a certain level is reached or ex-
ceeded, the voice quality deteriorates, which may re-
quire additional augmentation.

The comfort levels have not been well studied in vo-
cal disorders or in terms of the surgical outcome. In our
patients, it was apparent that, despite the perceptual qual-
ity projected by society, most patients, especially those
with sulcus vocalis, were content to gain comfort dur-
during phonation after surgery. The feeling of tension or fa-
tigue is an expected symptom in disorders with less ef-
ficient vibratory glottic closure and stiff vocal folds that
are characteristics of patients with sulcus vocalis. The re-
duction in glottic efficiency necessitates extra effort by
extralaryngeal muscles and breath support that results
in voicing and speech discomfort. Relaxation laryngo-
plasty techniques provide some advantage while reduc-
ing the glottic tension and length; they are also ex-
pected to increase the mucosal pliability at the midglottis,
where efficient vibratory dynamics occur. Another prob-
lem observed in the sulcus group was the presence of a
diplophonic voice quality. Although no phonosurgical
technique has been designed specifically to reduce dip-
lophonia, the relaxation technique may provide some ad-
vantages to overcome this problem.

For most laryngoplastic techniques, the extent of the
surgical area over the laryngeal cartilage and deep tis-
sues determines the extent of the intralaryngeal edema.14
This may lead to minor vocal changes or severe airway
problems postoperatively. When the surgical procedure
is prolonged, intraoperative edema may result in diffi-
culties with intraoperative voice monitoring and adjust-
ment. The anterior commissure region of the larynx is
resistant to edema formation because the tissue there is
firmer. Therefore, window anterior commissure relax-
ation laryngoplasty as a less invasive modification of the
standard technique seems advantageous in allowing ad-
tional fine adjustments.

Our study showed that the standard relaxation laryn-
goplasty technique devised by Isshiki can be refined to
localize the surgery to the anterior commissure region,
and that satisfactory results can be obtained with mini-
mal complications.

**COMMENT**

The fundamental frequency is one of the major voice mea-
sures and is a determinant of vocal perception. A shift
in one's frequency to the level of men, women, or chil-
dren is possible because of anatomic variation or vari-
ous abnormalities.13 This may lead to confusion in terms
of the sex or age of the speaker in the listener's mind.
The most common disorders leading to a high funda-
mental frequency are functional mutational falseto, atro-
phic glottis abnormalities, and sulcus vocalis. Regard-
less of the cause, relaxation techniques are effective at
reducing the fundamental frequency.3 However, the de-
sired values are still controversial. Putting the funda-
tain level of comfort postoperatively. The feeling disap-
ppeared in 6 of the 14 patients (43%) and was reduced in
the remaining 8 (57%).

**VOICE QUALITY**

Eleven of 21 patients (52%) had a diplophonic voice qual-
ity verified by the subharmonic signal output in narrow-
band spectrograms. The majority of these cases were in
the sulcus group (n=8). In the late postoperative evalua-
tion, a diplophonic voice quality and subharmonic mea-
sures were still observed in 6 cases, including 1 patient
who did not have this condition preoperatively. The tech-
nique improved the diplophonic voice quality by 45%,
but the change was not statistically significant.

**COMPLICATIONS**

No complications, displacement, or implant extrusion
were observed during the follow-up, and this was con-
firmed by computed tomography (Figure 6). In the first
2 to 3 weeks after surgery, all patients had minor glottic
edema at the anterior third without compromising the
airway, and this showed complete spontaneous resolu-
tion after 5 weeks.
Analysis and interpretation of data: Kocak, Dogan, Alkan Cakir, and Akpinar. Critical revision of the manuscript for important intellectual content: Kocak and Tadihan. Statistical analysis: Tadihan. Administrative, technical, and material support: Kocak, Dogan, Alkan Cakir, Bengisu, and Akpinar. Study supervision: Kocak.

Financial Disclosure: None reported.

REFERENCES