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Main Article

Mutational falsetto: intervention outcomes in 45 patients

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Abstract

Objective: The aim of this study was to evaluate the outcomes of therapeutic intervention in patients with mutational falsetto, by applying perceptual and acoustic analysis before and after voice therapy.

Materials and methods: Forty-five consecutive patients with mutational falsetto were studied retrospectively. Acoustic analysis (i.e. fundamental frequency, jitter, shimmer, and formants one, two and three) was performed using the Multi-Dimensional Voice Program. Perceptual voice analyses were performed, including graded severity–roughness–breathiness–aesthenicity–strain assessment.

Results: Subjects' fundamental frequency, voice formants one, two and three, jitter, and shimmer were greater before than after treatment. There were statistically significant differences between pre- and post-treatment average values for fundamental frequency, jitter and shimmer. There were also statistically significant differences between pre- and post-treatment average values for formants one and two. These results were maintained after six months of follow up, and there was no significant difference between results at three- and six-month follow up. According to perceptual evaluation, each subject's voice had altered from mutational falsetto to chest voice by completion of the intervention. Thus, all of the patients successfully lowered their modal speaking voice to an appropriate level.

Conclusion: In the light of objective evaluations, and by applying the study treatment protocol, these results suggest that normal voice can be maintained after intervention, at six months' follow up.

Key words: Voice; Puberty; Larynx; Outcome Assessment

Introduction

Mutational falsetto is a functional voice disorder, being the failure to change from the higher pitched voice of pre-adolescence to the lower pitched voice of adolescence and adulthood. The higher pitched voice of mutational falsetto patients persists beyond puberty. Falsetto voice is weak, thin, breathy, hoarse, effeminate and immature. The other symptoms are pitch breaks, inadequate resonance and shallow breathing.[1,2]

Other terms used to describe this condition include puberphonia, adolescent transitional dysphonia, persistent falsetto, incomplete mutation and pubescent falsetto.[1–3]

A search of the PubMed database revealed eight articles published since 1983.[4–11] The incidence of mutational falsetto is not well documented.[1,4] It is a problem usually encountered between the ages of 11 and 15 years.[4] Without intervention, mutational falsetto often becomes a chronic disorder.[5,12]

During childhood, patients apparently exhibit normal development of voice, speech and language. As the patient enters the rapid growth spurts associated with puberty, the larynx undergoes rapid dimensional changes.[13] At puberty, the larynx descends and the dimensions of the infraglottal sagittal and transverse planes increase. The angle of the male thyroid lamina decreases to 90°, compared with the female angle of 120°, the vocal folds increase in length, the mucosa becomes stronger and the epiglottis increases in size. The range of descent averages an octave for males and three to four notes for females. It is generally believed that the speaking voice completes mutation within about three to six months.[14]

The adolescent, using a young adult voice with newly lowered fundamental frequency, may experience abrupt changes into higher pitches that are more childlike.[6] In mutational falsetto, the mechanism of pitch breaks is correlated with the onset of uncontrolled changes in vocal performance, vacillating between child and young adult characteristics.[3]

Hartman and Aronson described the effect of peer reaction to dysphonic adolescents maintaining use of a childlike voice.[4]

There are three phases in the mutational period (9 to 16 years). In the pre-mutational phase, the

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first symptoms of mutational change of the voice occur, around the age of 9 to 10 years. The main mutational phase is characterised by a rough, hoarse voice quality and successive decreases in pitch over a relatively short period of time; it may last several months. The post-mutational phase is the last phase and involves stabilisation of the male voice; it is characterised by a lowering of the lower limit of vocal pitch range and a stabilisation of the vocal pitch. Most adolescents complete the mutational phase by the age of 17 years.[7]

Vocal register is a psychoacoustic property, and the term 'register' has been used to describe perceptually distinct regions of vocal quality which can be maintained over some ranges of pitch. Three major phonation modes have been classified as laryngeal modes or registers. These are the pulse (vocal fry), modal (chest) and loft (falsetto) registers. These three registers usually correspond to three frequency ranges: low, middle and high.[15]

Hard glottal attack is defined as a manner of initiating vowels in which the vocal folds adduct rapidly and completely prior to phonation.[16]

The signs and symptoms of mutational falsetto include: (1) downward pitch breaks occurring between falsetto and chest registers, with increased phonatory and respiratory effort; (2) a normal, low-pitched cough within chest register; (3) a normally low-pitched chest register voice as the larynx is manipulated downward by the examiner; and (4) a normally low-pitched voice with dorsoflexion of the head, depression of the mandible and hard glottal attack.[1]

The diagnosis of mutational falsetto relies on auditory-perceptual features, acoustic analysis and laryngovideostroboscopy findings. The diagnostic profile of individuals presenting with mutational falsetto is relatively simple. The patients are typically post-pubertal males with relatively normal physical development, including secondary sex characteristics. The vocal pitch of mutational falsetto patients is substantially higher than expected and similar to that of females. They also have infrequent downward pitch breaks into male chest register. Voice quality of mutational falsetto patients that exhibits mild breathiness or that is associated with falsetto in normal subjects. Because patients lack knowledge of their potential for a male chest voice, they are unaware of how to elicit and maintain a chest voice.[17]

Outcome data on the results of voice intervention in mutational falsetto are notably lacking in the literature. Therefore, the present study was performed to address this issue, and to present the results of our experience in treating mutational falsetto.

Materials and methods

Patients

We included in the study 45 consecutive patients with mutational falsetto, seen over a two-year period in the otorhinolaryngology department of Ankara University. All patients were male except one. Their ages ranged from 13 to 40 years.

Twenty-nine patients were in the post-mutational period (16–40 years), and 16 patients were in the mutational period (11–15 years).

The diagnosis of mutational falsetto followed comprehensive speech and voice evaluations by a laryngologist and a speech pathologist. After a complete, detailed history of each patient was taken, routine otorhinolaryngological and laryngovideostroboscopic examinations were conducted. After the soft palate and the posterior half of the tongue were topically anaesthetised using a 4 per cent xylocaine solution, the vibration of the vocal folds during phonation was video-recorded, using a 90°-angled rigid telescope (Karl Storz 8010 videostroboscopy system, Tuttlingen, Germany). The parameters investigated by videolaryngostroboscopy were glottal closure and mucosal wave.

Acoustic analysis was performed using the Multi-Dimensional Voice Program 5105 version 2.5.2 with computerised Speech Lab (Kay Elemetrics, New Jersey, USA) within a sound-treated room with 15 dB background noise level. A speech and language pathologist completed all the acoustic measurements for each participant. A standardised protocol was used for each voice assessment session. The subject was positioned adjacent to a microphone held at a fixed distance (10 cm) and at a 45° off-axis position to reduce aerodynamic noise from the mouth. The subject was then instructed to vocalise and sustain (three seconds) the vowel /a/ in a flat tone, and original acoustic signal data were sampled at a rate of 44.1 kHz. The reference fundamental frequency value of the Multi-Dimensional Voice Program for male speakers was 145.223 Hz and for females was 243.973 Hz. Perceptual voice analyses were performed by the speech and language therapist, including assessment using the graded severity–roughness–breathiness–aesthenicity–strain system.[18,19] Pre- and post-intervention acoustic analyses of fundamental frequency, jitter, shimmer, and formants one, two and three, were conducted on productions of /a/, sustained for three seconds. All patients' phonations were taped on magnetic tape, and the recorded tapes were then reviewed by clinicians and the speech and language therapist. Initial and follow-up acoustic assessments were performed by the same investigator to ensure a consistent recording technique.

Exclusion criteria included: (1) evidence of organic laryngeal pathological lesion on laryngovideostroboscopy; (2) endocrine dysfunction; (3) systemic illness during puberty; and (4) hearing loss.

Therapeutic intervention

The therapeutic intervention was established by modifying several current voice therapy techniques, such as manual manipulation of the larynx, larynx-depressing exercises and producing vegetative voice (i.e. coughing, yawning, humming and sighing). Patients were seen for intervention once a week for two weeks, in 30-minute sessions. After a brief explanation of the nature of mutational falsetto, elicitation of voice was first attempted by bringing the patient's head into full upward extension while the clinician

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applied downward and dorsal pressure on the patient's thyroid cartilage, during phonation of any allophonic production of /a/. We occasionally supplemented these facilitative tasks with others,[13] such as coughing and humming.[20] After eliciting repeatable productions of chest voice, the patient's head was brought to a normal position in a series of successive approximations. For the patient to recognise his newly acquired voice, he was told to vocalise the sounds of the voice, including both the lowered pitch and the habitually used, pre-intervention pitch. The patient then practised alternating between the falsetto and chest voices, until either could be used upon demand with 100 per cent consistency. Audio tape recordings were made and subsequently monitored by the patient in order to further enable their recognition of the two voices and to begin their acclimatisation to the newer alternative.

When the patient used a chest voice to vocalise /a/, they were asked to repeat various sounds, following the clinician's modelling, with attention focussed on maintenance of chest voice, regardless of configuration of the mouth, tongue or lips or mouth-opening. After achieving at least 80 per cent success on three sets of trials, the patient was made aware that various vowel sounds had been produced. The patient was then asked to repeat various combinations of vowels. The clinician then modelled vowel-ending consonants for the patient to imitate, producing nonsense syllables. Various vowels and consonants were practiced using nonsense syllables. Having achieved 80 per cent consistency in using chest voice for the production of multiple nonsense syllables, on three separate trials, the patient was then asked to use chest voice to repeat, after the clinician, various sets of meaningful syllables, then words, then sentences.

The criterion for progression from one level of speech complexity to the next was an 80 per cent success rate for sets of 20 productions on three occasions. If the patient was not convinced of their abilities, practice continued at the same level until the patient felt more confident. After the patient was able to successfully maintain chest voice during repeated sentence productions, they were then asked to read phrases and sentences in chest voice, until both the clinician and the patient were convinced that the patient could do this with an 80 per cent success rate. Then, the patient was asked to read paragraphs until the chest voice was maintained, according to the same criteria.

The patient was asked to vocalise sentences of their own creation, followed by monologues and, finally, dialogue, without production of mutational falsetto. The patient was instructed that, if a register other than chest voice appeared, they were to stop vocalising and produce a unit of chest voice in which they were confident. This cessation of narration and implementation of self-correction before continuing served two purposes. One was punishment for exhibiting mutational falsetto, and the other was cancellation of the mutational falsetto voice with chest voice. In the corrective process, permission to continue the narration reinforced the patient's production of chest voice.

Data evaluation

All analyses were performed before and three and six months after the initial treatment. Paired samples *t*-testing was used for statistical analyses for all 45 patients. The acoustic parameters analysed included fundamental frequency, formants one, two and three, jitter, and shimmer. The quality of voice was assessed using the graded severity–roughness–breathiness–aesthenicity–strain system, while the patient read a passage from a Turkish text. Voice quality was assessed as: zero = normal or absent deviance; one = slight deviance; two = moderate deviance; and three = severe deviance.[18,19]

Results

Hyperaemia and medial compression of the false vocal folds were the most prevalent laryngovideostroboscopy findings, occurring in nine of 45 (20 per cent) subjects. A mucosal wave appearing in the anterior one-third of the glottis was also common. Laryngovideostroboscopy confirmed a structurally normal larynx, free of mucosal disease or vocal fold paresis and paralysis.

According to perceptual evaluation, each subject had successfully altered their voice from mutational falsetto to chest voice by the completion of the intervention. Thus, all patients successfully lowered their modal speaking voice to that appropriate for their age and gender.

For all subjects, the fundamental frequency, vocal formants one and two, jitter, and shimmer were greater before than after treatment ($p < 0.05$) (Figure 1). There were statistically significant differences ($p < 0.001$) between the pre- and post-treatment average values for fundamental frequency, jitter and shimmer. There were also statistically significant differences ($p < 0.05$) between the pre- and post-treatment average values for formants one and two (Table I). These results were maintained after six months' follow up, and there was no significant difference between results at three and six months' follow up ($p < 0.05$).

After the first session, four patients were referred to the psychiatry department because of resistance to using their new chest voice. After this adaptation, therapeutic intervention continued.

Discussion

The fundamental frequency refers to the number of vibrations of the vocal folds per second. The formants refer to the resonant frequencies of the vocal tract. The first, second and third formants originate from the pharyngeal cavity, oral cavity and upper resonator regions, respectively. Harsh or rough qualities have been attributed to irregularities or perturbations in consecutive vibratory cycles, resulting in 'jitter' (irregular duration of cycles) and 'shimmer' (irregular amplitude of cycles) in the acoustic waveform.[2]

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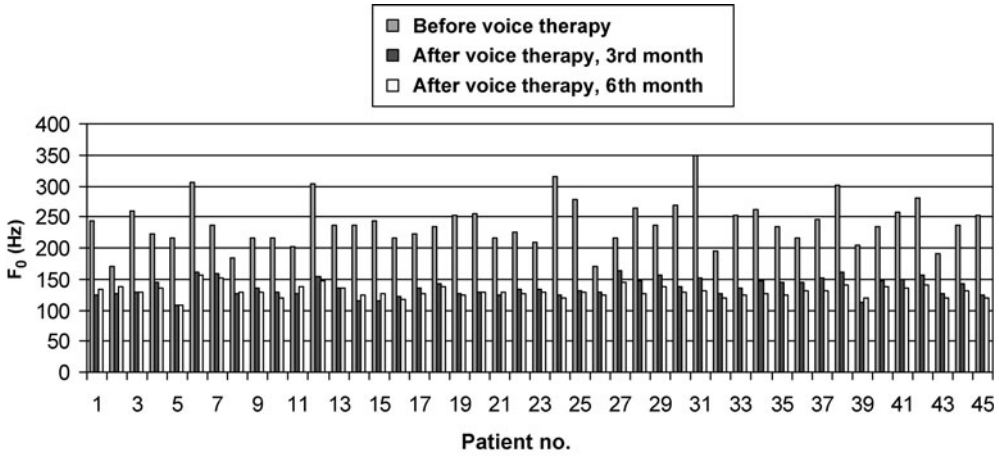

FIG. 1
Patients' fundamental frequencies (F_0), before and 3 and 6 months after treatment.

The laryngeal anatomy of individuals presenting with mutational falsetto appears to be normal. Despite this fact, the larynx is generally drawn up toward the hyoid bone or the base of the tongue.[2,8,21] Laryngoscopy reveals a tense glottis, and the cartilaginous glottis may be hyperadducted, restricting phonation to the anterior membranous vocal folds.[2] Furthermore, according to some clinicians, the vocal folds appear not to close completely in the posterior part of the glottis.[1,7,13,21] Hyperaemia of the vocal folds may also be found.[8,21]

Intervention in cases of mutational falsetto begins with an explanation that the disorder is purely functional, without organic deficiencies.[21] This is followed by eliciting from the patient productions of chest voice in which the larynx fails to move extensively upward. This may involve a variety of possible tasks, described as 'facilitative' techniques.[13] There are two techniques particularly noted to facilitate production of chest voice. One involves manual application of dorsal–caudal pressure on the thyroid cartilage (the thyroid cartilage notch area is compressed by the fingers backwards and downwards at the same time) in order to reduce thyroarytenoid muscle elongation. This manipulation prevents elevation of the larynx, reduces tension on the vocal folds and enhances the vocal fold contact area, inducing lower-pitched phonation. The other technique involves upward neck extension such that the chin is moved upward, stretching the anterior neck, so that the strap muscles anchor the larynx, preventing the rise typically seen in falsetto voice production. Once the patient is able to produce chest voice on a reliable basis, vocal acclimatisation involves maintenance of the chest voice during progressively more complex linguistic tasks.

Eliciting the chest voice and developing its communicative use may be accomplished in one session. Additional follow-up sessions may be required to persuade the patient to use the chest voice outside the clinical setting, to dispel remaining doubts or to develop further vocal attributes. Most patients can be permanently corrected within just a few days. The clinician may need to assist the patient to detect proprioceptive and kinaesthetic cues associated with mutational falsetto and chest voice production. Patients may use imagery in their training, since the voice will often respond appropriately to psychological and/or anatomical instruction (e.g. 'place your voice forcefully down into your chest', 'imitate my voice' or 'follow my hand signals as guidelines'). Patients may also need practice in learning to listen to their own voice. If the patient resists use of their newly developed chest voice, referral for psychological testing may be appropriate, if such assessment lies outside the expertise of the vocal clinician.

The lack of long-term follow up of our patients (which would have required long-distance travel for most) prevented assessment of how the vocal intervention may have affected their interpersonal relationships and employability. During the

TABLE I
RESULTS OF SPEECH ANALYSES, BEFORE AND 3 TO 6 MONTHS AFTER TREATMENT

Test time	Acoustic parameters ± SD					
	F_0 (Hz)	Jitter (%)	Shimmer (%)	F_1 (Hz)	F_2 (Hz)	F_3 (Hz)
Before	241 ± 41.4	1.18 ± 0.64	3.71 ± 1.00	731 ± 84.1	1211 ± 101.9	2511 ± 297.6
3 mths after	141 ± 13.6	0.57 ± 0.42	3.23 ± 1.17	713 ± 72.6	1208 ± 93.7	2532 ± 296.1
6 mths after	138 ± 15.9	0.54 ± 0.31	2.97 ± 1.04	695 ± 74.8	1182 ± 81.6	2563 ± 296.9
p	0.000	0.000	0.000	0.005	0.048	0.413

SD = standard deviation; F_0 = fundamental frequency; F_1 = formant one; F_2 = formant two; F_3 = formant three

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intervention, many patients indicated an increased self-confidence, judging by changes in how they spoke about their voice and its future effect on their lives.

- **Mutational falsetto is a functional voice disorder, being the failure to change from a pre-adolescent to an adult voice**
- **This study evaluated therapeutic outcomes in 45 patients with mutational falsetto**
- **Therapy included manual manipulation of the larynx, larynx-depressing exercises and production of a vegetative voice**
- **Using objective outcome measures, a normal voice can be maintained after therapy during a six-month follow-up period**

Voice therapy for mutational falsetto almost always achieves an appropriately pitched voice.[1,13,20] In addition, Woodson and Murry suggested botulinum toxin in patients with resistant mutational falsetto, as an adjunct to voice therapy, before progressing to surgical alteration of the glottis.[5] The injection of botulinum toxin can prevent excessive contraction of the suprahyoid muscles. However, its potential disadvantage is that its effects only last three to six months. Occasionally, surgical treatments have been recommended in cases unresponsive to voice therapy; such procedures include vocal fold relaxation techniques (e.g. Isshiki type III thyroplasty) and suprahyoid release.[9]

On reviewing the literature on mutational falsetto, two clinical studies and six case reports were found. Only one of the two clinical studies related to therapeutic aspects of mutational falsetto.[8] In this study by Prathanee, seven cases with mutational falsetto were treated with voice therapy and assessed by perceptual analysis.[8] The therapeutic intervention presented in the current study is no different; however, our series was larger.[8]

Conclusion

According to perceptual evaluation, all of our mutational falsetto patients successfully lowered their modal speaking voice after the therapeutic intervention. Acoustic analysis showed that the fundamental frequency, voice formants one and two, jitter, and shimmer were greater before than after the treatment.

In the light of objective evaluations, and by applying the study treatment protocol, these results suggest that a normal voice can be maintained six months after such intervention.

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