

# Gender-Affirming Voice Surgery: Considerations for Surgical Intervention

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## ABSTRACT

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The purpose of this article is to provide an overview of the current state and available evidence surrounding surgical voice care for the transgender and/or gender expansive population. The term “gender expansive” has been proposed as an inclusive term to classify those who do not identify with traditional gender roles but are otherwise not confined to one gender narrative or experience. We aim to review indications and candidacy for surgery, surgical procedure options for altering vocal pitch, and typical postoperative expectations. The role of voice therapy and considerations for perioperative care will also be discussed.

**KEYWORDS:** transgender, voice care, gender-affirming care, voice surgery, glottoplasty

**Learning Outcomes:** As a result of this activity, the reader will be able to:

- Recognize potential indications for laryngoscopy/stroboscopy when providing gender-affirming voice care.
- List the various surgical options available for pitch elevating surgery and benefits/limitations for each.
- Counsel patients on the typical postoperative course with regard to vocal rehabilitation and limitations.

Gender dysphoria is an increasingly recognized medical condition associated with great psychological distress that results from incongruence between one’s gender identity and their sex assigned at birth. A multifaceted and multidisciplinary care model is recommended by

the World Professional Association for Transgender Health (WPATH) given the complexity and variety of challenges individuals may face.<sup>1</sup> The goals of care are aimed toward helping an individual achieve satisfaction with their identity, function, and/or physical form. This in turn is

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anticipated to alleviate the psychological distress manifesting as gender dysphoria. Specialists in the fields of speech-language pathology (SLP) and otolaryngology—head and neck surgery (OHNS; specifically laryngology) are well poised to improve many aspects of patient's quality of life, specifically with respect to gender-affirming voice care and modification.<sup>1-3</sup> Laryngologists are otolaryngologists that specialize in advanced diagnosis and treatment of conditions of the upper aerodigestive tract (conditions related to voice, breathing and swallowing). These individuals have extra training in their area of expertise and usually work closely with SLP.

The morphology of the larynx (especially the laryngeal prominence of the thyroid cartilage) and the voice itself are secondary characteristics associated with sex. As such, they are important considerations recognized by the WPATH when providing gender-affirming care. The laryngeal prominence of the thyroid cartilage (Adam's apple) is a physical feature strongly associated with people assigned male at birth<sup>4</sup>—as such, surgical procedures to reduce visibility of this portion of the larynx is often sought by transgender women or other transfeminine individuals who do not want to be associated with such. Additionally, the human voice carries many signals in our society including traditional gender roles and thus contributes heavily to gender assumptions made by the listener. Thus, altering the voice to achieve the desired attributions from others is critical to a successful transition process for many transgender individuals. One objective difference between the stereotypical cis male and cis female voice that is easily measured and contributes to gender attribution is fundamental frequency (vocal pitch). Pitch ranges between 80 and 120 Hz are typical for cis males, and between 180 and 220 Hz for cis females. There is a gender ambiguous range between 145 and 165 Hz, whereby the gender identification based on pitch is less predictable.<sup>5-8</sup>

Vocal pitch is largely determined by three fundamental parameters: (1) length of the vibratory vocal fold edge, (2) vocal fold mass, and (3) vocal fold tension. Modification of these parameters set the premise of available surgical inter-

ventions. For transgender women and some gender non-conforming individuals, a feminine-sounding voice may be a fundamental component of an individual's overall transition process. Conversely, pitch-lowering surgical options are available, though uncommonly performed. While pitch is a major driver of gender perception, there are other significant characteristics of voice and resonance that contribute to perception of gender. There exist gender differences in physical, neurophysical, and acoustic characteristics that make voice therapy integral to the gender-affirming voice care process. Behavioral voice therapy focuses on addressing voice and communication variables, which can include modification of oropharyngeal resonance, pitch, intonation, intensity, language, and non-verbal gestures/communications.

Not every transgender and/or gender expansive (TGE) individual experiences challenges with or warrants professional treatment for their voice. Nonetheless, those who do desire these services can experience significant barriers. In general, access to voice therapy as well as voice surgery can be extremely limited by lack of insurance coverage.<sup>9</sup> It is thought that access to voice therapy may be better than surgery due to the limited number of surgeons offering pitch elevating surgery. Regardless, voice and communication specialists are well positioned to provide information and guidance to TGE individuals who express dissatisfaction with their voice and communication.<sup>1</sup>

### **When Should Individuals Seeking Gender-Affirming Voice Care Undergo Laryngoscopic Evaluation?**

Voice concerns endorsed by the treatment seeking TGE individual commonly include undesirable pitch, misgendering based on voice (especially on the telephone), and inadequate gender-related voice characteristics. They may also endorse voice symptoms such as hoarseness, roughness, raspiness, vocal strain, effort or fatigue, inadequate volume, inability to sustain learned vocal techniques, among many others. A comprehensive voice assessment can be considered before initiating voice therapy or considering surgery. For patients seeking

gender-affirming voice care, an interdisciplinary evaluation with a voice-specialized otolaryngologist/laryngologist and SLP with experience caring for TGE individuals would be ideal so that all options for voice care can be presented. This is unfortunately not realistic for all patients due to limited access and remains an area for improvement.

Laryngoscopy (with or without stroboscopy) remains a fundamental component of comprehensive voice evaluations. It allows direct visualization of the larynx, assessment of vocal fold structure and physiology, and holds high diagnostic weight. Without visualization of the larynx, an accurate clearance from or diagnosis of a potential voice problem cannot be established. While the majority of TGE patients seeking gender-affirming voice care will have no significant underlying vocal fold pathology, there are individuals who may have concurrent suspected underlying pathology or unexpected laryngeal findings.<sup>10</sup> If the voice specialist is suspicious of an underlying voice problem separate from the gender-related voice concerns, laryngoscopy should be considered. Additionally, failure to achieve satisfactory progress during a course of voice therapy is another indication for pursuing laryngoscopic evaluation to ensure there are no anatomic/physiologic barriers to voice modulation. In general, it is valuable to have a baseline examination prior to initiating any voice/medical changes. The laryngoscopy exam can also serve as a useful educational tool for the treating providers on the vocal production mechanisms that can be used as an adjunct to voice therapy and may help guide treatment planning and decision making.

It is recognized that the rate of laryngoscopic pathology overall is low in the TGE population. A study examining 61 transgender women presenting to a tertiary care, multidisciplinary care clinic (jointly assessed by a fellowship trained laryngologist and voice specialized SLP) found a 5% rate of pathology separate from the patients' concerns about gender incongruence following stroboscopic examination.<sup>10</sup> Further studies are needed to identify the incidence of vocal pathology in TGE individuals.

Conversely, it is worth mentioning that the TGE population is disproportionately affected by several health and socioeconomic disparities, which in turn may affect vocal health. The persistent marginalization experienced by TGE individuals is in part responsible for the elevated risk of substance abuse behavior—including tobacco, alcohol, and other substances—to cope with stress and other mental health burdens.<sup>11–13</sup> These are established risk factors for vocal pathology such as Reinke's edema, leukoplakia, dysplasia, malignancy, and nonspecific diffuse inflammatory change. If there is suspicion for such pathologies, a laryngoscopy can provide diagnostic value.

As per the American Speech-Language Hearing Association (ASHA), endoscopy is an imaging procedure included within the scope of practice for SLPs, whereby SLPs with specialized training in flexible/nasal endoscopy, rigid/oral endoscopy, and/or stroboscopy use these tools for the purpose of evaluating and treating disorders of speech, voice, resonance, and swallowing function.<sup>14</sup> SLPs make anatomic, physiologic, and behavioral assessments during laryngeal examination; however, they are restricted from providing formal diagnoses based on endoscopic findings. If a formal diagnosis is required to obtain coverage for voice therapy services (by the public health care system, insurance company, etc.) then laryngoscopy by an OHNS is recommended. Patient's being considered for voice surgery will almost inevitably be evaluated preoperatively by endoscopic laryngeal evaluation for surgical planning. Similar to the barriers precluding multidisciplinary assessment, access to laryngoscopy may also be an inevitable challenge, and should not significantly delay access to any available voice therapy services (local or via tele-medicine).

### **What Treatment Options Should SLPs and Other Voice Specialists Be Aware of to Help with Decision Making and Preparation for Pitch-Modifying Surgery?**

When providing care for an individual, it is important to be aware of the spectrum of treatment options that are available to manage a patient's concerns. To be able to educate and serve as patient advocates, providers offering

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**Summary.** Potential benefits and indications for laryngoscopy (+/– stroboscopy) include:

- If access and “cost” (financial, time, and psychological costs) associated with a laryngoscopy procedure are not significant barriers for the patient, then diagnostic and educational value of the procedure is valuable.
  - Diagnostic confirmation (or lack thereof) of underlying pathology (both benign and neoplastic).
  - Laryngoscopy is usually required before pursuing pitch-modifying surgery.
  - Failure to achieve adequate progress during voice therapy should prompt endoscopic evaluation of the larynx.
  - Laryngoscopy should be considered for individuals with a “dysphonic” voice where there is clinician-suspected vocal pathology.
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gender-affirming voice care should have some established knowledge about the risks and benefits of surgery. Many individuals choose not to undergo surgery based on their evaluation of medical possibilities, risks, and limitations. For voice concerns related to gender presentation, treatment options include hormone replacement therapy, voice therapy, and surgery. For transgender men seeking voice care, knowledge that testosterone therapy is often effective in lowering of pitch (due to testosterone’s permanent effect on vocal fold mass) is an important point as the need for surgery is less likely than for their transgender female counterparts. Voice therapy can be an effective treatment method to manage and guide vocal concerns before and during initiation of testosterone-based replacement therapy. It should be recognized that not all transmasculine individuals chose to pursue testosterone, and those who do sometimes fail to achieve a voice result that matches their expectations with testosterone therapy alone.<sup>15–25</sup> Some experience inadequate pitch lowering, compromised vocal quality, difficulties with volume, projection, vocal endurance, pitch range, and flexibility. A recent meta-analysis of 19 studies assessing the acoustic effects of testosterone on voice after a minimum of 1 year estimated 21% of study participants did not achieve cis-gender normal frequencies, and 21% reported incomplete gender-congruent voice; 16% remained unsatisfied with their voice.<sup>25</sup> These patients should be counseled on behavioral voice therapy as an effective method to address these residual voice concerns. Although uncommonly needed, there do exist surgical procedures effective at lowering vocal pitch for individuals who do not achieve satisfactory voice results following adequate duration testosterone replacement therapy. These are briefly discussed later in the article.

Unfortunately, for post-pubertal individuals, the prior effects of androgens on the skeleton and voice (including the visible laryngeal prominence) cannot be altered or reversed. Once testosterone is withdrawn, muscle and mucosal atrophy and other vocal fold changes are minimal.<sup>17,19</sup> This translates into limited changes of existing vocal pitches and formant frequencies. Additionally, estrogen-based therapy has minimal effect on voice and pitch.<sup>26</sup> As such, many of the transgender patients presenting to laryngology practices for gender-affirming care are transgender women (assigned male at birth). This is also the group of transgender individuals where most of the literature evaluating surgical outcomes is focused. Surgery for this group does not come without risks, and permanent hoarseness or inadequate elevation of pitch are potential outcomes following surgery (more information is presented below). It is important to consider that absolute voice rest for at least 1 week is often recommended after pitch-elevating surgeries. All patients are expected to experience at least transient hoarseness following surgery—this can include aphonia, breathiness, roughness and strain, pitch instability, and breaks. The vocal quality is often initially worse, with gradual improvement over several weeks. As such, patients should plan accordingly to have adequate time away from work, childcare, and other duties/commitments requiring vocalization.

### **Do All Patients Need Voice Therapy Prior to Consideration of GA Voice Surgery?**

The WPATH SOC8 recommends that health care professionals working with transgender and gender diverse individuals considering voice surgery be referred to a clinician who can provide pre- and/or postoperative support.<sup>1</sup> Although this

statement supports the importance of behavioral intervention in the operative processes, it does not mandate or address the question regarding whether transgender individuals should have voice therapy before considering or even discussing surgical options. The literature does, however, support great potential benefit to an individual engaging in some degree of voice therapy—either indirect and/or direct—for a multitude of reasons. Indirect voice therapy can provide the patient with informational counseling based on voice assessment, and discussion surrounding expected voice outcomes related to voice therapy, possible surgical intervention, and risks of surgery. Additionally, voice therapy allows the SLP to learn more about where the patient is in their gender affirmation process, explore goals and expectations, and empower the individual to explore their current vocal capabilities, potential behavioral vocal modifications, and understand that they can impact change in their voice with or without surgery. Voice therapy also highlights what aspects of voice can be realistically controlled and which aspects may be more difficult and limiting.

For these reasons, prior to laryngeal surgery (as with many other voice problems and pathologies), voice therapy is often preferred prior to surgery, as well as in the postoperative recovery period. Postoperative voice therapy aims to ensure a return of functional and healthy voice production.<sup>27,28</sup> It is well known that surgical interventions are aimed at altering pitch only, and many other aspects of voice and communication contribute to perceived femininity or masculinity. Voice therapy focuses on voice production and pitch modulation techniques to help the TGE individual modify various aspects of voice such as intonation patterns, resonance and formants, pitch and pitch range, articulation, language, and nonverbal communication patterns. There is no available literature comparing patients who underwent voice therapy prior to surgery versus surgery alone. Most currently published studies of surgical outcomes reflect the combined effects of voice therapy and surgical intervention.<sup>28–31</sup> It is therefore recommended by the authors herein that patients be encouraged to engage in voice therapy, ideally with a voice specialized SLP who has experience treating gender expansive individuals with concerns of incongruence between voice,

communication, and gender. While access to high-quality voice therapy remains a barrier to treatment, the use of teletherapy maybe an alternative to in-person therapy and increase access to specialize voice therapy care. This may be especially true if barriers such as travel distance, occupational or childcare restrictions, parking/travel expenses, and lack of local voice-care providers exist.<sup>32</sup>

The current literature demonstrates that voice therapy can successfully help individuals achieve a more feminine sounding voice both with and without pitch elevating phonosurgery. The degree to which voice changes immediately following voice therapy is sustained long-term remains unclear. Longitudinal studies following patients beyond 1 year suggest there may be a decline in perceived femininity of voice.<sup>26</sup> There are a growing number of studies emphasizing the possible benefits of combining surgical treatment with voice therapy.<sup>28,29,33</sup> While a trial of voice therapy before surgery can be quite beneficial, standardizing an absolute requirement or number of preoperative voice therapy sessions is not suggested. In general, however, the literature suggests that some degree of meaningful progress with voice therapy is often observed within four to six therapy sessions.<sup>29</sup> Patient autonomy and shared decision-making should be the focus of establishing a treatment regimen. For this reason, assessment in a joint multidisciplinary clinic can assist transgender individuals with making informed decisions that best align with their individual goals and likelihood of improvement with voice therapy techniques. There is likely a small subset of patients in whom pitch is the major driver for being misgendered, and other aspects of their voice and communication are likely hindered by this factor alone. These patients may benefit from upfront or early surgical intervention, with postoperative voice therapy reserved to address any residual voice concerns, if they exist.

### **What Are the Surgical Options for Pitch-Elevating Surgery?**

Surgery for gender-affirming voice care has been performed for many years and has an “interesting” history and a bright present. The

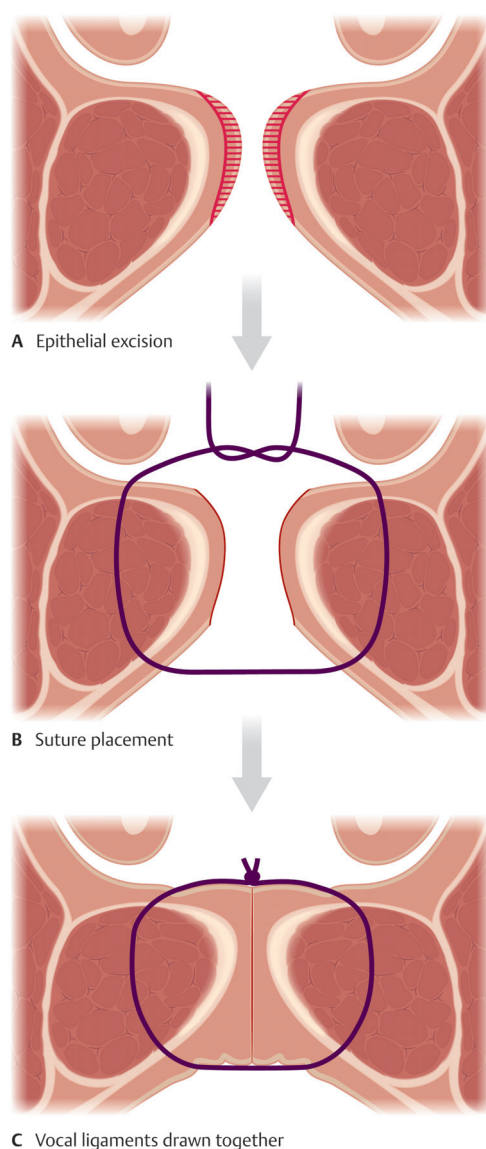
vast majority of past and present work has focused on pitch-elevation for the TGE individual (assigned male at birth) and thus that will be the focus for this section. Below we discuss four surgical topics: past suboptimal results; present procedures to avoid; current gold standards; and finally procedures that are not adequately studied thus far.

Twenty plus years ago, cricothyroid approximation surgery was advocated to elevate pitch for TGE individuals. This procedure was originally part of the innovative set of surgeries that Nobuhiko Isshiki, MD, proposed in 1989.<sup>34</sup> Professor Isshiki described a “type 4 thyroplasty” which resulted in simulating the contraction of the cricothyroid muscle to elevate pitch. This surgery involves placement of sutures between the lower aspect of the thyroid cartilage and the cricoid cartilage to diminish the cricothyroid space and causing a “lengthening of the vocal folds.” This surgery can be done under local or “monitored anesthesia care (MAC)” and can be done simultaneously with chondrolaryngoplasty (surgery to reduce protrusion of the thyroid notch). Longer-term reports on cricothyroid approximation have shown decline in pitch elevation over time.<sup>35–38</sup> Over time, surgeons found that the pitch gained with the surgery was lost and thus this surgery is no longer suggested given that the short-term nature of the benefit is lost several years postoperatively.

In the early 2000s, surgeons advocated a laser-assisted reduction of the vocal fold bulk and laser-assisted “tightening” of the vocal folds to elevate pitch.<sup>39,40</sup> This procedure is sometimes referred to as laser-assisted voice adjustment (LAVA). These surgeries were done under general anesthesia and involved laser removal of vocal fold mucosa and muscle. The results of these surgeries have not been well documented nor have any long-term results been published. The concept of inducing scar tissue within the incredibly delicate and important vibratory aspects of the vocal folds especially the lamina propria and medial aspect of the thyroarytenoid muscle cause great concern to any health care professional trained in vocal medicine. This concept of inducing vocal fold scar and removing bulk of the vocal fold to attempt to elevate pitch should be strongly

dissuaded given the severity of the result, inability to recover following the surgery, and much better surgical options.

In 1990, Wendler described an endoscopic surgical approach to shorten the vibrating length of the vocal folds by creating an anterior glottal web.<sup>41</sup> The sequence of surgical steps for Wendler glottoplasty is illustrated in Fig. 1. This surgery has been extensively studied and favorable results have been reported by many different surgical groups and long-term benefit has been documented in the peer-reviewed literature.<sup>29,31,38,42–44</sup> In theory, this procedure

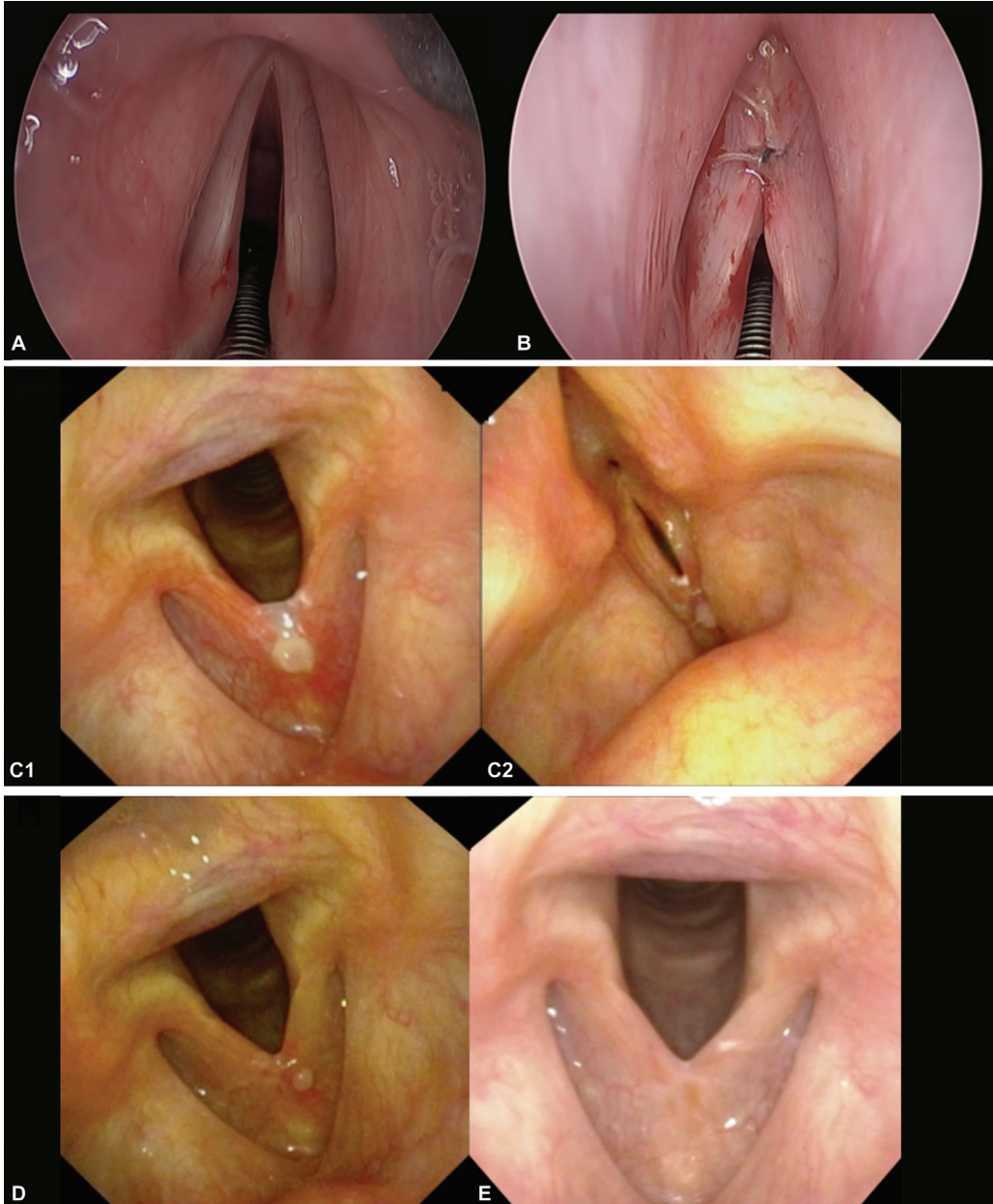


**Figure 1** Schematic illustration of Wendler glottoplasty.



could be reversed in a similar manner for which iatrogenic anterior glottal webs are treated. The surgery is done under general anesthesia and is typically performed as an outpatient surgery with no incisions in the neck. The surgery is technically demanding with a steep learning curve, but specialized laryngeal surgeons have

the skills and equipment to perform this surgery in a consistent and effective manner. The surgery is followed by a period of voice rest and usually takes at least several months to finalize healing (see Fig. 2 for intraoperative and postoperative appearance). During the early postoperative period, dysphonia is expected,



**Figure 2** Wendler glottoplasty. (A) Intraoperative view of vocal folds prior to intervention. (B) Intraoperative view following suture approximation. (C) Laryngoscopy—1-month postoperative appearance. (D) Laryngoscopy—3-month postoperative appearance. (E) Laryngoscopy—9 to 12 months final postoperative appearance.

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**Summary.** Surgical options for pitch elevation may include the following:

- Wendler glottoplasty—endoscopic surgery creating an anterior glottic web, thereby shortening length of vocal folds. Present gold standard, well studied, and good long-term results have been documented.
  - Cricothyroid approximation—open surgery shortening the cricothyroid space, thereby tensing vocal folds which has limited lasting benefit.
  - Anterior commissure advancement—open surgery creating a window of cartilage centered on the anterior commissure and pulling it forward, thereby tensing the vocal folds. Open surgery of the larynx with little outcome results or no long-term result information.
  - LAVA—endoscopic surgery using a laser to remove vocal fold mucosa and muscle lateral to the vibratory margin, thereby reducing the mass of the vocal fold.
  - FemLar—open surgery that involves a laryngofissure (surgical midline division of the larynx) and endolaryngeal reconstruction to shorten the length of the vocal folds and alter the supraglottic resonating chamber. Substantive change to the structure of larynx and limited long-term results available.
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and voice therapy is extremely helpful to assist the adjustment to the individual's "altered vocal apparatus" and maximize vocal recovery. This surgery has been shown to provide long-term pitch elevation given the nature of the alteration of the voice physiology (shorter vibrating vocal folds result in elevated pitch production). The procedure has been modified in a handful of ways from the original description by Wendler, such as the vocal fold shortening with retrodisplacement of anterior commissure (VFSRAC) procedure by Kim. These various modifications are yet to be compared head-to-head, but this does not take away from the excellent results that are achieved by this type of surgeries (surgical creation of shorter vibrating vocal folds). When done by a skilled and experience surgeon, Wendler glottoplasty or a variation of this surgery is the present gold standard for pitch elevation voice surgery.

Several "open" laryngeal surgical procedures have been advocated to elevate the pitch. There are limited descriptions of anterior commissure advancement surgery, and more recently, feminization laryngoplasty (FemLar).<sup>45–47</sup> The FemLar procedure involves a laryngofissure (surgical midline division of the larynx) and subsequent reconstruction to shorten the length of the vocal folds and alter the supraglottic resonating chamber. The former surgery involves "stretching" or "lengthening" the vocal fold by surgically moving the anterior commissure into a more anterior position. Neither of these procedures has significant data results reported in the peer-reviewed literature nor results from

multiple different surgeons. The anterior commissure advancement may have the same long-term problems that the type 4 thyroplasty (crico-thyroid approximation) surgery experienced. The FemLar surgery is an aggressive, destructive, and irreversible procedure. Neither of these procedures have empirical or clinical support comparable to that of the Wendler glottoplasty or variation.

### **What Are the Surgical Options for Pitch-Lowering Surgery?**

As discussed previously, the incidence of TGE individuals (assigned female at birth) presenting for pitch-lowering surgery is quite low due to the pitch-lowering effect of testosterone therapy and use of voice therapy to address and residual voice concerns. There is a paucity of literature to support one technique over another at the present time, and a brief overview of surgical options is provided. Pitch-lowering surgery has been largely based on techniques to reduce tension on the vocal folds. Isshiki Type III thyroplasty (relaxation thyroplasty) and variations thereon have been reported.<sup>48</sup> These are open surgeries where the thyroid cartilage is exposed via an incision in the neck. A strip of cartilage is removed on either side of the midline thyroid cartilage, thereby reducing the length of each thyroid ala and, in turn, providing relaxation of the enclosed vocal folds. Alternatively, retrodisplacement of the anterior commissure can provide relaxation of the vocal folds.<sup>49,50</sup> This is performed by creating either a



window or levered piece of cartilage centered on the anterior commissure attachment, pushing it backward into the larynx, thereby relaxing the vocal folds. For these above open-neck pitch-lowering procedures, augmentation of the laryngeal prominence can also be simultaneously performed. Finally, descriptions of vocal fold augmentation to add bulk/mass to the vocal folds have been reported as pitch-lowering surgical interventions.<sup>51</sup>

### **Which Patients Are Considered Candidates for Gender-Affirming Voice Surgery?**

In an attempt to provide unbiased care, individuals seeking gender-affirming voice care should be informed about the option of surgery. This may not ultimately be recommended by the treating clinician or chosen by the patient but is an established treatment option warranting consideration. Surgical candidacy is currently poorly defined and incompletely understood, and there are no well-established recommendations by the WPATH for voice surgery. The WPATH does provide a statement suggesting “health care professionals counsel eligible transgender and gender diverse people about the options for gender-affirmation surgery unless surgery is not indicated or medically contraindicated.”<sup>1</sup> The exact indications for patients who are anticipated to benefit from pitch-elevating phonosurgery are not well defined. Patients who make inadequate progress and remain dissatisfied with their voice following voice therapy can be considered for surgery. Some patients report good success with voice therapy, but find the techniques unsustainable, mentally and cognitively taxing, or find they “slip” into a less preferred voice when emotional, upset, yelling, coughing, or laughing. These patients may wish to consider surgery to address these voice concerns. There are patients whose pitch remains problematic and within the masculine-sounding range, despite progress with the other elements of voice (i.e., intonation, resonance, etc.) in voice therapy. If no medical contraindications, these patients are candidates for surgery, as surgery can effectively elevate the pitch of the voice into a gender neutral or cis female range.

Most surgeons follow the WPATH and Endocrine Society guidelines, which suggest that surgeries take place only after a year of hormone treatment.<sup>1,52,53</sup> The rationale for this suggestion is that patients should have a stable treatment regimen before undergoing more invasive interventions. For patients seeking surgery without desire or need for hormone treatment, a different surrogate for a stable regimen may be considered, such as living in the gender role matching their identity for a year.<sup>54</sup> Unfortunately, as with many other operations, standards for evaluating surgeons’ qualifications (such as number of surgeries) or quality of surgical outcomes do not exist and are not readily available. As such, referral to a center offering multidisciplinary voice care (including a laryngeal surgeon/laryngologist and voice-specialized SLP) is suggested.

### **What Are the Important Risks Associated with Pitch-Elevating Surgery? Are There Any Vocal Tradeoffs to Consider?**

Surgery does not come without risks, and permanent hoarseness and inadequate elevation of pitch are potential outcomes following surgery. All patients are expected to experience at least transient hoarseness following surgery—this can include aphonia, breathiness, roughness and strain, pitch instability, and breaks (see Fig. 2 for typical postoperative vocal fold appearance). Loss of access to lower register and vocal pitches is expected after pitch-elevating surgery. There are reports of vocal roughness following Wendler glottoplasty, likely due to aperiodicity in the glottal flow waveform.<sup>43,44,55</sup> Nonetheless, the majority of publications report favorable effects and high rates of patient satisfaction with surgical procedures. A large number of studies support pitch-elevating surgery with low complication rates, hoarseness, or need for revision surgery.<sup>36,56</sup> Chang et al specifically assessed changes in various objective acoustic measures following Wendler glottoplasty.<sup>30</sup> They concluded that the Wendler glottoplasty can safely be performed without worsening of acoustic measures associated with voice quality. Overall increases in average speaking fundamental frequency were observed.

Revision rates following surgery are variable, and likely depend on surgeon volume and techniques used. Revision rates following endoscopic shortening procedures (Wendler glottoplasty, VFSRAC) are variable, with reports ranging from 0 to 12.5%.<sup>56</sup> Revision rate for the open feminization laryngoplasty procedure first described by Thomas and Macmillan was 26.6%.<sup>47</sup> In comparison, the only other study reporting on this procedure quoted a revision rate of 7%, and 41% required in office KTP laser treatment to smooth or further feminize the voice.<sup>46</sup> Revision surgery with Wendler glottoplasty, VFSRAC, and LAVA following cricothyroid have been reported on numerous occasions in the literature,<sup>33,37,40</sup> though exact revision rate following this surgery is largely unknown. Meta-analysis also suggests this procedure most likely to fail for elevating pitch, and there was lowering of the pitch over time.<sup>35</sup>

Several patients inquire about the effect of surgery on the singing voice. Little is reported on the effects of singing voice for those patients who consider this important. Most likely the result is unpredictable given the intricacies of singing itself. It is expected there will be a shift in vocal range, and loss of access to lower and higher registers may result. Singers may experience difficulties with smooth pitch transitioning, inability to accurately produce desired vocal notes, and note decreased volume and power to the voice. Kim reports on eight professional singers who underwent vocal fold shortening and retrodisplacement of the anterior commissure (VFSRAC)—a variant on the Wendler glottoplasty surgery. Although individual acoustic data are not presented, he reports that the singer's reasonable singing range shifted up to the female range without alterations in voice quality after adapting to controlling the new vocal folds in a singing voice rehabilitation program.<sup>33</sup> In contrast, Chang et al reported variable effects on average speaking fundamental frequency, with half experiencing a reduction in their upper pitch range. This could be of particular concern in performance voice users and remains an area to be further understood.<sup>30</sup>

Following procedures aimed at pitch elevation, decreased projection and reduced loudness are cited concerns by surgeons and SLPs.

Reduced vocal loudness is an associated outcome commonly described following numerous types of pitch-elevating surgeries and across several studies.<sup>33,39,57–59</sup> Specifically for endoscopic shortening procedures, it has been determined that raising  $f_0$  likely occurs at the expense of reduced acoustic power based on a computational simulation model.<sup>55</sup> The clinical relevance of this outcome remains to be further clarified. Interestingly, this was of low clinical significance for transgender females completing the Trans Women Voice Questionnaire (TWVQ) following Wendler glottoplasty. In fact, the smallest change among all 30 statements following Wendler glottoplasty was “people have difficulty hearing me in a quiet room” (mean change:  $-0.5$ ,  $p = 0.0938$ ).<sup>28</sup>

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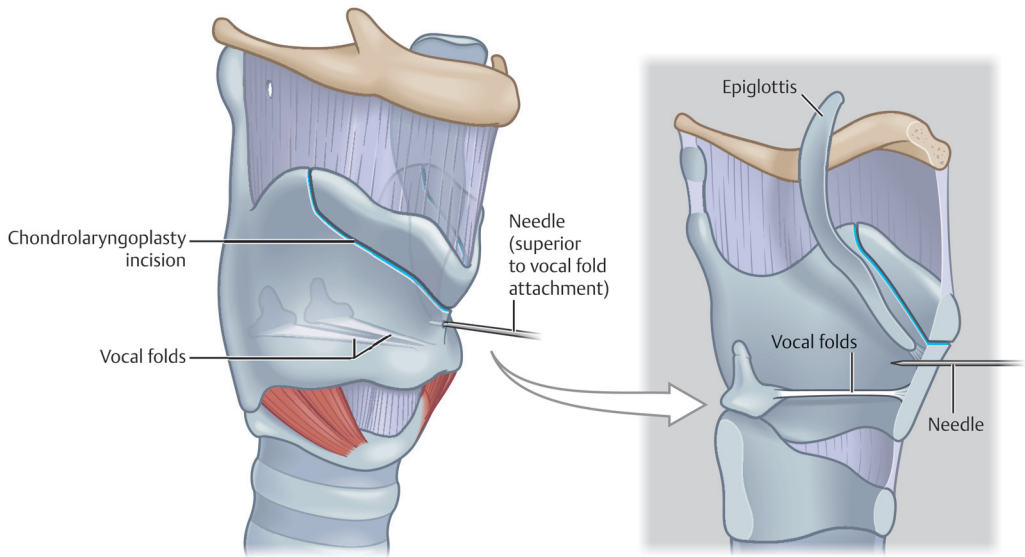
**Summary.** Potential postoperative risks/vocal trade-offs associated with pitch-elevating surgery

Voice rest upward to 1–2 weeks following surgery.

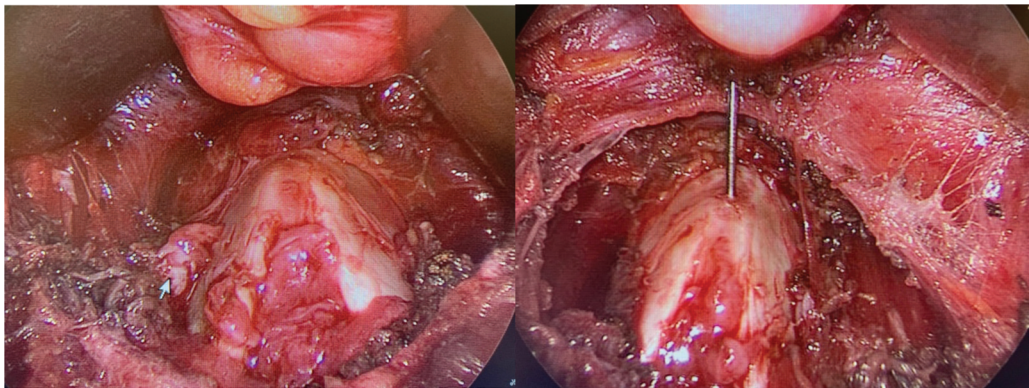
- Transient hoarseness/loss of voice that can take upwards to 3 months to recover from.
  - Permanent hoarseness.
  - Reduced volume/projection of voice.
  - Loss of lower-register pitches.
  - Singing voice change.
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### Can Pitch-Altering Surgery Be Combined with Chondrolaryngoplasty? Which One Should Come First?

Chondrolaryngoplasty is a surgical procedure that reduces the projection of the laryngeal prominence (see Fig. 3). Pitch-altering surgery can be combined with chondrolaryngoplasty or performed separately. Surgical procedures aimed at increasing vocal pitch through an open fashion (with an incision in the neck) can be concurrently combined with chondrolaryngoplasty to reduce the laryngeal prominence. Open pitch-altering surgeries include cricothyroid approximation, the FemLar procedure, and anterior commissure advancement surgery. For patients undergoing endoscopic approaches to pitch-altering surgery, there are no specific contraindications to concurrent chondrolaryngoplasty. It should be noted that after endoscopic pitch elevating surgeries (especially



**Figure 3** Chondrolaryngoplasty.



**Figure 4** View of thyroid cartilage and laryngeal prominence during an “incisionless” chondrolaryngoplasty approach.

Wendler glottoplasty), intubation for other surgical procedures should ideally be delayed 3 to 6 months to allow for adequate healing and to create an anterior glottic web and to minimize traumatic disruption of this. In the event that chondrolaryngoplasty is not combined with pitch altering surgery, the order of operation is dependent on the patient’s preference and treatment goals during their transition process. Some individuals prioritize voice and focus on this aspect of the care before addressing (if important to the patient) their prominent thyroid cartilage notch. Alternatively, other patients planning on undergoing facial

feminization surgery can be considered for concurrent chondrolaryngoplasty. It should be noted that if the patient is entertaining lower facial surgery that includes mandibular recontouring, the chondrolaryngoplasty can be concurrently performed through an incisionless approach (Fig. 4). This is gaining attention and popularity within the literature, with several techniques described.<sup>60–63</sup>

Kim compared changes in fundamental frequency after VFSRAC according to whether a previous thyroid cartilage reduction had been performed. Those who had not previously undergone thyroid cartilage surgery had greater

increases in pitch than those who had undergone prior chondrolaryngoplasty (mean pitch increase of 67 vs. 80 Hz).<sup>33</sup> Nuyen et al found no difference in voice outcomes following open FemLar procedure whether patients had previous cosmetic chondrolaryngoplasty.<sup>46</sup> Further studies are needed to confirm the influence of chondrolaryngoplasty on vocal pitch outcomes following phonosurgery, and ideal timing thereof.

## CONCLUSION

In summary, the field of gender-affirming voice care has great potential for further expansion and research to improve the overall quality of life for individuals struggling with a voice that is not congruent with their identity. Voice specialists can help TGE individuals understand and consider a growing number of behavioral, medical, and surgical options for gender-affirming care.

## FINANCIAL SUPPORT

None.

## CONFLICTS OF INTEREST

C.A.R. reports the following disclosures and financial relationships: Olympus America Inc.: consultant; Instrumentarium: royalties; Freudenberg Medical: consultant; Reflux Gourmet LCC: shareholder. S.L.S.: MedBridge royalties. The other authors have no financial relationships or conflicts of interest to disclose.

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