Pitch Elevation in Male-to-female Transgender Persons—the Würzburg Approach

Jonas Meister, Rudolf Hagen, Wafaa Shehata-Dieler, Heike Kühn, Fabian Kraus, and Norbert Kleinsasser, *Würzburg, Germany*

Summary: Objectives. The present study reports objective and subjective voice results of Wendler's glottoplasty modified by Hagen.

Study design. This is an outcomes research study.

Methods. A total of 21 patients underwent Wendler's glottoplasty modified by Hagen. Parameters in the follow-up session were laryngoscopy, voice range profile, Voice Handicap Index, Life Satisfaction Questionnaire, and a visual analog scale for individual satisfaction with the voice.

Results. The fundamental frequency was elevated into the typical female fundamental frequency range. Furthermore, an elevation of the lower frequency limit was shown without a reduction of the frequency range. About one third of the population feels affected by the restricted dynamic range. This change of the vocal pitch is seen as part of the voice feminization by some of the patients. The Dysphonia Severity Index as a marker for voice quality was unchanged. Subjective satisfaction with the voice showed a strong correlation with the individual elevation of the pitch.

Conclusion. Wendler's glottoplasty modified by Hagen is an effective and low-risk method of raising the vocal pitch of male-to-female transgender persons. However, elevated Scores of the Voice Handicap Index indicated that in everyday life, transgender persons continue to feel handicapped because of their voice. Another indicator for the lack of social acceptance and integration is the reduced general life satisfaction in the Life Satisfaction Questionnaire especially in the domain "friends, acquaintances, relatives." Therefore, a better multidisciplinary therapy concept for voice feminization is necessary.

Key Words: Pitch elevation–Transgender voice–Glottoplasty–Voice feminization–Phonosurgery.

INTRODUCTION

Transsexualism is a problem of gender identity with the individuals being firmly convinced that their psychological gender is the opposite of their anatomic gender.[1] The feeling to live in the wrong body is compelling and, if suppressed, the level of suffering may even lead to suicide.[2–5] After long and burdensome therapy procedures consisting of medical and psychological treatments, transgender persons obviously wish to be accepted in the society with their new gender role. The voice as a secondary sexual characteristic is an important factor of gender perception.[6,7] Male-to-female (MtF) transgender persons, in whom hormonal treatment shows no influence on the voice,[8–10] are often stigmatized by their deep voice betraying their biological gender in everyday life communication. Thus, speech feminization is a very important element in the multidisciplinary therapy of MtF transsexuals.[1,11–20]

The most important parameter for gender perception of a voice is the fundamental frequency f(0).[6,8,17,21–25] Oates and Dacakis[14,26] introduced a classification of typical frequency ranges: male voices typically vary in a range of 80–165 Hz; female voices typically vary in a range of 145–275 Hz. Consequently, there exists an overlap range from 145 Hz to 165 Hz where the fundamental frequency cannot be assigned to one gender uniquely.

Beside the fundamental frequency there are other parameters influencing gender perception of a voice. These are, for example, the formant frequencies, which are higher in female persons than in male persons.[6,17,27,28]

Further differences between male and female speakers in voice quality include a broad spectrum. The most important aspect of voice quality for MtF transgender patients is breathiness.[14,29–31] Furthermore, frequently mentioned targets in conservative voice therapy are intonation patterns. The relevance of these differences between male and female speakers for gender perception is discussed controversially. Some authors reported about an important role of intonation and prosodic characteristics in conservative voice therapy with MtF.[15,17] In contrast, Hancock et al[32] could not show any differences in intonation patterns between male, female, MtF transgender, and female-to-male transgender speakers.

THERAPY OF THE TRANSGENDERED VOICE

Conservative voice therapy is the first step in voice feminization. In the topic-related literature, some data sets show that for some persons, a successful feminization of the voice is possible with conservative voice therapy only.[15,33–36] But not all patients are able to reach a satisfying feminine voice with conservative voice therapy only, and some develop functional disorders because of the high tension in the larynx.[14,16,34,37] Even if the pitch alteration is sufficient, the male voice may appear in uncontrolled and emotional situations like yawning, coughing, and laughing.[5,38]

If there is no satisfying result with conservative voice therapy, surgery may be offered. In principle, there is a variety of techniques to elevate vocal pitch. Surgically, increase of the tension of the vocal cords with a cricothyroid approximation (CTA) is

Accepted for publication July 22, 2016.

From the Department of Otorhinolaryngology, Plastic, Aesthetic and Reconstructive Head and Neck Surgery, University Hospital of Wuerzburg, Würzburg, Germany.

Address correspondence and reprint requests to Norbert Kleinsasser, Department of Otorhinolaryngology, Plastic, Aesthetic and Reconstructive Head and Neck Surgery, University Hospital of Wuerzburg, Josef-Schneider-Str. 11, 97080 Würzburg, Germany. E-mail: Kleinsasser_n@ukw.de

Journal of Voice, Vol. 31, No. 2, pp. 244.e7–244.e15
0892-1997

http://dx.doi.org/10.1016/j.jvoice.2016.07.018

an option. CTA has the advantage not to surgically interfere with the internal structures of the larynx. Consequently, the risk of voice irregularities after the surgery appears to be low.[16] Many authors describe good early results,[33,39,40] but there are also reports of a loss of the tension in the long term, necrosis of cartilage, and damages on the larynx because of the high tension.[4,5,41–44] Neumann and Welzel[16] modified the CTA via miniplates. Long-term results showed a sufficient elevation of vocal pitch, but for about 30% of the patients, there was only a slight rise of the pitch and, in two cases, even a decrease of the fundamental frequency. Kanagalingam et al[4] combined a CTA with a subluxation of the cricoid. After good early results, however, the fundamental frequency of the patients decreased within 6 month from 191 Hz to 175 Hz in median.

Another possibility for pitch elevation is the reduction of the mass of the vocal cords. Published results of this intervention are rare and seemed to be inhomogeneous. Orloff[45] reported on 31 MtF after "laser-assisted voice adjustment." The fundamental frequency was elevated about 26 Hz in average, but there were three patients without any change of vocal pitch and three patients with a deeper voice after laser-assisted voice adjustment. Koçak et al[46] could show good long-term results in eight MtF patients with a laser-reduction glottoplasty.

A third established method for pitch elevation is to shorten the vibrating length of the vocal folds creating a new anterior commissure. This "glottoplasty" in endoscopic approach was first described by Wendler.[47] Gross,[5] Remacle et al,[41] and Mastronikolis et al[48] showed good long-term results with a postoperative fundamental frequency of about 200 Hz. Anderson[49] reported on positive results with a modified technique without any sutures. The advantage of this surgery is the low invasiveness without an external approach. One disadvantage of this method is the irreversibility of the measure and the risk of postoperative hoarseness. Additionally, the frequency range[41] or the dynamic range[5] might be restricted after surgery.

Another very invasive concept is the "feminization laryngoplasty," which includes the excision of the anterior thyroid ala and vocal folds.[50,51] Thus, the purpose is to change the shape of the vocal tract and to elevate, in addition to the fundamental frequency, the formant frequencies too. Thomas and Macmillan[51] investigated long-term results of 76 patients with a significant elevation of the vocal pitch. A total of 25 patients were very dissatisfied with the result and underwent a revision surgery despite this very complex process.

The aim of the present study is to report a series of 21 patients after Wendler's glottoplasty modified by Hagen. In this modified technique, the new anterior commissure is stabilized by two to three 4-0 vicryl sutures. Additionally, a voice rest for several weeks is induced by injecting botulinum toxin in the vocal muscle on both sides. We investigated the success of the surgery regarding objective voice parameters and the subjective satisfaction with the result.

INDIVIDUALS, MATERIALS, AND METHODS

All 37 MtF transgender patients who underwent glottoplasty in Würzburg between December 2005 and April 2013 were invited to attend a follow-up session in the University Hospital Würzburg, Department of Otorhinolaryngology, Plastic, Aesthetic, and Reconstructive Head and Neck Surgery without any exclusion criteria. A total of 25 patients could be tracked due to a variety of reasons including change of addresses, names, and strict German legislation concerning data protection. Two patients refused our invitation because of personal problems, and two other patients felt to be a woman completely and did not want to be reminded on the transition anymore.

SURGICAL PROCEDURE

For a permanent elevation of the vocal pitch, a glottoplasty based on the endoscopic technique of Wendler[47] modified by Hagen was applied. The endoscopic surgery was performed under general anesthesia. The Kleinsasser endoscope was adjusted to the anterior commissure. In the area of the anterior third of the vocal folds and the anterior commissure, the epithelium was resected. The adaption of the anterior third of the vocal cords was fixed by vicryl 4.0 sutures. In 11 cases, the anterior commissure was fixed with 3 sutures, in 9 cases with 2 sutures, and in 1 case with 1 suture only. A voice rest for several weeks was induced by injection of 25 I.E. botulinum toxin into vocal muscle on each side according to Hagen's modifications of the Wendler technique. Figure 1(A–F) shows individual steps of the glottoplasty. If desired, an Adam's apple reduction according to Wolfort et al[52] was performed in the same session.

OBJECTIVE EVALUATION

One method of choice to examine the larynx with the new anterior commissure was the video laryngoscopy. The examination was carried out using a 90° Hopkins optics (8707 DA, Karl Storz, Tuttlingen, Germany) or, in case of gagging reactions, using a nasal endoscope (ENF VQ, "chip on the tip," Olympus, Shinjuku, Japan).

The most often used method to collect objective voice parameters is the voice range profile. The collected voice data are fundamental frequency, frequency range, dynamic range, maximum phonation time, and the dimensionless Dysphonia Severity Index as a parameter for voice quality.[53–55] In the present study, the voice range profile was performed based on the standard method for German speakers[55–57] using the software *DiVAS Stimmumfangsprofil 2.4.53* of XION (XION-medical, Berlin, Germany).

SUBJECTIVE EVALUATION

To objectify the subjective voice perception of the individuals, the Voice Handicap Index[58] was used, which is an established and validated instrument in the German version.[59] To examine general life satisfaction for those having completed the transition from male to female, we used the Life Satisfaction Questionnaire (FLZ).[60] To examine subjective satisfaction with voice, a 10-cm visual analog scale (VAS) from 0 ("very dissatisfied") to 10 ("very satisfied") was used.

STATISTICAL ANALYSES AND GRAPHS

For statistical analyses and graphs, *IBM SPSS Statistics* (IBM SPSS Statistics Version 21, IBM, Armonk, NY, USA) was used. Pre- and postsurgery data were analyzed with the Wilcoxon

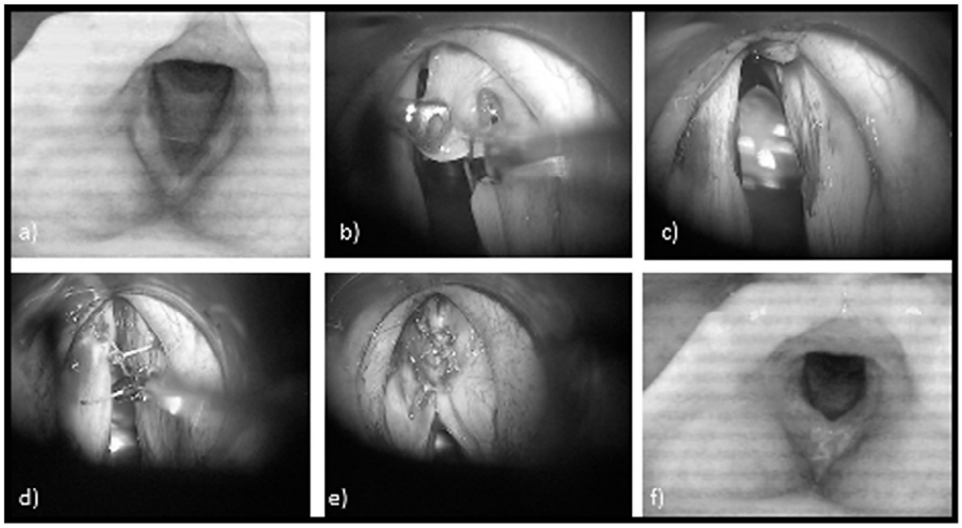

FIGURE 1. Documentation of a Wendler's glottoplasty modified by Hagen: (**A**) preoperative respiration position; (**B**) endoscopical deepithelization; (**C**) complete deepithelization of the anterior third of the vocal fold; (**D**) suturing of the new anterior commissure; (**E**) new anterior commissure; (**F**) respiration position one day after surgery.

signed-rank test. Comparison of individual elevation of the vocal pitch between patients with two and three sutures was done with the Mann-Whitney *U* test. The distribution into the fundamental frequency ranges was analyzed with the McNemar test. Statistical comparison of the Voice Handicap Index and the FLZ with validated control groups was performed with the one-sample *t* test. All correlations were analyzed with the spearman correlation.

RESULTS

This series included 21 patients. Out of those patients, 18 agreed to attend a follow-up session in the Department of Otorhinolaryngology, Plastic, Aesthetic, and Reconstructive Head and Neck Surgery of the University Hospital Würzburg, and three patients agreed to do a follow-up by questionnaires only. Four of them had a previous cricothyroidopexy without satisfying results. In 11 cases, the glottoplasty was combined with an Adam's apple reduction plasty. Population data of the 21 patients are listed in Table 1. The postoperative examination period ranged from 3 month up to 78 month. In all of the 21 cases, there were no major complications. For patient no. 3, a revision surgery was necessary because the synechia was only on the mucosal level. Within the scope of the follow-up sessions, we had to admit on laryngoscopy that the synechia of patient 12 had not lasted and the original anterior commissure had persisted. The cosmetic results of all 11 patients who underwent Adam's apple reduction plasty were satisfying. The number of sutures had no significant influence on the objective voice parameters.

OBJECTIVE VOICE PARAMETERS

Table 2 summarizes preoperative and postoperative data from the voice range profile including f(0), Dysphonia Severity Index, dynamic range, and frequency range as well as individual subjective evaluation data.

Figure 2 shows the comparison of pre- and postoperative objective voice data regarding fundamental frequency, frequency range, lower frequency limit, dynamic range, and Dysphonia Severity Index.

Comparison of pre- and postoperative data of the fundamental frequency (n = 21; Figure 2A) showed an elevation of the vocal pitch for all patients except for patient no. 12. Preoperatively, the median of the fundamental frequency was 132 Hz (110–160 Hz; standard deviation [SD] = 16.4 Hz). The postoperative median of the fundamental frequency was 170 Hz (130–215 Hz; SD = 24.3 Hz). The elevation of the fundamental frequency was significant ($P < 0.001$). There was no correlation between the elevation of the fundamental frequency and the number of conservative voice therapy sessions (Spearman rank correlation r = –0.169; $P = 0.464$; data not shown).

The patients were classified in five groups regarding the elevation of the fundamental frequency (Figure 3). Only patient no. 12 showed no elevation of the vocal pitch. Three patients showed a small elevation of the vocal pitch (<20 Hz), four patients showed a moderate elevation (20–39 Hz), five patients showed a strong elevation (40–59 Hz), and eight patients showed a very strong elevation of the fundamental frequency (≥60 Hz).

Analysis of pre- and postoperative fundamental frequency range, shown in Figure 2B, showed no difference ($P = 0.653$). Preoperatively, the median was 308 Hz (145–502 Hz; SD = 88.2 Hz). Postoperatively, the median was 282 Hz (75–695 Hz; SD = 151.5 Hz).

The lower frequency limit, illustrated in Figure 2C, showed a significant elevation from a median of 85 Hz (65–140 Hz; SD = 23.7 Hz) preoperatively and a median of 113 Hz (83–190 Hz; SD = 27.0 Hz) postoperatively ($P = 0.005$). There was no change for the upper frequency limit ($P = 0.981$; data not shown).

The dynamic range, illustrated in Figure 2D, showed a significant decrease in comparison of pre- and postoperative data ($P = 0.012$). Before surgery, the median was 42.5 dB (33–56 dB; SD 6.8 dB). After surgery the median was 37 dB (21–47 dB;

TABLE 1.
Population Data of All 21 Patients Listed Numerically

No	Age at Surgery (Years)	Age at Follow-up (Years)	Interval Surgery to Follow-up (Months)	Number of Sutures	Voice Therapy Sessions Preoperative	Voice Therapy Sessions Postoperative	Previous Surgery	Height (m)	Weight (kg)	Smoker
1	47	50	40	2	20	12	0	1.88	80	0
2	54	60	68	2	50	20	1	1.7	65	1
3	39	44	46	2	0	30	0	1.83	95	0
4	51	57	73	2	60	20	1	1.74	89	1
5	35	41	68	3	0	50	0	1.69	63	1
6	41	45	52	2	10	10	0	1.89	112	1
7	43	50	78	3	0	10	0	1.7	110	0
8	44	48	55	2	10	20	0	1.8	87	1
9	57	59	24	3	10	20	1	1.81	78	1
10	43	45	27	3	20	20	0	1.85	78	1
11	36	41	68	3	70	150	0	1.78	91	1
12	45	52	71	3	12	12	0	1.76	95	0
13	30	34	46	2	0	10	0	1.63	60	1
14	52	53	13	2	10	20	0	1.78	100	1
15	24	29	61	1	10	0	0	1.71	62	1
16	49	49	3	2	20	0	0	1.75	70	0
17	45	45	3	3	5	10	0	1.84	86	1
18	31	35	42	3	10	0	0	1.71	68	1
19	34	34	6	2	20	20	0	1.72	90	0
20	36	41	53	3	35	8	1	1.8	78	1
21	48	53	55	3	2	8	0	1.74	65	0
Median	43	45	52		10	12		1.76	80	
Minimum	24	29	3		0	0		1.63	60	
Maximum	57	60	78		70	150		1.89	112	

Notes: The following are shown: age at surgery and at the follow-up session, the interval between surgery and follow-up session, the number of sutures and the number of voice therapy sessions before and after surgery, previous surgical intervention (0 = no; 1 = yes), height and weight of the patients, and nicotine abuse (0 = no; 1 = yes).

SD = 7.2 dB). The minimum and maximum intensities showed no difference (data not shown).

The comparison of pre- and postoperative data regarding the dimensionless Dysphonia Severity Index, illustrated in Figure 2E, showed no change (n = 14; $P = 0.125$). Preoperatively, the median was 2.6 (–0.4 to 5.4; SD = 1.57). Postoperatively, the median was 2.1 (–0.7 to 5.3; SD = 1.71).

SUBJECTIVE EVALUATION OF SUCCESS

Table 3 shows the mean values of the VHI domains "functional," "physical," and "emotional" plus the VHI score compared with a German control group from Weigelt et al.[61] All mean values of our patients were below the check values from Weigelt et al ($P < 0.001$). Figure 4 shows the classification of the voice handicap into the degrees of severity according to the classification of the German Society of Phoniatrics and Pedaudiology.[62]

The FLZ showed a significant reduction of the general life satisfaction with a mean "stanine" score of 3.68 compared with the validated and age-matched check values ($P = 0.026$). The deficiencies in the category "friends, acquaintances, relatives" were significant ($P = 0.016$; data not shown).

The VAS "satisfaction with voice" showed a median of 6.1 cm (0–9 cm) and the VAS "feminity of the voice" showed a median of 5.3 (0–9.2 cm). There was a very strong correlation between the VASs (r = 0.904; $P < 0.001$; data not shown).

The correlation of the 10-cm VAS "satisfaction with voice" with the postoperative fundamental frequency (r = 0.577; $R^2 = 0.377$; $P = 0.006$) is shown in Figure 5A. The correlation with the VAS and the individual difference of the pre- and postoperative fundamental frequency (r = 0.663; $R^2 = 0.403$; $P = 0.001$) is illustrated in Figure 5B.

DISCUSSION

The present study describes the outcomes of Wendler's glottoplasty modified by Hagen in 21 MtF transgender persons. Except for one patient, an elevation of the vocal pitch could be achieved. Similar to the results of Gross,[5] Remacle et al,[41] and Mastronikolis et al,[48] Wendler's glottoplasty in the modified technique of Hagen also proved to be an effective and low-risk method to raise the fundamental frequency of MtF transgender persons, which is the strongest parameter for gender perception.[27,28,63]

Regarding the typical fundamental frequency ranges used by Oates and Dacakis[14,26] after surgery, the median fundamental frequency of the present study population was in the female frequency range (>165 Hz). The voice pitch of seven patients was in the overlap range (145–165 Hz) where the pitch cannot

TABLE 2.
Individual Voice Data of Patients Listed Numerically

No	f(0) Preoperative (Hz)	f(0) Postoperative (Hz)	f(0)min Preoperative (Hz)	f(0)min Postoperative (Hz)	Frequency Range Preoperative (Hz)	Frequency Range Postoperative (Hz)	Dynamic Range Preoperative (dB)	Dynamic Range Postoperative (dB)	DSI Preoperative	DSI Postoperative	VHI	FLZ (Stanine)	VAS (cm)
1	110	130	75	98	308	431	52	40	3.30	2.70	26	9	4.5
2	114	160	82	113	298	198	43	32	1.80	0.40	6	8	0
3	145	155	88	125	290	137	48	21	2.60	0.70	89	1	0.4
4	138	200	95	102	271	423	50	43	3.90	4.90	14	4	3.4
5	135	140	109	123	247	182	38	36	2.60	2.10	14	4	7.0
6	120	160	72	98	448	342	54	46	1.20	3.30	27	3	2.2
7	150	205	80	115	328	277	56	32	4.20	0.80	30	3	7.7
8	115	196	85	109	245	259	40	29	0.40	2.10	29	2	7.8
9	150	215	139	165	441	295	38	38	–	2.10	8	–	8.6
10	130	196	65	107	355	431	39	41	5.40	3.60	17	–	9.0
11	140	170	77	140	331	528	34	44	–	2.60	47	5	4.9
12	155	155	110	100	503	234	42	41	2.30	1.60	63	2	1.6
13	110	170	–	135	–	288	–	39	–	4.10	39	6	8.8
14	120	150	78	83	242	247	44	29	0.90	0.50	56	1	5.2
15	125	196	108	145	312	695	38	47	–	5.30	34	1	8.4
16	110	150	75	105	145	157	33	29	1.44	0.02	32	2	5.1
17	135	150	127	86	368	322	43	37	3.74	1.83	72	7	0.3
18	155	185	–	131	–	362	–	28	–	0.70	21	3	6.1
19	132	196	–	–	–	–	–	–	–	–	18	4	9.0
20	160	200	140	190	250	75	40	29	–	1.60	26	2	8.0
21	115	185	75	98	–	–	–	–	–	–	10	3	7.9
Mean	131	174	94	119	317	310	42.9	36	2.3	2.5	32	3.7	5.5
Median	132	170	85	113	308	288	42	37	2.3	2.1	27	3	6.1
Minimum	110	130	65	83	145	75	33	21	–0.4	–0.7	6	1	0
Maximum	160	215	140	190	503	695	56	47	5.4	12	89	9	9

Notes: The following are shown: the preoperative (f[0] pre) and postoperative (f[0] post) fundamental frequency, preoperative (f[0]min pre) and postoperative (f[0]min post) minimum frequency, pre- and postoperative frequency range, pre- and postoperative dynamic range, pre- and postoperative Dysphonia Severity Index (DSI), the postoperative Voice Handicap Index (VHI), and the standards of nine from the score of the Life Satisfaction Questionnaire (FLZ stanine). Missing data in preoperative frequency range, f(0)min, dynamic range, and DSI appeared because of incomplete voice range profiles for patients nos 13, 18, 19, 20, and 21. Partial missing data of patient no 19 are due to external measurement of the voice range profile. For patient no 21, an incomplete postoperative voice range profile from a former follow-up session was used.

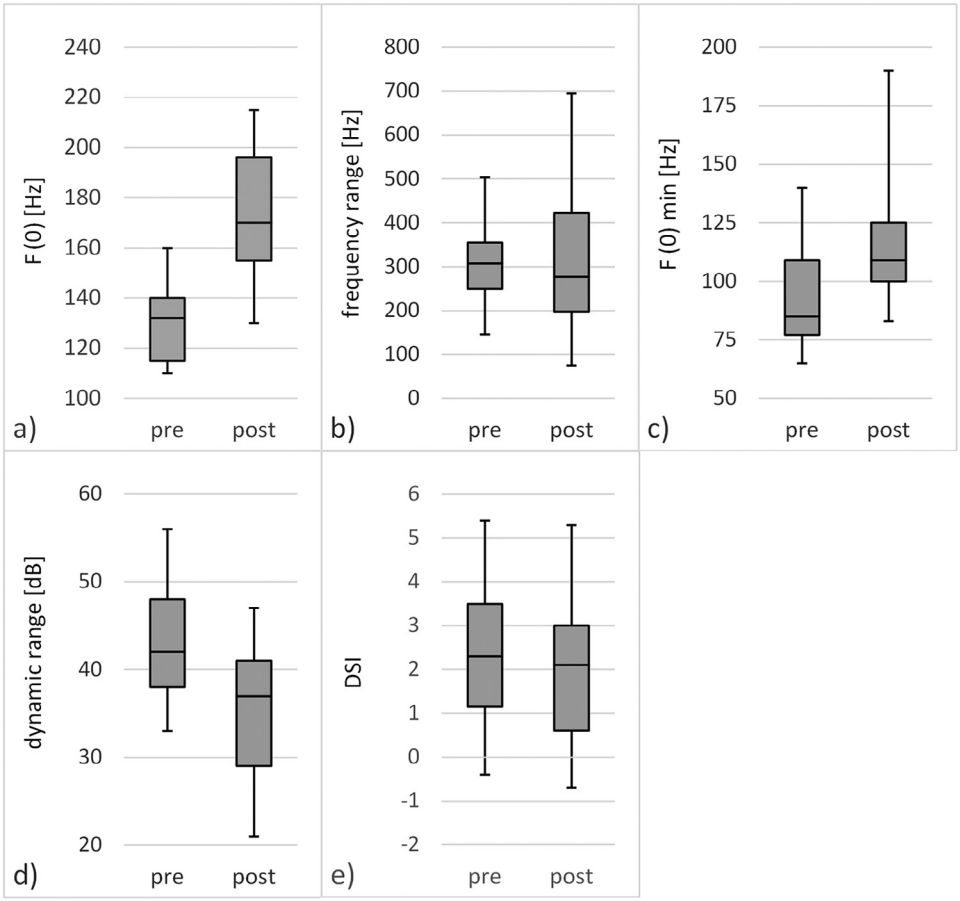

FIGURE 2. Comparison of preoperative and postoperative data regarding (**A**) fundamental frequency f(0) ($P < 0.001$), (**B**) frequency range ($P = 0.563$), (**C**) lower frequency limit f0(min) ($P = 0.005$), (**D**) dynamic range ($P = 0.012$), and (**E**) Dysphonia Severity Index ($P = 0.125$).

be assigned to one gender uniquely. Only one patient remained in the male frequency range. Furthermore, the voice range profile showed no change in frequency range but a significant increased lower frequency limit. This reduction of the low frequencies, also reported by Gross[5] and Thomas and Macmillan,[51] is part of the feminization effect and leads to a stable higher pitch level also in uncontrolled situations. Similarly, the restriction of the dynamic range could be considered as desired effect in voice feminization because a slight voice is associated with female speakers.[15,21,34,64,65] According to the findings of Gross,[5] about one third of our patients desired a louder voice.

In voice therapy, especially in MtF transgender persons, there exists a frequently mentioned discrepancy between objective voice parameters and subjective voice perception or satisfaction:[13,25,40,66–69]

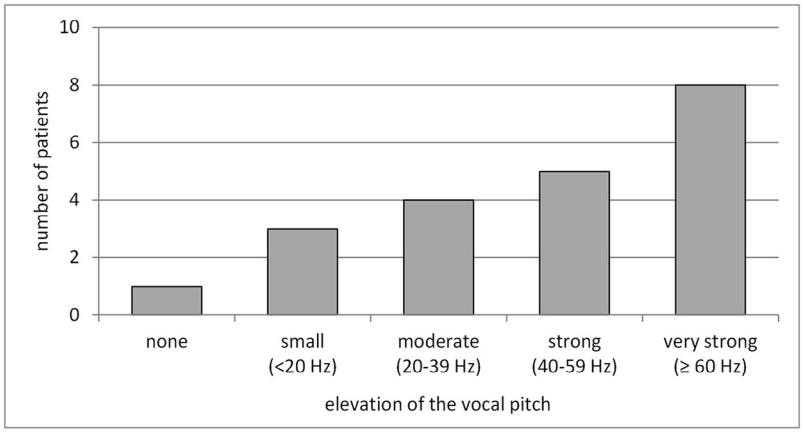

FIGURE 3. Classification of the patients into five groups regarding the elevation of the fundamental frequency. The following categories are shown: "no change of vocal pitch" (0 Hz), "small change of vocal pitch" (elevation of <20 Hz), "moderate change of vocal pitch" (elevation of 20–39 Hz), "strong change of vocal pitch" (elevation of 40–59 Hz), and "very strong change of vocal pitch" (elevation of ≥60 Hz).

TABLE 3.
Comparison of Voice Handicap Index Mean Values with a German Control Group[61]

	n	Mean (Patients)	Mean (Control Group)	*t* Test
"Functional"	21	9.81	1.7	$P < 0.001$
"Physical"	21	12.48	2.5	$P < 0.001$
"Emotional"	21	10.00	1.0	$P < 0.001$
VHI score	21	32.29	5.2	$P < 0.001$

analysis of the relationships between objective and subjective evaluation showed that the individual change of vocal pitch is of wider importance for personal satisfaction with the voice than the absolute value of the fundamental frequency. Another important factor for satisfaction is the interpersonal communication, which influences the social integration of transsexual persons.[26] Obviously, the desire of the patients is to pass with their new gender role in society. The wish to acquire a female voice was shown with a strong correlation between the self-assessment of the voice femininity and the subjective voice satisfaction. The more female the persons perceived their own voice, the higher is the subjective satisfaction. But a higher pitch does not guarantee being perceived as female: especially in absence of the visual transport of information like on the telephone, the MtF persons feel stigmatized by being appealed as male.[12,22,34,36,68–72] This misperception and irritation of conversation partners may be coresponsible for the deficient social integration of transsexuals in our society. In our report, this lack of integration after completed therapy procedure could be seen by the results of the FLZ especially in the domain "friends, acquaintances, relatives."

This incomplete rehabilitation of the transgendered voice, which is composed of physiological and social components,[20] is reflected in increased VHI scores. The VHI showed a persistence of the voice handicap although the voice quality, measured with the DSI,[54] was not reduced after surgery.

There were several limitations to the present study. According to most other reports with transgender persons, the number of subjects was relatively small. Despite best efforts, only 21 out of all 37 patients who underwent glottoplasty in Würzburg participated in the follow-up examinations. This may have led to a certain negative selection bias, which may have influenced our results because several patients who were very satisfied with their voice did not want to accept the journey for the follow-up session and to feel again as a patient. Also, there is loss of data within the study: the preoperative voice range profiles were not

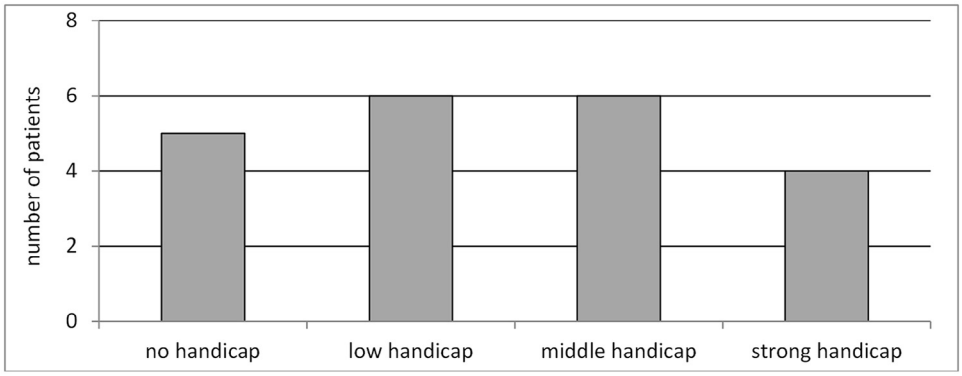

FIGURE 4. Classification in degrees of severity of the voice handicap according to the classification of the German Society of Phoniatrics and Pedaudiology.[62] The categories are "no handicap" (25th percentile, VHI score = 0–14), "low handicap" (50th percentile, VHI score = 15–28), "middle handicap" (75th percentile, VHI score = 29–50) and "strong handicap" (100th percentile, VHI score = 51–120).

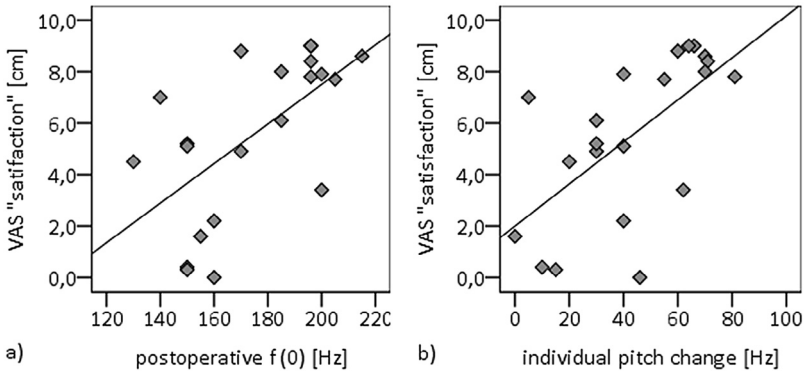

FIGURE 5. Correlation between the visual analog scale (VAS) "voice satisfaction," and (**A**) the postoperative fundamental frequency and (**B**) the individual elevation of vocal pitch.

complete for all patients. The postoperative voice range profiles of patient nos. 19 and 20 were done by external ear, nose, and throat doctors. For patient no. 21, a voice range profile of a former follow-up session was used. The population of our study was very inhomogeneous regarding intervals since surgery and because of the number of conservative voice therapy sessions and former surgical intervention. Four patients had already undergone CTA in other departments. Additionally, some of the patients continued smoking after surgery.

Hence, in the future, a holistic treatment concept is necessary for the feminization of voice and communication. Conservative voice therapy is obligatory for all patients. The attempt of elevating the vocal pitch can be combined with the work on aspects like breathier and softer voice timbre[18,30,73,74] and communication training with nonlinguistic parameters.[8,15,34] Additionally, conservative voice therapy can help to elevate also the formant frequencies[75] and consequently feminize not only the vocal pitch, but also the timbre of a voice. In case of not satisfying results, phonosurgery should be performed as "sandwich therapy" with pre- and postoperative conservative voice therapies for improving quality, efficiency, and femininity of the voice.

Finally, a standardized procedure for evaluating therapy success is necessary. Therefore, a specific and validated questionnaire for therapy of the MtF transgender voice is of major interest. Dacakis et al published in 2013 the Transgender Voice Questionnaire.[76] Actually, there exists a cooperation project with the Department of Otorhinolaryngology, Plastic, Aesthetic, and Reconstructive Head and Neck Surgery of the University Hospital Würzburg to translate this questionnaire into German.

To quantify the perception of the transgender voice in everyday life, an objective and realistic test is preferable. For this purpose, we developed a test procedure that evaluates the gender perception of a voice on the telephone.

CONCLUSION

Regarding objective voice parameters, Wendler's glottoplasty modified by Hagen is an effective and low-risk method to elevate the vocal pitch without affecting voice quality. Despite the elevation of the vocal pitch, the patients reported problems in everyday life. These issues lead to stigmatization and social problems. Frequently, the situation on the telephone, where the patients were addressed as male, was mentioned. Therefore, a specific voice therapy program additional to phonosurgical intervention is necessary.

Acknowledgment

The support of our voice therapists Mrs. Giacomuzzi and Mrs. Mark is strongly acknowledged. We are also grateful to the Graduate School of Life Science Würzburg for provision of expertise.

REFERENCES

1. Oates JM, Dacakis G. Speech pathology considerations in the management of transsexualism—a review. *Br J Disord Commun*. 1983;18:139–151.
2. Meszaros K, Vitez LC, Szabolcs I, et al. Efficacy of conservative voice treatment in male-to-female transsexuals. *Folia Phoniatr Logop*. 2005;57:111–118.
3. Landen M, Walinder J, Lundstrom B. Prevalence, incidence and sex ratio of transsexualism. *Acta Psychiatr Scand*. 1996;93:221–223.
4. Kanagalingam J, Georgalas C, Wood GR, et al. Cricothyroid approximation and subluxation in 21 male-to-female transsexuals. *Laryngoscope*. 2005;115:611–618.
5. Gross M. Pitch-raising surgery in male-to-female transsexuals. *J Voice*. 1999;13:246–250.
6. Wolfe VI, Ratusnik DL, Smith FH, et al. Intonation and fundamental frequency in male-to-female transsexuals. *J Speech Hear Disord*. 1990;55:43–50.
7. Owen K, Hancock AB. The role of self- and listener perceptions of femininity in voice therapy. *Int J Transgend* 2011;12:272–284.
8. Rosanowski F, Eysholdt U. Phoniatrische Begutachtung vor der Stimmangleichung bei Mann-zu-Frau-Transsexualismus. *HNO*. 1999;47:556–562.
9. Gooren L. Hormone treatment of the adult transsexual patient. *Horm Res*. 2005;64:31–36.
10. Moore E, Wisniewski A, Dobs A. Endocrine treatment of transsexual people: a review of treatment regimens, outcomes, and adverse effects. *J Clin Endocrinol Metab*. 2003;88:3467–3473.
11. Davies S, Goldberg JM. Clinical aspects of transgender speech feminization and masculinization. *Int J Transgend* 2006;9:167–196.
12. Freidenberg CB. Working with male-to-female transgendered clients: clinical considerations. *Contemp Issues Commun Sci Disord*. 2002;29:43–58.
13. Byrne LA, Dacakis G, Douglas JM. Self-perceptions of pragmatic communication abilities in male-to-female transsexuals. *Int J Speech Kang Pathol*. 2003;5:15–25.
14. Dacakis G. The role of voice therapy in male-to-female transsexuals. *Curr Opin Otolaryngol Head Neck Surg*. 2002;10:173–177.
15. de Bruin MD, Coerts MJ, Greven AJ. Speech therapy in the management of male-to-female transsexuals. *Folia Phoniatr Logop*. 2000;52:220–227.
16. Neumann K, Welzel C. The importance of the voice in male-to-female transsexualism. *J Voice*. 2004;18:153–167.
17. Gelfer MP, Schofield KJ. Comparison of acoustic and perceptual measures of voice in male-to-female transsexuals perceived as female versus those perceived as male. *J Voice*. 2000;14:22–33.
18. Van Borsel J, Van Eynde E, De Cuypere G, et al. Feminine after cricothyroid approximation? *J Voice*. 2008;22:379–384.
19. Wollitzer L. *Acoustic and Perceptual Cues to Gender Identification: A Study of Transsexual Voice and Speech Characteristics [Masterarbeit]*. Vancouver: University of British Columbia; 1994.
20. Wiltshire A. Not by pitch alone: a view of transsexual vocal rehabilitation. *NSSLHA*. 1995;22:53–57.
21. Gunzburger D. Acoustic and perceptual implications of the transsexual voice. *Arch Sex Behav*. 1995;24:339–348.
22. Simpson AP. Dynamic consequences of differences in male and female vocal tract dimensions. *J Acoust Soc Am*. 2001;109(5 pt 1):2153–2164.
23. Hammer SS, Heptner M. *Stimmtherapie mit Erwachsenen*. London: Springer; 2007.
24. Perez Alvarez JC. Stimme und Identität bei Transsexualitat. *Handchir Mikrochir Plast Chir* 2011;43:246–249.
25. Spencer LE. Speech characteristics of male-to-female transsexuals: a perceptual and acoustic study. *Folia Phoniatr*. 1988;40:31–42.
26. Oates J Dacakis G. Voice change in transsexuals. *Venereology*. 1997;10:178–187.
27. Gelfer MP, Mikos VA. The relative contributions of speaking fundamental frequency and formant frequencies to gender identification based on isolated vowels. *J Voice*. 2005;19:544–554.
28. Whiteside SP. The identification of a speaker's sex from synthesized vowels. *Percept Mot Skills*. 1998;87:595–600.
29. Klatt DH, Klatt LC. Analysis, synthesis, and perception of voice quality variations among female and male talkers. *J Acoust Soc Am*. 1990;87:820–857.
30. Andrews ML, Schmidt CP. Gender presentation: perceptual and acoustical analyses of voice. *J Voice*. 1997;11:307–313.
31. Van Borsel J, Janssens J, De Bodt M. Breathiness as a feminine voice characteristic: a perceptual approach. *J Voice*. 2009;23:291–294.

32. Hancock A, Colton L, Douglas F. Intonation and gender perception: applications for transgender speakers. *J Voice*. 2014;28:203–209.
33. Brown M, Perry A, Cheesman AD, et al. Pitch change in male-to-female transsexuals: has phonosurgery a role to play? *Int J Lang Commun Disord*. 2000;35:129–136.
34. Mount KH, Salmon SJ. Changing the vocal characteristics of a postoperative transsexual patient: a longitudinal study. *J Commun Disord*. 1988;21:229–238.
35. Dacakis G. Long-term maintenance of fundamental frequency increases in male-to-female transsexuals. *J Voice*. 2000;14:549–556.
36. Gelfer MP. Voice treatment for the male-to-female transgendered client. *Am J Speech Lang Pathol*. 1999;8:201–208.
37. Wagner I, Fugain C, Monneron-Girard L, et al. Pitch-raising surgery in fourteen male-to-female transsexuals. *Laryngoscope*. 2003;113:1157–1165.
38. Keil T. Transsexualität und Stimme. Möglichkeiten und Grenzen der stimmlichen Anpassung im Geschlechtsangleichungsprozess. *Sprechen—Zeitschrift für Sprechwissenschaften*. 1994;12:4–14.
39. deJong F, Norbart T. Cricothyroid approximation for the raise of vocal pitch in androphonia. In: Kleinsasser O, Glanz H, Olofsson J, eds. *Advances in Laryngology in Europe*. Marburg: Elsevier Science; 1996:435–439.
40. Yang CY, Palmer AD, Murray KD, et al. Cricothyroid approximation to elevate vocal pitch in male-to-female transsexuals: results of surgery. *Ann Otol Rhinol Laryngol*. 2002;111:477–485.
41. Remacle M, Matar N, Morsomme D, et al. Glottoplasty for male-to-female transsexualism: voice results. *J Voice*. 2011;25:120–123.
42. McNeill EJ. Management of the transgender voice. *J Laryngol Otol*. 2006;120:521–523.
43. Isshiki N. *Phonosurgery: Theory and Practice*. Berlin: Springer-Verlag; 1989.
44. Isshiki N, Taira T, Tanabe M. Surgical alteration of the vocal pitch. *J Otolaryngol*. 1983;12:335–340.
45. Orloff LA, Mann AP, Damrose JF, et al. Laser-assisted voice adjustment (LAVA) in transsexuals. *Laryngoscope*. 2006;116:655–660.
46. Koçak I, Akpinar ME, Cakir ZA, et al. Laser reduction glottoplasty for managing androphonia after failed cricothyroid approximation surgery. *J Voice*. 2010;24:758–764.
47. Wendler J. Vocal pitch elevation after transsexualism male to female. In: *XVIth Union of the European Phoniatricians Congress*. Salsomaggiore, Italy: 1990.
48. Mastronikolis NS, Remacle M, Biagini M, et al. Wendler glottoplasty: an effective pitch raising surgery in male-to-female transsexuals. *J Voice*. 2013;27:516–522.
49. Anderson JA. Pitch elevation in transgendered patients: anterior glottic web formation assisted by temporary injection augmentation. *J Voice*. 2014;28:816–821.
50. Kunachak S, Prakunhungsit S, Sujjalak K. Thyroid cartilage and vocal fold reduction: a new phonosurgical method for male-to-female transsexuals. *Ann Otol Rhinol Laryngol*. 2000;109:1082–1086.
51. Thomas JP, Macmillan C. Feminization laryngoplasty: assessment of surgical pitch elevation. *Eur Arch Otorhinolaryngol*. 2013;270:2695–2700.
52. Wolfort FG, Dejerine ES, Ramos DJ, et al. Chondrolaryngoplasty for appearance. *Plast Reconstr Surg*. 1990;86:464–470.
53. Nawka T, Franke I, Galkin E. Objektive Messverfahren in der Stimmdiagnostik. *Forum Logopädie*. 2006;4:14–21.
54. Wuyts FL, De Bodt MS, Molenberghs G, et al. The Dysphonia Severity Index: an objective measure of vocal quality based on a multiparameter approach. *J Speech Lang Hear Res*. 2000;43:796–809.
55. Hacki T. Tonhöhen- und Intensitätsbefunde bei Stimmgeübten. *HNO*. 1999;47:809–815.
56. Seidner W, Schutte H. Empfehlungen der UEP: Standardisierung Stimmfeldmessung/Phonetographoie. *HNO-Praxis*. 1982;7:305–307.
57. Schneider-Stickler B, Feichter F, Bigenzahn W, et al. Stimmfeldmessungen im Vergleich unterschiedlicher kommerzieller Softwareprogramme. In: *29. Wissenschaftliche Jahrestagung der Deutschen Gesellschaft für Phoniatrie und Pädaudiologie (DGPP)*. Bonn: German Medical Science Publishing House; 2012.
58. Jacobson BH, Johnson A, Grywalski C, et al. The Voice Handicap Index (VHI): development and validation. *Am J Speech Lang Pathol*. 1997;6:66–70.
59. Nawka T, Wiesmann U, Gonnermann U. Validierung des Voice Handicap Index (VHI) in der deutschen Fassung. *HNO*. 2003;51:921–930.
60. Fahrenberg J, Myrtek M, Schumacher J, et al. *Fragebogen zur Lebenszufriedenheit (FLZ). Handanweisung*. Göttingen: Hogrefe; 2000.
61. Weigelt S, Krischke S, Klotz M, et al. Voice handicap index. *HNO*. 2004;52:751–756.
62. DGPP. Voice Handicap Index, deutsche Fassung. 2003. Available at: http://www.dgpp.de/cms/media/download_gallery/vhi-dt_2006.pdf. Accessed July 22, 2013, 2013.
63. Hillenbrand J, Clark M. The role of f 0 and formant frequencies in distinguishing the voices of men and women. *Atten Percept Psychophys* 2009;71:1150–1166.
64. Gelfer MP, Young SR. Comparisons of intensity measures and their stability in male and female speakers. *J Voice*. 1997;11:178–186.
65. Holmberg EB, Oates J, Dacakis G, et al. Phonetograms, aerodynamic measurements, self-evaluations, and auditory perceptual ratings of male-to-female transsexual voice. *J Voice*. 2010;24:511–522.
66. Bralley RC, Bull GL, Gore CH, et al. Evaluation of vocal pitch in male transsexuals. *J Commun Disord*. 1978;11:443–449.
67. Soderpalm E, Larsson A, Almquist SA. Evaluation of a consecutive group of transsexual individuals referred for vocal intervention in the west of Sweden. *Logoped Phoniatr Vocol*. 2004;29:18–30.
68. Pasricha N, Dacakis G, Oates J. Communicative satisfaction of male-to-female transsexuals. *Logoped Phoniatr Vocol*. 2008;33:25–34.
69. Gelfer MP, Mordaunt M. Pitch and intonation. In: Adler RK, Hirsch S, Mordaunt M, eds. *Voice and Communication Therapy for the Transgender/Transsexual Client. A Comprehensive Clinical Guide—Second Edition*. San Diego, CA: Plural Publishing inc.; 2012:187–223.
70. T'Sjoen G, Moerman M, Van Borsel J, et al. Impact of voice in transsexuals. *Int J Transgend* 2006;9:1–7.
71. McNeill EJ, Wilson JA, Clark S, et al. Perception of voice in the transgender client. *J Voice*. 2008;22:727–733.
72. Dacakis G. Assessment and goal setting: revisited. In: Adler RK, Hirsch S, Mordaunt M, eds. *Voice and Communication Therapy for the Transgender/Transsexual Client. A Comprehensive Clinical Guide—Second Edition*. San Diego, CA: Plural Publishing, Incorporated; 2012:111–138.
73. Palmer D, Dietsch A, Searl J. Endoscopic and stroboscopic presentation of the larynx in male-to-female transsexual persons. *J Voice*. 2012;26:117–126.
74. Mendoza E, Valencia N, Muñoz J, et al. Differences in voice quality between men and women: use of the long-term average spectrum (LTAS). *J Voice*. 1996;10:59–66.
75. Carew L, Dacakis G, Oates J. The effectiveness of oral resonance therapy on the perception of femininity of voice in male-to-female transsexuals. *J Voice*. 2007;21:591–603.
76. Dacakis G, Davies S, Oates JM, et al. Development and preliminary evaluation of the transsexual voice questionnaire for male-to-female transsexuals. *J Voice*. 2013;27:312–320.