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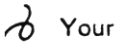
	TAKE OUT CHARACTER INDICATED	 Your proof.
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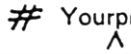
	INSERT SPACE	 Yourproof.
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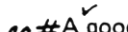
	EVEN SPACE	 A good proof.
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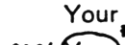
	CAPITALS	Your proof.  Your proof.
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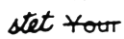
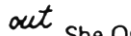
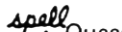
	DELETE, SEE COPY	 She Our proof.
	SPELL OUT	 Queen Eliz.
	START PARAGRAPH	 read. Your
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Cricothyroid Approximation and Subluxation in 21 Male-to-Female Transsexuals

Jeeve Kanagalingam, MA, MRCS, DLO; Christos Georgalas, MRCS, DLO;
Gary R. Wood; Suki Ahluwalia, MRCS, DOHNS; Guri Sandhu, FRCS (ORL-HNS);
Anthony D. Cheesman, FRCS

Fnu

Objectives: **To evaluate the medium-term outcome of cricothyroid approximation and subluxation (CTAS) with postoperative speech therapy for pitch elevation in male-to-female transsexuals.** ***Study Design:*** **Retrospective study of male-to-female transsexuals who underwent pitch-raising surgery between November 1996 and August 2001.** ***Methods:*** **Twenty-one male-to-female transsexuals opted for surgical feminization of their voices after inadequate improvements with speech therapy alone. Electrolaryngographic measurements were obtained by a single speech therapist of modal fundamental frequencies and the percentage of irregularities before, at 2 weeks, and 6 months after surgery. All 21 patients underwent CTAS, and 20 underwent simultaneous cosmetic thyroid chondroplasty by a single surgeon.** ***Results:*** **Electrolaryngographic results 2 weeks after surgery showed an average postoperative gain in modal frequency of free speech of 71.05 Hz (95% confidence interval [CI]: 42.9–99.2, *P* < .001). There was a concomitant average rise in irregularities of 9.9% (95% CI 0.7–18.5, *P* = .03). At median follow-up of 6 months after six sessions of speech therapy (n = 15), there was a decrease in irregularities to preoperative levels. The overall gain at 6 months in modal frequency of free speech was 56.9 Hz (95% CI 38.3–75.4, *P* < .001). Smoking and age did not predict a worse outcome.** ***Conclusions:*** **Cricothyroid approximation effectively raises pitch in male-to-female transsexuals. There is a concomitant rise in voice irregularities that is effectively addressed by speech therapy.**
Key Words: **Pitch-raising surgery, male-to-female transsexual, cricothyroid approximation.**
***Laryngoscope,* 115:●●●–●●●, 2005**

INTRODUCTION

Transsexualism is a recognized disorder of gender identity in which people believe themselves to be born into the "wrong" gender body. The prevalence is estimated at 1 in 37,000 with three quarters being male-to-female transsexuals.[1] Transsexuals are distinct from transvestites and cross-dressers and are not homosexuals. They hate every aspect of their male bodies and may have a history of self-castration and suicide attempts. The acceptance of this disorder has led to a variety of medical and surgical approaches for physical alteration to help male-to-female transsexuals conform to their conceptual sex.

The use of female hormones in oral and periodic parental forms is widely used by male-to-female transsexuals. These lead to smooth finer skin and larger breasts. Surgical procedures are often used after the patient has successfully led a life as a woman for some time. These include genital conversion surgery, mandibular angle contouring, breast augmentation, rhinoplasty, and blepharoplasty.

Although these therapies give patients a female appearance, their masculine voice and prominence of the Adam's apple often remain and are a frequent cause of embarrassment in public. Estrogen has no effect on the vocal cords or laryngeal framework in adulthood, and consequently these patients retain a physiologically male larynx.[2] Even if pitch is raised functionally, in uncontrolled situations like yawning, coughing, laughing, and sneezing, the male voice appears. In some cases, the habitually raised voice may lead to functional and organic voice pathology.

Although much can be done with speech training to achieve perceived femininity in voice without raising pitch, surgical pitch elevation is often necessary. Of the many strategies that have evolved, cricothyroid approximation or cricothyropexy is the most popular. This was first described by Isshiki et al.[3,4] (Isshiki's type IV thyroplasty) and was used in a series of 11 patients, all but 1 female, suffering from androphonia. The rationale of this technique is that by increasing vocal fold tension, one can increase fundamental speech frequency. Despite its popu-

From the Royal National Throat Nose and Ear Hospital, London, UK.

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Send Correspondence to Mr. J. Kanagalingam MA, MRCS, DLO, 12 Waldo Close, London SW4 9EY, UK. E-mail: jeevekana@hotmail.com

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larity, evidence for the efficacy of cricothyroid approximation in pitch elevation is poor.

There has been a long history in the surgical management of the transsexual voice at our unit. The initial surgical attempts at pitch elevation were directed at vocal fold shortening by way of a laryngofissure approach. Although the resulting voice was appreciated by the patients, critical analysis showed a decrease in fundamental frequency but an increase in "breathiness" (A. R. Perry, personal communication). The next step in surgical development was to duplicate the action of the cricothyroid muscle in pitch elevation. The technique of cricothyroid approximation was similar to Isshiki's type IV procedure. The current technique has evolved to further increase tension by subluxation of the thyroid cartilage forward over the cricoid. This is achieved by a unique method of suture placement that also ensures good long-term fixation and reduces the risk of suture extrusion.

We present a series of 21 patients who underwent cricothyroid approximation and subluxation for pitch elevation performed by a single surgeon (A.D.C.). Comprehensive preoperative and postoperative electrolaryngographic data were obtained from all 21 patients. Fifteen patients attended further speech therapy by a single speech therapist (G.W.) for 6 months, and electrolaryngographic data for this group are also presented.

MATERIALS AND METHODS

Subjects

Between November 1996 and August 2001, 21 male-to-female transsexuals underwent speech therapy and surgery for voice feminization in our hospital. The median age of these patients at the time of surgery was 39 (range 25–55) years. All 21 patients had been on a regime of hormone therapy for at least 3 years and undergone gender reassignment surgery. Four of the 21 patients were smokers and continued to smoke postoperatively. Twenty of the 21 patients were native English speakers. Fifteen of the 21 patients attended speech therapy sessions after surgery and were available for assessment 6 months after surgery.

Procedure

Anesthesia. The procedure is carried out under general anesthesia. A single dose of intravenous steroid (Dexamethasone, 8–10 mg) and a broad-spectrum antibiotic is administered. Intravenous antibiotics are continued for the first 24 hours after surgery and then orally for 5 days.

Approach. A 4 to 6 cm horizontal incision is placed in a suitable skin crease over the cricothyroid membrane. A superior and inferior subplatysmal dissection is carried out, extending from the lower border of the cricoid cartilage to above the laryngeal prominence. The strap muscles are separated in the midline, exposing the thyroid and cricoid cartilages as well as the cricothyroid muscles.

Thyroid chondroplasty. The level of the vocal folds at the anterior commissure is marked at a point half way from the thyroid notch to the lower border of the thyroid cartilages in the midline. Using a scalpel, the perichondrium along the superior border of the thyroid cartilages is cut. A subperichondrial dissection is carried out, using a Freer's elevator, on both the anterior and posterior aspects of the thyroid cartilages, staying above the level of the vocal folds. The perichondrium on the inner aspect of the thyroid cartilage is attached more firmly above the anterior commissure and can be divided later. The thyroid cartilage to be removed is marked with a line. Interrupted stabs are made along this line and into the cartilage using a number 10 blade, taking care not to damage the inner perichondrium. A Freer's elevator is used to join these stabs. Parts of the thyroid cartilage may be calcified and need cutting with scissors. The final release of the cartilage is made by sharp dissection of the inner perichondrium at the anterior commissure. Any sharp edges of cartilage are smoothed down with a blade or drill. After hemostasis, the outer and inner layers of perichondrium are sutured together using a absorbable suture. This will ensure that the petiolus of the epiglottis remains attached.

Cricothyroid approximation and subluxation. It is necessary to expose the lower border of the thyroid cartilage and upper and lower borders of the corresponding part of the cricoid cartilage. This will require part of the cricothyroid muscle to be removed. A scalpel is used to cut into the perichondrium along the anterior edge of the lower border of the thyroid cartilage in a manner similar to thyroid chondroplasty. The perichondrium is reflected posteriorly, freeing the thyrohyoid membrane from the lower border of the thyroid laminae. This will allow subluxation of the cricoid under thyroid cartilage to maximize approximation. The contour of the lower border of the thyroid cartilage can be shaped to reduce hindrance to cricothyroid approximation.

Two horizontal mattress sutures, one each side of the midline, are used to produce the cricothyroid approximation. The authors prefer 2/0 Ethibond (Ethicon W6977) suture with a needle at both ends. Each needle is inserted through the middle of the inferior border of cricoid cartilage but must exit the superior border at its anterior edge. It is important that the sutures do not enter the lumen of the larynx because of the danger of infection of the nonabsorbable sutures. The mattress sutures are completed by going under the thyroid cartilage and coming out on the surface, below the level of the vocal folds, approximately 5 to 8 mm apart. Figures 1 and 2 illustrate how this suture placement causes both approximation and subluxation of the laryngeal cartilages.

The sutures are tied with multiple knots while under tension. If the thyroid cartilage is calcified, it is sometimes necessary to drill small holes for the sutures. It is useful for later outcome analysis if the cricothyroid gap is recorded before and after the mattress sutures.

Wound closure. A small vacuum drain is used to drain residual blood and serum. The strap muscles are approximated and overlapped using an absorbable suture. The platysma is closed with an absorbable suture and the skin closed using a subcuticular monofilament (4/0 prolene) and steristrips.

Speech Therapy

All patients in this study had opted for surgical voice feminization after speech therapy had failed to elevate voice pitch satisfactorily. All patients were seen and managed by a single speech therapist (G.W.) before and after surgery.

Before surgery, the patient's voice was assessed to achieve a baseline of their normal male voice and to highlight any "hyperfunctionality." This was a common occurrence, as evidenced by a high degree of voice irregularity preoperatively. The surgery and postoperative care necessary was explained to the patients. Unreasonable expectations of outcome were addressed at this stage.

Forty-eight hours of complete voice rest was advised after surgery and then conservative voice use for the first 2 weeks. Patients were seen for the first postoperative assessment and therapy session 2 weeks after surgery. Therapy at this stage focuses on five key areas: centering breathing, relaxation of articulators, resonance laddering, pitch peaking and extension, and singing.

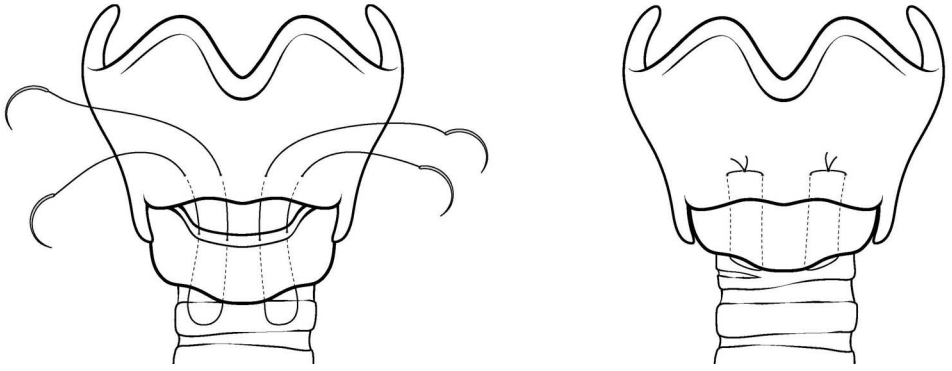

Fig. 1. Cricothyroid approximation and subluxation: anteroposterior view.

The "new" and "old" voices were compared. Voice work was patient specific with general exercise undertaken with singing to develop pitch range and stability. These techniques were then carried over to free-speech. All patients were encouraged to return for six postoperative therapy sessions.

Electrolaryngography

Voice characteristics (modal, mean and median fundamental frequencies and voice irregularities) in free-speech, singing, and reading were measured by electrolaryngography using the PITCH version of the PCLX computer program. Patients were asked to describe how they came to hospital to record their free-speech voice. The "Happy Birthday" song was used for their singing voice and the "Rainbow Passage" for their reading voice.

T1-T3 These recordings were made before surgery, 2 weeks, and then 6 months postoperatively. Tables I to III summarizes the free-speech, reading, and singing voice characteristics of these patients at these three time points.

Statistical Analysis

The Excel data set was transferred to SPSS version 11.0 for analysis. Modal frequencies, age, and irregularities present were assessed for normality and equality of variance by way of Kolmogorov-Smirnov testing and normality plots. Because they were found to lie in a normal distribution, a paired sample t test was used to assess the differences after surgery and after six sessions of speech therapy. Analysis of variance was used to assess the effect of age and smoking status on the final outcome. Two-tailed comparisons were used while significance level was set in 5%.

RESULTS

All 21 patients underwent surgery as inpatients. Nineteen patients underwent simultaneous thyroid chondroplasty, and one patient had both laryngeal procedures and a rhinoplasty. Median postoperative hospital stay was 1 (range 1–3) day. None of the 21 patients had immediate postoperative complications. Postoperative electrolaryngographic measures were made 2 weeks after surgery and then at a median follow-up of 6 months.

The average modal fundamental frequencies in free-speech preoperatively and postoperatively for the group were 120 (range 76–202) Hz and 191 (range 113–381) Hz. This represents a significant gain of 71 Hz (95% confidence interval [CI] 42.9–99.2, $P < .001$). The postoperative gain in modal frequency when singing and reading was 56.6 (95% CI 27.8–85.3, $P < .001$) and 74.7 Hz (95%CI: 44.3–105.5, $P < .001$), respectively. The rise in pitch was accompanied by significant average increases in voice irregularity of 9.9% (95% CI 0.7–18.5, $P = .03$; free-speech), 12.4% (95% CI 4.4–20.5, $P = .004$; reading), and 27.1%(95% CI 16.7–37.6, $P < .001$; singing).

Fifteen of the 21 patients complied with a further six sessions of speech therapy postoperatively and were avail-

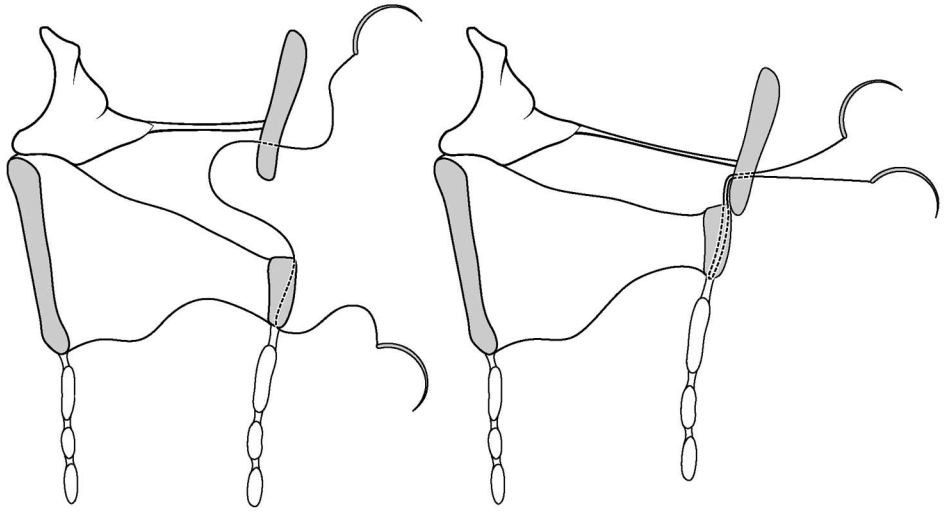

Fig. 2. Cricothyroid approximation and subluxation: sagittal view.

TABLE I.
Case Summaries: Free-Speech Voice Characteristics Before, 2 Weeks, and 6 Months after Surgery.

Patient No.	Age (years)	Smoking Status	Modal Freq Preop (Hz)	Modal Freq at 2 Weeks (Hz)	Modal Freq at 6 Mths (Hz)	Irregularities Preop (%)	Irregularities at 2 Weeks (%)	Irregularities at 6 Mths (%)
1	42	No	78	117	117	19	24	24
2	50	No	76	158	142	38	32	66
3	31	No	107	151	158	14	34	14
4	30	No	107	185	165	32	68	48
5	51	Yes	167	277		14	61	
6	36	Yes	107	117	165	7	17	29
7	37	No	117	147	135	27	24	35
8	51	No	106	113		44	36	
9	37	No	117	270		18	24	
10	41	No	113	233	202	5	20	17
11	27	No	113	156		20	8	
12	45	No	139	180		8	24	
13	39	No	110	170	185	37	17	15
14	33	No	127	202	192	8	42	10
15	28	No	117	214	156	13	66	26
16	40	No	127	240	185	31	13	19
17	25	No	127	196	160	20	12	16
18	49	Yes	117	381	270	18	23	17
19	48	No	140	139	180	12	27	12
20	33	Yes	110	185		20	25	
21	55	No	202	185	214	31	46	45
Mean	39		120	191	175	21	31	26

TABLE II.
Case Summaries: Reading Voice Characteristics Before, 2 Weeks, and 6 Months after Surgery.

Patient No.	Age (years)	Smoking Status	Modal Freq Preop (Hz)	Modal Freq at 2 Weeks (Hz)	Modal Freq at 6 Mths (Hz)	Irregularities Preop (%)	Irregularities at 2 Weeks (%)	Irregularities at 6 Mths (%)
1	42	No	98	139	202	12	22	32
2	50	No	76	160	134	47	47	6
3	31	No	104	135	154	8	22	16
4	30	No	116	185	175	48	64	39
5	51	Yes	110	269		16	55	
6	36	Yes	124	120	208	12	47	16
7	37	No	120	143	139	24	31	14
8	51	No	104	120		36	22	
9	37	No	110	320		16	22	
10	41	No	147	247	196	5	15	10
11	27	No	120	160		15	8	
12	45	No	165	202		8	19	
13	39	No	113	180	185	23	16	15
14	33	No	124	190	190	9	33	10
15	28	No	143	210	170	17	67	13
16	40	No	151	247	180	17	12	14
17	25	No	127	196	170	20	8	14
18	49	Yes	139	370	269	18	59	20
19	48	No	142	135	165	12	18	13
20	33	Yes	180	349		26	47	
21	55	No	208	214	220	24	42	27
Mean	39		130	204	184	20	32	17

TABLE III.
Case Summaries: Singing Voice Characteristics Before, 2 Weeks, and 6 Months after Surgery.

Patient No.	Age (years)	Smoking Status	Modal Freq Preop (Hz)	Modal Freq at 2 Weeks (Hz)	Modal Freq at 6 Months (Hz)	Irregularities Preop (%)	Irregularities at 2 Weeks (%)	Irregularities at 6 Months (%)
1	42	No	175	269	131	14	57	22
2	50	No	147	180	220	20	52	3
3	31	No	124	151	162	4	19	10
4	30	No	142	226	276	21	58	14
5	51	Yes	151	311		6	31	
6	36	Yes	185	135	165	3	74	7
7	37	No	135	160	175	12	20	17
8	51	No	160	143		22	17	
9	37	No	185	277		12	22	
10	41	No	180	350	294	1	43	14
11	27	No	147	202		7	6	
12	45	No	190	240		11	12	
13	39	No	151	214	200	17	46	8
14	33	No	172	246	230	3	26	8
15	28	No	196	202	214	20	44	33
16	40	No	202	247	202	10	7	10
17	25	No	124	254	208	16	78	12
18	49	Yes	196	362	302	3	21	12
19	48	No	180	170	205	8	84	40
20	33	Yes	210	180		3	39	
21	55	No	233	254	233	27	54	31
Mean	39		171	227	214	11	39	16

able for voice analysis at a mean follow-up of 6 months. Electrolaryngographic data from this subgroup were analyzed separately. Postoperative gains in free-speech, reading, and singing for this subgroup were 56.9 Hz (95% CI 38.3–75.4, $P < .001$), 55 Hz (95%CI: 38.3–75.4, $P < .001$), and 45 Hz (95% CI 16.8–73.2, $P = .001$), respectively. More importantly perhaps, a decrease of voice irregularities was noted, resulting in levels that were not significantly different from the preoperative ones.

The main reason for poor compliance with speech therapy was geographic distance from our center. Many of our subjects declined to travel back to our center for further voice therapy and analysis. The early outcomes at 2 weeks in the group that attended speech therapy and the group of nonattendees were not significantly different.

In the group that complied with speech therapy, voice irregularity improved considerably. This was at the ex- F3-F4 pense of some deterioration in pitch elevation. Figures 3 and 4 show the changes in modal frequency and voice T4 irregularity in this subgroup, and Table IV summarizes these results.

If a fundamental frequency of 155 Hz is taken as a threshold above which voice is perceived as feminine (vide infra), 12 of 15 of our patients achieved sufficient pitch elevation in free-speech and reading, with 14 of 15 achieving this when singing. In patients 1, 2, and 7, who failed to reach a fundamental free-speech frequency of 155Hz, pitch rose and remained elevated at 6 months from preoperative levels.

Patients 3, 4, 10, and 13 to 18 had good outcomes with good pitch elevation and minimal rise in voice irregularities. In patient 2, a good outcome was complicated by

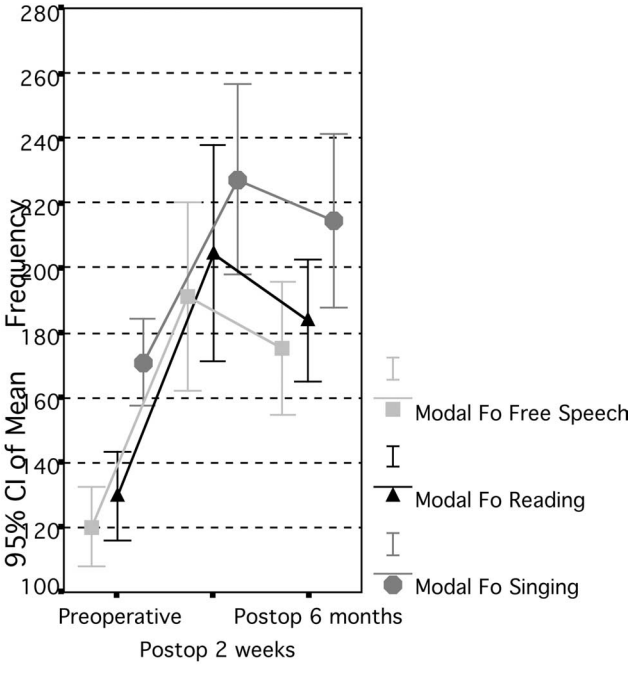

Fig. 3. Change in modal frequency.

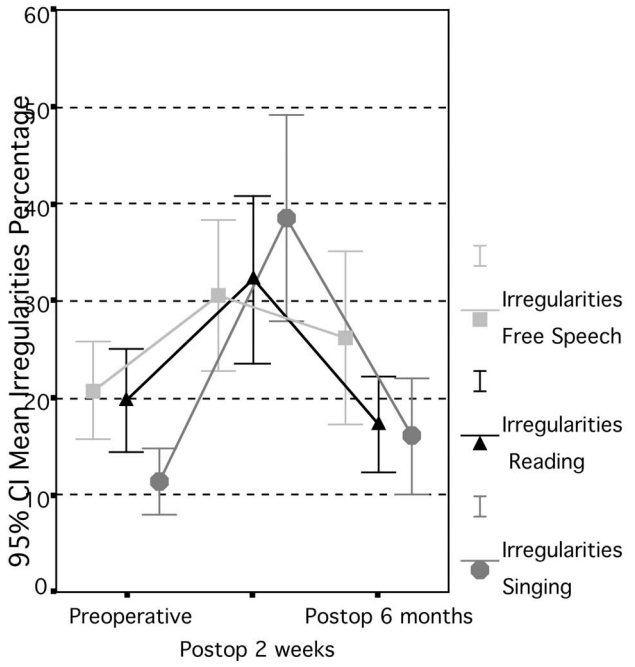

Fig. 4. Change in voice irregularity.

a large rise in voice irregularity in free-speech at 6 months. Curiously, this rise in irregularity was not seen in reading or singing.

Patient 21 was clearly a failure. Surgery was undertaken despite a preoperative frequency in excess of 200 Hz because the patient's voice was hyperfunctional. Postoperative voice irregularities were worse, and modal frequencies had failed to improve at 6 months. No further investigations or reexploration of the larynx was undertaken in this patient to elucidate the cause of failure, such as loosening of sutures.

In most patients, surgery contributed relatively more to pitch elevation than postoperative speech therapy. However, there were two notable exceptions (patients 6 and 19) where the reverse was true. In fact, immediate postoperative results in both these patients were dismal. Voice irregularity did rise in both these patients after surgery, suggesting some alteration in laryngeal function after surgery.

If our group of 15 patients was divided into those with significant preoperative voice irregularity (suggesting hyperfunctional use of the larynx) and those without significant irregularity, there was a trend toward better results in the group with less preoperative irregularities (e.g., free-speech) in the group, with less than 20% preoperative irregularities in free-speech, and mean improvement from surgery was 83 Hz, against 59 Hz in the group with more than 20% irregularities. However the difference was not statistically significant ($P = 0.23$, two-tailed test with equal variances).

Neither the age of the patient nor smoking status reliably predicted a worse outcome. More specifically, there was no correlation between the change in modal frequency and age (free-speech $P = .48$, reading $P = .77$, and singing $P = .55$). The two patients who smoked had actually a better result at 6 months, although the difference was not significant ($P = .44$, $P = .27$, $P = .97$ for free speech, reading, and singing, respectively).

DISCUSSION

Much can be done to achieve perceived femininity in voice before raising pitch. Indeed, current practice in speech therapy for male-to-female transsexuals is to adapt voice behavior to a more female gender role instead of training them to raise their pitch. These include increasing intonation variability in general and more upward inflections specifically, minimizing chest resonance and stimulating the use of head resonance, stimulating a light and delicate articulation by increasing the precision and prominence of consonant production, and adapting speech rate and volume.[5]

Notwithstanding these important adaptations, pitch remains a pivotal aspect in the perception of femininity among male-to-female transsexuals. Two studies suggest that a fundamental speech frequency (F_o) of 155 Hz or 160 Hz is the critical threshold for feminine perception.[6,7] Transsexuals who are able to attain frequencies of 145 to 155 Hz may modify their speech intonation to produce a feminine voice. For transsexuals who are unable to achieve this pitch without risking organic vocal fold pathology, phonosurgery is indicated. In our series, all but three of our patients had fundamental free-speech frequencies below 145 Hz preoperatively. The preoperative voice irregularity in our group of patients was high, suggesting hyperfunctional use of the larynx.

The fundamental speech frequency (F_o) is determined by the tension, mass, and length of the vocal folds, and less significantly, the subglottal pressure. The following formula applies: $F_o = 1/2L\sqrt{(T/P)}$, where L is the length of the vocal fold, T is the mean longitudinal stress, and P is tissue density.[8] It is often instructive to patients to draw analogies with string instruments. The longer strings of a cello generate a lower note than the shorter strings of a violin, just as longer vocal folds produce lower fundamental frequencies than shorter ones. Similarly, increased tension and smaller mass of violin string raises pitch, just as increased vocal fold tension, because of cricothyroid muscle contraction, and lighter folds raise vocal pitch.

Surgical methods for raising pitch have thus far focused on three fundamental principles: increasing vocal fold tension by cricothyroid approximation or anterior commissure advancement, altering tissue density or mass by scarification, triamcinolone injections or CO_2 vaporization, and vocal fold shortening by plication or anterior webbing. Of these, the most commonly used surgical method has been cricothyroid approximation, as described by Isshiki et al.[3] This method (Isshiki's type IV thyroplasty), which involved a very high tension on the thyroid and cricoid cartilages, has subsequently been modified using a different suture technique by Lee et al.[9] and using a longer-lasting technique of cricothyroid "fixation" by Sataloff.[10]

The objective evidence for cricothyroid approximation for pitch elevation in male-to-female transsexuals is poor.

TABLE IV.
Gain in Modal Frequencies and Change in Voice Irregularities Postoperatively (2 weeks) and After Speech Therapy (6 months).

	2 Weeks (postop)		6 Months (posttherapy)	
	Gain in Modal Frequency (Hz)	Change in Voice Irregularity (%)	Gain in Modal Frequency (Hz)	Change in Voice Irregularity (%)
Free-speech	+71.0 (42.9–99.2)	+9.9 (0.7 to 18.5)	56.9 (38.3–75.4)	+3.3 (−1.75–12.5)
	$P < .001$	$P = .03$	$P < .001$	$P = .2$
Reading	+74.7 (44.3–105.5)	+12.4 (4.4–20.5)	55.0 (36.7–73.2)	−2.6 (−9.8–4.6)
	$P < .001$	$P = .004$	$P < .001$	$P = .4$
Singing	+56.6 (27.8–85.3)	+27.1 (16.7–37.6)	45.0 (16.8–73.2)	+4.1 (−2.1–10.4)
	$P < .001$	$P < .001$	$P < .001$	$P = .2$

Indeed, Isshiki et al.'s[4] published series of 11 patients in 1983 included only one male-to-female transsexual. This patient enjoyed a pitch rise of 54 Hz, but no information is provided about the length of follow-up. Koufman and Isaacson,[11] in their treatise on laryngoplastic phonosurgery, suggest that the excellent short-term results from Ishhiki's type IV thyroplasty were not maintained.

Brown et al.[12] published a series of 14 transsexuals undergoing cricothyroid approximation in which mean pitch remained unchanged after surgery but modal, or "most frequently used," pitch increased significantly. Patient satisfaction in this group was high, but median follow-up was only 2 weeks. Yang et al.[13] studied changes in pitch, pitch range, and perturbation of 20 male-to-female transsexuals undergoing cricothyroid approximation and followed patients for a mean of 22 months. Initial rises in pitch diminished after 1 year.[13] In 14 of 20 patients in whom acoustic data were available at 24 months, pitch rise for speech was 5 semitones or 46 Hz (136 Hz, C#3–182 Hz, F#3). Our results mirror these findings. Pitch ranges in Yang's series appear to widen at long-term follow-up, and changes in perturbation appear to have been insignificant. Wagner et al.[14] published a series of 14 transsexuals in whom only 8 had cricothyroid approximation alone for pitch-elevation. The median follow-up was 6 months, and the median postoperative gain was only 11 Hz.

In our series, the mean overall gains in F_o of free-speech, reading, and singing were 71, 74.7, and 56.6 Hz, respectively, immediately after surgery. Initially, pitch elevation caused significant voice irregularity. However, with speech therapy, these irregularities were lessened, resulting in no significant change from their preoperative state. This improvement in irregularities did cause some deterioration in initial pitch-elevation results, and at 6 months follow-up in 15 of 21 patients, mean overall gains in of free-speech, reading, and singing were 56.9, 55.0, and 45.0 Hz, respectively. Importantly, in 12 of the 15 patients, modal fundamental frequencies rose above 155 Hz, a level where perception of femininity is achieved.

Patients in our series had a high degree of voice irregularity before surgery that may have impacted on the outcome of surgery. This is principally because of the inappropriate use of the larynx to achieve a feminine pitch. Indeed, patients who had a lower degree of preoperative voice irregularity appear to have had better outcomes in terms of pitch elevation. We therefore concur with the views of Yang and other authors that years of artificially raising one's pitch produces a condition akin to muscle-tension dysphonia in our subjects. They are unable to produce relaxed phonation, and this adversely affects the outcome of pitch-elevating surgery. There is consequently a strong argument in favor of undertaking voice surgery early in the transformation process of male-to-female transsexuals to achieve optimum results.

Cricothyroid approximation and subluxation produces significant tension in the soft tissues of the larynx. It is inevitable that this degree of tension will diminish over time. This may account for the improvement in voice irregularity and reduction in pitch elevation noted at 6 months after surgery. Without acoustic data from patients who did not attend speech therapy, we cannot ascribe improvements in irregularity to speech therapy alone. However, a questionnaire-based survey of 42 subjects at 40 months after cricothyroid approximation by our senior author (A.D.C.) found prolonged improvement in voice in 70%.[15] Two thirds of those enjoying good pitch elevation attributed their positive outcome to surgery.

CONCLUSION

Cricothyroid approximation and subluxation using our modification of Isshiki's type IV thyroplasty raises fundamental speech frequency effectively. This procedure changes laryngeal dynamics and causes a significant rise in voice irregularity. This irregularity may be addressed by speech therapy, which enables transsexuals to use their new voices appropriately. This study provides evidence of good medium-term results at 6 months follow-up.

Minimizing hyperfunctional use of the larynx preoperatively in male-to-female transsexuals improves the outcome of pitch-elevation surgery. Preoperatively speech therapy should focus on this aspect of voice use.

There is some variability in outcome that warrants further research. Factors that predict a poor outcome may help select male-to-female transsexuals who are more likely to benefit from this type of phonosurgery. More information is also required on the changes in pitch range that occur with cricothyroid approximation and fixation. Finally, there is need for long-term objective results at 3 to 5 years postsurgery before final conclusions may be drawn about the efficacy of surgery.

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AUTHOR QUERIES

AUTHOR PLEASE ANSWER ALL QUERIES **1**

AQ1—'Please give Perry's affiliation. '

AQ2—'Anteroposterior view correct?'