Using Manual Tension Reduction Treatment in Treating Pediatric Functional Dysphonia

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Functional dysphonia (FD) is a voice disorder that presents with vocal quality aberrations including aphonia, strain, and/or severe dysphonia with no presence of structural abnormality of the vocal folds or the existence of benign organic lesions. Other voice disorders in this category can be described similarly and include muscle tension dysphonia (MTD), persistent falsetto, conversion dysphonia/aphonia, and hyperfunctioning of the larynx (Aronson, 1990; Roy & Leeper, 1993).

ABSTRACT: **Purpose:** This study examined the effects of a manual tension reduction technique on acoustic and perceptual parameters of voice in a pediatric client diagnosed with functional dysphonia (FD).
Method: A single pediatric client with FD was treated using circumlaryngeal massage (CM) for approximately 2 hr during a diagnostic evaluation. Acoustic and perceptual parameters of voice were taken before, after, and 1 year after treatment to determine the effects of the manual tension reduction treatment.
Results: The participant demonstrated significant improvement in the perception of her overall vocal quality, strain, breathiness, pitch, and loudness after treatment. Acoustic measures of fundamental frequency and perturbation were normalized after treatment in both a sustained vowel production and a reading task. One-year follow-up demonstrated no change in the client's ability to maintain posttreatment vocal characteristics.
Conclusion: A manual tension reduction technique was used successfully to treat a pediatric client's FD and return her voice to expected acoustic and perceptual values.

KEY WORDS: functional dysphonia, circumlaryngeal massage, muscle tension, pediatric

Generally, perceptual voice qualities associated with FD include a range of difficulties such as a breathy high-pitched quality, a complete loss of voice where the client simply whispers, and a gravely hoarse voice with periods of complete aphonia. Typically, clients fall into one of these three vocal categories.

Voice disorders that are categorized as functional in adults have been attributed to such variables as psychological stress, anxiety, certain personality traits, learned adaptations after respiratory infection, compensation for underlying vocal diseases (i.e., vocal fold paralysis, paresis), and misuse of the laryngeal structures during demanding vocal tasks (Demmink-Geertman & Dejonckere, 2002; Roy, Ford, & Bless, 1996; Roy, McGory, Tasko, Bless, & Ford, 1997).

In adolescents, some of the same etiologic variables are indicated, such as psychogenic and psychosocial personality traits and psychosexual bases, along with learned patterns (not psychogenic in nature; Aronson, 1969; Peppard, 1996). Peppard (1996) identified other high-risk factors that may lead to FD in children, including other communication deficits (i.e., hearing loss, cleft palate, stuttering, and misarticulations), medical problems (i.e., respiratory difficulty, colds, allergies, and sinus infections), vigorous vocal activity (i.e., cheering, singing, and acting), vigorous physical activity (i.e., weight lifting and sports), educational performance, substance abuse, eating disorders, acquisition of secondary sex characteristics, and dramatic pitch change at puberty. It is likely that a functional voice disorder could present if a child has any or all of these high-risk factors (Peppard, 1996).

Diagnostic symptoms of FD and MTD can include specific visible characteristics seen during direct observation of the larynx, including ventricular fold activation, narrowing

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of the pharyngeal structures, and anteroposterior squeezing of the muscles that surround the vocal folds (Morrison, Rammage, & Gilles, 1983). Pharyngeal and/or laryngeal muscle tension, which may completely obstruct the view of true vocal fold vibration during an endoscopic examination, may also be present in clients with FD. Clients with FD can have related MTD symptoms or have no visible, physical evidence of muscle tension. However, muscular tension is usually present in most clients with FD (Koufman & Blalock, 1991; Roy & Leeper, 1993).

In contrast to adults, adolescents have been found to possess consistent characteristics of FD. In this population, diagnostic signs include auditory perceptual symptoms such as severe aphonia (not typically seen in organic pathology) and a lack of struggle symptoms to achieve phonation, such as changes in speaking rate, rhythm, or facial tension (also seen more frequently in organic pathology; Peppard, 1996). Other signs of FD found in adolescents include acoustic indications such as an increased, decreased, or variable fundamental frequency; reduced pitch range; and increased frequency perturbation and amplitude variability (i.e., jitter and shimmer). Increased or decreased vocal loudness and decreased loudness range are also common in children with FD. Laryngoscopic observations can include a continuum of symptoms from edematous to normal-appearing vocal folds.

A psychological etiology has been indicated as a major cause of FD and has recently been investigated. Roy, McGory, et al. (1997) studied FD clients to determine if there was a specific personality type that was more likely to contract FD. The personality traits associated with FD and MTD have been identified as neuroticism and a propensity to be meticulous and organized (Roy, McGory, et al., 1997).

Treatment regimes for FD and MTD in adults have had success using a manual tension reduction technique known as circumlaryngeal massage (CM; Aronson, 1990; Roy, Bless, Heisey, & Ford, 1997; Roy & Leeper, 1993; Roy et al., 1996; Van Lierde, De Ley, Clement, De Bodt, & Van Cauwenberge, 2004). CM employs a massage or manipulation that is designed to relax the client's musculature and re-organize the position of his or her larynx. The CM technique involves the clinician encircling the client's thyrohyoid space with the thumb and forefinger and firmly bringing the fingers in a forward downward movement that is intended to open the space and essentially reduce the suprahyoid muscular tension that is responsible for bringing the larynx into an elevated hypertensive state. The object is to get the client to accomplish clear voicing and then to remove the clinician's hand slowly until the client is able to maintain voicing on his or her own. The general relaxation of the laryngeal musculature is important to reorient the client to the feeling or sensation of the laryngeal position that he or she had before the loss of voice.

The CM technique has been used successfully with several groups of clients, including adults with FD, professional voice users, and a small group of children with FD and associated nodules (Lee & Son, 2005; Roy & Leeper, 1993; Van Lierde et al., 2004). All of the studies demonstrated that manual tension reduction techniques effectively reduced clients' MTD and functional loss of voice. Case study evidence from treatment sessions using CM has also shown CM to be successful in improving clients' vocal quality (Roy et al., 1996). Subjective measures including rating scales, and objective measures of acoustic and aerodynamic parameters, have been used to determine the effectiveness of using manual tension reduction as a treatment for FD (Roy & Leeper, 1993; Van Lierde et al., 2004). Roy and Leeper (1993) measured perceptual and acoustic parameters of 17 adult clients with FD before and after treatment using CM and found a significant change in normalization of vocal quality after a single treatment session. There is also evidence that the positive effects on vocal quality using CM have long-term carryover (Roy, Bless, Heisey, & Ford, 1997).

In other studies, Van Lierde et al. (2004) used a series of objective and subjective measures to demonstrate the effectiveness of CM in professional voice users with FD. These authors found that all participants demonstrated improved perceptual vocal quality according to the Grade, Roughness, Breathiness, Asthenia and Strain Scale (GRBAS), which is a perceptual voice rating scale that was developed by the Japan Society of Logopedics and Phoniatrics (Hirano, 1981), and the Dysphonia Severity Index (DSI; Wuyts et al., 2000), which was designed to establish an objective and quantitative correlate of perceived vocal quality using a weighted combination of acoustic measures of voice. The acoustic measures of jitter and shimmer were improved in almost all of the clients (Van Lierde et al., 2004).

Using CM to improve vocal quality in functional voice disorders has been demonstrated to have a positive effect on vocal quality in adults; however, there is little evidence of its effectiveness in children. One study demonstrated voice treatment, including CM, to be effective in reducing the symptoms of MTD and associated vocal nodules in eight Korean male children (Lee & Son, 2005) with marked strained and breathy voices. A variety of voice treatment techniques were used to treat these clients, including improving awareness, relaxation, easy onset phonation exercises, and CM in coordination with respiratory relaxation exercises. The GRBAS scale was used to measure perceptual changes, and acoustic measures of speaking fundamental frequency (SFF), jitter, and shimmer were collected. Results indicated that after an average of 1–2 months of treatment, all children demonstrated an improvement in their GRBAS ratings, especially for grade, strain, and pitch in connected speech, and their jitter and shimmer values returned to normative values. Other symptoms such as anterior–posterior contraction of the supraglottal cavity and incomplete closure were relieved into a relaxed normal configuration after treatment (Lee & Son, 2005). Vocal nodules were reduced or absent following treatment, and long-term follow-up suggested no reoccurrence of vocal disorders (Lee & Son, 2005).

A report by Peppard (1996) described several case study examples that used techniques such as negative practice, producing normal phonation during nonspeech activities such as throat clearing and coughing, auditory discrimination tasks, and vocal hygiene lessons to manage functional disorders in adolescents. Functional aphonia symptoms resolved in 1–2 treatment sessions for one client and after

6 months in another client (Peppard, 1996). Muscle tension reduction techniques have been shown to reduce muscle tension in adolescents with functional voice-related problems and groups of children with vocal nodules. Although vocal nodules are an overused organic pathology, their presence has been related to excessive laryngeal muscle tension. The MTD exacerbates the presence of abuse and misuse of the vocal folds and is additive to the pathologic condition. Other treatment techniques that have been useful in reducing MTD, other than manual reduction, have been the classic arrangement of voice treatment techniques such as easy onset, tongue-anchoring exercises, yawn-sigh, and chanting talk (Boone, McFarlane, & Von Berg, 2005).

To date, there have been no investigations studying the effects of manual tension reduction in children with FD without the simultaneous administration of other therapeutic techniques. This study investigated a single pediatric participant with diagnosed FD to determine if CM would improve her voice perceptually and normalize her acoustic parameters. Measurement of acoustic parameters of voice and qualitative rating scales were used to determine the client's pre- and posttreatment voice quality.

METHOD

Participant

The participant in this study was a 6-year-old female who was diagnosed with FD. The client's FD reportedly persisted for 5 years before any physician saw her or any type of evaluation or intervention occurred. The diagnosis of FD was confirmed during a transoral fiberscopic laryngeal examination by an otolaryngologist. The otolaryngologist reported normal vocal fold mobility with no evidence of any abnormality or pathology on two separate visits. The otolaryngologist then referred the client for a voice evaluation by a licensed speech-language pathologist. The physician's report described the client's vocal quality as excessively breathy, strained, and high in pitch. Other relevant medical history included allergies and asthma, for which the client was prescribed Flovent Albuterol. Her asthmatic condition was most severe before 2 years of age and reportedly had not affected her current condition of FD. The client was assessed by two clinicians at the time of the voice assessment and was initially referred by the otolaryngologist 1 week after her second laryngoscopic evaluation.

Diagnostic Evaluation and Treatment Procedures

The diagnostic evaluation of voice, speech, and language was completed according to Aronson's standard practices, including a heightened awareness of possible psychosocial factors that may have precipitated the voice problem (Aronson, 1990; Roy & Leeper, 1993). The assessment included a client history, pretreatment perceptual and acoustic measures, a hearing test, and an oral–peripheral examination. Treatment was administered during the evaluation and included Aronson's manual laryngeal tension reduction technique, or CM. Posttreatment qualitative and quantitative measures were taken after the client regained an adequate quality of voice as judged by three clinicians using the Consensus Auditory–Perceptual Evaluation of Voice (CAPE–V; American Speech-Language-Hearing Association [ASHA] Special Interest Division 3, 2006), and acoustic measures were collected using the Computerized Speech Lab (CSL) Multi-Dimensional Voice Program (MDVP) Model 5105 (Kay Elemetrics, 2000a). Normal vocal quality was regained approximately 2 hr after diagnostic treatment commenced. One year after treatment, perceptual and acoustic measures were collected again to determine if the improved vocal quality generated during the primary evaluation was maintained.

Interview and Voice Assessment Procedure

The client's case history included medical, developmental, educational, and familial history questions. General open-ended questions included (a) onset of the voice disorder (conditions including how and when the voice trouble began; sudden or gradual), (b) course of the voice disorder (vocal disorder present since the onset, any periods of normal voice), and (c) associated events of onset (familial conflict, emotional stress, anxiety, communication problems; Aronson, 1990; Roy & Leeper, 1993). After the case history was administered, typical areas of vocal function were assessed. The CAPE–V was given to assess perceptual parameters of voice, informal observation of breathing support for speech was assessed, and an oral–peripheral and hearing examination were also administered.

The instrumental assessment procedure included using the MDVP program to measure several acoustic parameters of voice before and after CM was administered. Noninstrumental measures included maximum phonation time and musculoskeletal tension palpation of the shoulder, neck, and larynx. Palpation was used to determine the extent of laryngeal elevation and pain in response to pressure in and around the larynx. Laryngeal elevation was determined by the clinician encircling the client's thyrohyoid space with the thumb and the pointer finger and determining if the space was more narrow than expected. Pain usually was indicated if the client winced or demonstrated any sign of being uncomfortable during the probing. The entire evaluation was videotaped for analysis and comparison.

Perceptual Assessment

The client's voice was digitally recorded using the MDVP before, after, and 1 year after the initial CM treatment. The recordings included the client sustaining the vowel /a/ for approximately 4 s for three trials and reading the first four sentences listed on the CAPE–V (see the Appendix). The recordings took place in a sound-treated room with a noise floor of < 30 dBSPL. The client was asked to produce all tasks using a comfortable vocal pitch and loudness that were determined before collection using the MDVP. The comfortable pitch and loudness were acquired

on the MDVP before recording the data to enable the client to practice the tasks and understand the instructions. The client read the sustained vowel and the CAPE–V sentences into a Shure head-mounted professional-grade condenser-style microphone that was attached to the CSL console and positioned at a 45-degree angle to the client's mouth at a distance of 4 cm. The positioning of the microphone in this way served to reduce aerodynamic noise from the mouth during speech (Titze & Winholtz, 1991).

The MDVP was used to record and analyze all speech tasks at the client's determined comfortable pitch and loudness. The recordings from the MDVP program were digitized at a 50-kHz sampling rate, and the software provided DC coupling and low fidelity within the acquisition hardware, which accommodated the physiologic signals that augment the microphone signal. During recording, the MDVP provided real-time feedback for clipping by changing the signal to a red coloration when the A/D converters were being overloaded. If this occurred, the sample was taken again after appropriate volume adjustments were made on the CSL instrument.

Three clinicians completed the CAPE–V to rate the client's pre, post, and post 1–year treatment voice samples. The CAPE–V was developed as a tool for clinical auditory–perceptual assessment of voice. The CAPE–V indicates salient perceptual attributes such as overall severity, roughness, breathiness, strain, pitch, and loudness. The developed scale displays each attribute accompanied by a line that is 100-mm long, forming a visual analog scale. The rater uses a tic mark to indicate where along the line he or she feels a speaker's particular attribute falls in terms of perceived deviance in comparison to normal. Judgments may be assisted by referring to the regions below each scale or line: MI refers to *mildly deviant,* MO refers to *moderately deviant,* and SE refers to *severely deviant*. The tic mark is then measured out of 100 mm using a metric ruler (0 = *mildly severe,* 100 = *very severe*). If, for example, the line is measured to be 45 mm long, the rating would translate into 45%, indicting a moderate level of severity for that parameter. To the right of each scale are two letters, *C* and *I*, which represent consistent and inconsistent presence of a particular voice attribute. The rater circles the letter that best describes the consistency of the judged parameter. The tasks for rating the voice may include sustained vowel productions of /i/ or /a/, reading predesigned sentences to elicit various laryngeal behaviors, and/or running speech for at least 20 s in duration.

In this study, three sustained /a/ samples and a reading task were randomly presented to each clinician to judge, and a 25-s delay was provided between samples in order for the clinician to judge the sample and complete the rating scale. The three clinicians used the CAPE–V to rate the client's sustained /a/ and reading samples from before treatment, after treatment, and 1 year after treatment. Interobserver reliability was established and agreement was achieved if the clinicians' scores were within 10% of one another on each parameter of the CAPE–V. For both the sustained vowel and reading tasks, an interobserver concordance level of 91% was achieved.

Acoustic Measurement Protocol

The same samples were used to measure the acoustic parameters of the client's voice before, after, and 1 year after treatment. The sustained vowel acoustic measures taken included fundamental frequency in hertz (F_0) and jitter and shimmer percentages (jitter %, shimmer %). The acoustic parameters measured for the reading task included SFF and speaking frequency range.

The recording of the sustained vowel was approximately 3–4 s in length, and the middle 100 ms portion of each vowel was analyzed. The sentences were marked and analyzed by placing the two cursors around the beginning and end of each sentence and taking an average of the entire production for each acoustic parameter. The beginning marker was placed at the first vocal fold oscillation, and the end cursor was placed at the last vocal fold oscillation determined by making an oscillogram of the recording. All three productions were analyzed, and acoustic parameter results were averaged over all trials.

Treatment Protocol

Diagnostic treatment was administered during the assessment to determine the most effective treatment techniques in reducing the symptoms of muscle tension associated with FD. The client's laryngological report was reviewed to determine if any evidence supported an organic vocal pathology. There was an initial discussion regarding how the client dealt with environmentally stressful situations in order to determine if her emotional responses and coping strategies were linked to her dysphonia.

After assessing the larynx via palpation and determining the existence of MTD, CM was administered. CM (Aronson, 1990) employs a massage and re-organization of the larynx. The technique began by the clinician encircling the client's thyrohyoid space with her thumb and index finger and moving the fingers in a posterior direction until the major horns of the hyoid were located. Light to moderate pressure was exerted in a circular motion over the tips of the hyoid bone. Then this same movement was administered to the thyrohyoid space downward toward the thyroid notch, intending to open the space and essentially reduce the suprahyoid muscular tension responsible for elevating the larynx in a hypertensive state.

After the thyrohyoid space was found and manipulated, the clinician positioned her fingers on the client's superior border of the thyroid lamina. Pressure was provided on the thyroid lamina in a downward direction, pushing down to depress the larynx. At times, the larynx was moved from side to side to assess any improvements in flexibility and general movement of the larynx. At this stage, the client was instructed to keep her head in a comfortable position and not to extend her neck upward or outward in an attempt to accommodate the clinician's hand during manipulation. Once the larynx was depressed, the clinician held the client's thyroid in an optimal position and asked the client to vocalize by humming and by prolonging vowels, noting any change in her vocal quality, pitch, or

loudness. If the client's voice began to improve in terms of clarity, voice quality, pain reduction, and/or laryngeal height, then an improvement and relief of muscle tension was assumed.

The final stage of the treatment involved continuing the laryngeal manipulation during increasingly difficult speech tasks. Speech tasks graduated from the production of prolonged vowels to rote counting, repeating days of the week, and finally, reading. The ultimate objective was to get the client to accomplish clear voicing and then to remove the clinician's hand slowly until the client was able to maintain the voicing on her own. It should be noted that during repositioning of the thyroid cartilage and downward depression, there was also a massage of the thyroid all the way down the length of the larynx, and then the fingers were repositioned back in the thyrohyoid space once again; this was repeated before the voicing exercises began.

Once the appropriate vocal parameters were achieved, the manipulation ceased and the client attempted the new vocal production without the aid of the CM. Postacoustic measures and perceptual ratings were taken to determine the effect of the manipulation during the evaluation. The evaluation was completed within 2 hr. Exactly 1 year after treatment, the client returned and the same acoustic measures and perceptual ratings were taken in the same room under the same conditions.

Statistical Analysis

Descriptive and inferential statistics were used to analyze the perceptual and acoustic data for each measure. Trial means and standard deviations were calculated for measures obtained for each of the perceptual rating criteria and acoustic parameters. The trial means were used to calculate group means and standard deviations for all measures. The group means were entered into the SPSS statistical analysis software program (SPSS, 2006). Analysis of both perceptual and acoustic measures included using paired *t* tests to compare means and to determine any differences between the pre, post, and post 1–year treatment perceptual measures (overall severity, roughness, breathiness, strain, pitch, and loudness) and acoustic measures (fundamental frequency, SFF, jitter %, and shimmer %).

The probability level for all comparisons was set at $p < 05$. A Bonferroni adjustment was completed to adjust the alpha level of each individual test and decrease the risk of a Type I error. After completing the Bonferroni adjustment, the alpha level for each *t* test was .00166. Interobserver reliability estimates were established for the perceptual ratings of severity. Interobserver ratings were considered to be in agreement if clinicians' severity ratings were within 10% of each other on each individual parameter of the CAPE–V. For both the sustained vowel production and reading task. Pearson product–moment *r* correlation coefficients were completed to determine correspondence levels.

RESULTS

Interview and Case History

The initial interview indicated that the client's voice quality had not changed since her first vocalization at approximately 18 months of age. The client's mother described the client's voice as always being high in pitch, soft, and breathy. There was also no noticeable change throughout the day, and it was often difficult to hear her voice as it was extremely soft (i.e., low vocal loudness). Questions that probed psychosocial development, stress, and anxiety revealed that the client was a high achiever and often became upset if she did not achieve success in her daily routine of activities. The client and her parents, friends, and teachers were aware of her deviant vocal quality. Medical history indicated asthma and allergies, for which Flovent Albuterol was taken. The client was also treated for urethra reflux as an infant and had spinal meningitis. There were no other activities or information given in the history that were pertinent to the FD diagnosis.

Upon palpation of the client's larynx, a moderate level of extrinsic laryngeal tension was appreciated, especially in the thyrohyoid and suprahyoid spaces. Her larynx was elevated more than expected for a child of her age. The client also raised her shoulders when she initiated voicing of any kind and had difficulty in lowering them when prompted or physically maneuvered (i.e., holding down her shoulders during voicing). The client exhibited this same behavior when asked to produce a sustained phonation and during every reading task. When asked to increase vocal loudness, the client was unable to and raised the pitch of her voice instead. The client was very compliant in the evaluation and performed all tasks as instructed during the assessment and manual manipulation of the larynx.

Perceptual Evaluation

Three clinicians used the CAPE–V perceptual rating scale to rate the digital recordings of the client's vocal characteristics during production of sustained vowel /a/ and a reading task.

For the sustained vowel production task, the client's overall vocal quality severity was significantly lower after treatment, $t = 15.571$, $p < .001$, and 1 year after treatment, $t = 18.478$, $p < .000$, when compared to pretreatment. Breathiness also decreased after treatment, $t = 38.105$, $p < .000$, and 1 year after treatment, $t = 35.403$, $p < .000$, as did pitch ($t = 47.128$, $p < .000$ after treatment and $t = 31.912$, $p < .000$ 1 year after treatment). There was no difference in the perception of strain after treatment, $t = 9.696$, $p < .002$, and 1 year after treatment, $t = 4.276$, $p < .023$. Loudness was perceived to increase after treatment, $t = 27.360$, $p < .000$, and 1 year after treatment, $t = 19.247$, $p < .000$. When comparing posttreatment sustained vowel production perceptual measures to 1 year after treatment, it was found that there were significant decreases in overall severity, $t = 19.667$, $p < .000$, but no change in breathiness,

$t = -3.181$, $p < .050$, strain, $t = -5.019$, $p < .015$, pitch, $t = 1.711$, $p = .186$, or loudness, $t = -7.667$, $p < .005$.

For the reading task, the client's overall vocal quality severity was significantly lower after treatment, $t = 30.115$, $p < .000$, and 1 year after treatment, $t = 44.738$, $p < .000$, when compared to pretreatment. Breathiness also decreased after treatment, $t = 35.058$, $p < .000$, and 1 year after treatment, $t = 153.014$, $p < .000$, as did pitch ($t = 35.666$, $p < .000$ after treatment and $t = 82.000$, $p < .000$ 1 year after treatment). Strain was also perceived as decreasing 1 year after treatment, $t = 34.857$, $p < .000$, compared to pretreatment, but no difference was found when comparing pre- and posttreatment, $t = 11.110$, $p < .002$. Loudness was perceived to increase after treatment, $t = 35.707$, $p < .000$, and 1 year after treatment, $t = 58.869$, $p < .000$. When comparing posttreatment reading perceptual measures to 1 year after treatment, it was found that there were significant decreases in overall severity, $t = 29.698$, $p < .000$, breathiness, $t = 11.350$, $p < .001$, and pitch, $t = 45.696$, $p < .000$; an increase in loudness, $t = 17.299$, $p < .000$; and no difference in strain, $t = 7.937$, $p < .004$.

Mean scores are reported in Tables 1 and 2 for the sustained vowel /a/ and reading tasks, respectively. The scores presented in Table 1 and 2 are averages of the three clinicians' ratings of the client's voice. For both the sustained vowel production and the reading task, an interobserver correspondence was calculated. The correspondence value was 93% for the sustained vowel production and 97% for the reading task (see Table 3). The posttreatment measures were taken after 2 hr of CM within the diagnostic session. Post 1–year treatment measures were taken 1 year from the time of the initial evaluation, which included more than 4 months of speech treatment using CM as well as other treatment methods, such as vocal hygiene training and pitch biofeedback training on the Real Time Pitch Program (Kay Elemetrics, 2000b).

Acoustic Evaluation

Pretest measures included three trials of a sustained vowel /a/ and reading four sentences from the CAPE–V (see the Appendix). Results indicated that the client's fundamental frequency and jitter and shimmer percentages were significantly lower immediately after and 1 year after treatment for both the sustained vowel production and the reading task as compared to pretreatment (see Figures 1 and 2).

During the sustained vowel production, fundamental frequency showed statistically significant decreases when comparing pre- and posttreatment means, $t = 67.066$, $p < .0001$, and pre and post 1–year treatment means, $t = 60.053$, $p < .0001$. During reading, fundamental frequency also decreased when comparing pre- and posttreatment means, $t = 81.113$, $p < .0001$, and pre- and post 1–year treatment means, $t = 85.230$, $p < .0001$.

During the sustained vowel task, jitter, or the cycle-to-cycle variations in frequency of vocal fold vibration, were measured and showed statistically significant decreases when comparing pre- and posttreatment means, $t = 2.853$, $p < .0001$, and pre and post 1–year treatment means, $t = 2.133$, $p < .0001$. Shimmer was also measured during the sustained vowel production and demonstrated a statistically significant decrease when comparing pre- and posttreatment means, $t = 3.12$, $p < .0001$, and pre and post 1–year treatment means, $t = 3.69$, $p < .0004$.

It should be noted that the pretreatment fundamental frequency was measured initially as being within normal range for the client's age and sex; however, it did decrease during the diagnostic treatment and was rated as perceptually within normal limits on the CAPE–V only after CM was administered. Combined with her breathy quality and higher perturbation measures, the client's pretreatment voice was acoustically and qualitatively dysphonic. The post 1–year treatment measures indicated an elevation in all acoustic parameters taken compared to the measures taken after 2 hr of treatment but were still statistically different when compared to the pretreatment results. These results indicated that with the initial CM treatment session and 4 months of voice treatment, with various techniques administered, the client maintained normal vocal quality.

DISCUSSION

The purpose of this study was to investigate how the manual tension reduction technique of CM normalized perceptual ratings and acoustic measures of voice in a child who had been diagnosed with FD. Based on the results, it appears that CM improved the overall quality of the client's voice and normalized her fundamental frequency and perturbation measures in one diagnostic treatment session. Also, the client was able to maintain posttreatment vocal quality and normal acoustic performance 1 year later. It should be

Table 1. Group means and severity levels for the Consensus Auditory–Perceptual Evaluation of Voice (CAPE–V; ASHA Special Interest Division 3, 2006) perceptual rating parameters for the sustained vowel /a/ production task before, after, and 1 year after treatment.

Characteristic	*Pretreatment score*	*Pretreatment severity rating*	*Posttreatment score*	*Posttreatment severity rating*	*Post 1–year treatment score*	*Post 1–year treatment severity rating*
Overall severity	63%	Moderate-Severe	35%	Mild-Moderate	21%	Mild
Roughness	0%	Within normal limits	0%	Within normal limits	0%	Within normal limits
Breathiness	64%	Moderate-Severe	20%	Mild	25%	Mild
Strain	24%	Mild	11%	Mild	16%	Mild
Pitch	75%	Severe	23%	Mild	20%	Mild
Loudness	83%	Severe	25%	Mild-Moderate	31%	Mild-Moderate

Table 2. Group means and severity levels for the CAPE–V perceptual rating parameters for the reading task before, after, and 1 year after treatment.

Characteristic	*Pretreatment score*	*Pretreatment severity rating*	*Posttreatment score*	*Posttreatment severity rating*	*Post 1–year treatment score*	*Post 1–year treatment severity rating*
Overall severity	75%	Moderate-Severe	32%	Mild-Moderate	11%	Mild
Roughness	0%	Within normal limits	0%	Within normal limits	1%	Within normal limits
Breathiness	77%	Severe	22%	Mild	4%	Within normal limits
Strain	22%	Mild	10%	Mild	0%	Within normal limits
Pitch	86%	Severe	33%	Mild-Moderate	5%	Within normal limits
Loudness	86%	Severe	44%	Moderate	10%	Mild

noted that even though the client may have made significant gains during the evaluation, she received additional treatment for 4 months after the initial evaluation session. This treatment focused on CM; increasing awareness through discussions of appropriate hygiene; bridging vocal exercises such as yawn-sigh, chant talk, and vocal easy onsets; and other techniques to decrease muscle tension and improve easy contact of the vocal folds. These techniques were facilitated through the use of age-appropriate treatment activities that involved puppets, biofeedback with computer applications, and other similar activities. The results of the follow-up 1 year later could have been affected by the additional treatment as well as the CM; however, all techniques reinforced appropriate vocal behaviors.

It seems reasonable to assume that maintenance of the client's current vocal quality can be attributed to both the initial CM diagnostic session and the treatment after evaluation. The vocal improvement in the initial session appears to have occurred rapidly and therefore can be attributed directly to use of the manual tension reduction technique only. The CAPE–V demonstrated that three independent clinicians heard a significant improvement in the client's voice after one session and also after long-term follow-up. Also, CM altered the client's acoustic measures, such as decreasing her fundamental frequency, jitter, and shimmer and returning her vocal parameters to normal levels in the sustained vowel production. Her SFF also decreased during reading (i.e., jitter and shimmer cannot be measured during reading). Past studies have confirmed that CM improves a client's voice quality and resonance; normalizes fundamental frequency; increases pitch range; and decreases hoarseness, pain, and discomfort (Roy, Bless, et al., 1997; Rubin, Lieberman, & Harris, 2000).

Tips for Successful CM

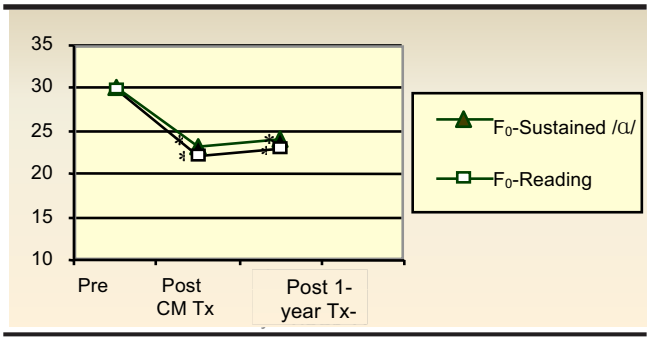
Manual tension reduction in most clients can be beneficial in obtaining improved voice quality; however, there are specific indications that may be helpful in identifying when CM may be most useful. Before initiating CM in clients, there are basic physiological markers that should be witnessed in clients to determine if FD or MTD is causing musculoskeletal tension. First, the height of the larynx in the neck should be assessed as well as palpation of the suprahyoid muscles that suspend the larynx, such as the mylohyoid, stylohyoid, geniohyoid, hyoglossus, and diagastric muscles. When these muscles are found to feel taut (i.e., similar to bunched rubber bands), and the larynx is being held in a high position in the neck, then muscle hyperactivity is likely (Rubin et al., 2000). In 1991, Koufman suggested that infrahyoid muscles should also be palpated in the event that the client is "anchoring" the larynx too low (Koufman & Blalock, 1991). This positioning was found in one of his clients, and he termed the pattern "the Bogart-Bacall syndrome." The low-pitched voice was the result of this low laryngeal positioning (Koufman & Blalock, 1991). Other examination components include palpating the thyrohyoid space, checking alignment of the hyoid bone to the spinal column, deciding if there is adequate spacing of the cricoid and thyroid at rest, determining if adequate excursion of the cricothyroid mechanism occurs during a pitch range exercise, and determining the ease of moving the larynx laterally (Rubin et al., 2000).

Rubin et al. (2000) suggested that being able to move the cricothyroid joint freely aids in pitch manipulation. In cases where there is a repetitive injury, such as using muscle groups inappropriately, the muscles shrink and may become fibrosed, scarred, and painful when palpated (Rubin et al., 2000). The theory of CM is centered on the idea that by working these muscles and joints, the scar tissue will be stretched, the muscle belly will be lengthened, blood flow will increase to the muscle, and joint mobility will improve. The other important goal of CM is to improve the client's awareness of poor alignment of the larynx and cause him or her to adopt new musculoskeletal patterns of movement. In various studies, when CM was used in clients with FD,

Table 3. Mean, standard deviation, and significance levels for pre, post, and post 1–year treatment ratings of the CAPE–V overall severity index.

	Pretreatment		*Post treatment*		*Post 1-year treatment*		*Significance level*
Speech task	M	SD	M	SD	M	SD	α
Sustained vowel /a/	62%	2%	36%	2.4%	20%	1.4%	$p < 0.0001$
Reading	75%	3%	34%	3.5%	12%	2%	$p < 0.0001$

Figure 1. Fundamental frequency (F_0) in hertz measured during a sustained /a/ production and reading task before, after, and 1 year after treatment.



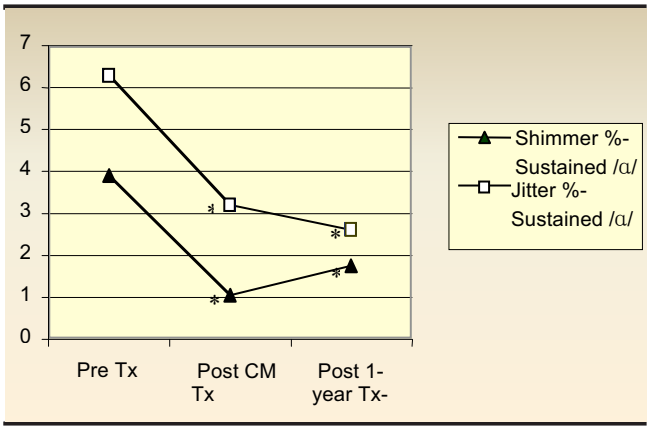
Note. CM = circumlaryngeal massage, TX = treatment.

*Indicates statistical significance at $\alpha \leq .05$ when compared to pretreatment measures.

immediate and long-term improvements were achieved (Roy, Bless, et al., 1997; Rubin et al., 2000), and clients reported improved stamina, vocal flexibility, and range (Rubin et al., 2000).

Aronson (1990) and others (Lee & Son, 2005; Roy & Leeper, 1993) suggested that there is a link between increased laryngeal muscle tension and the symptoms of FD. Although these studies have not tested muscle tension values through objective means, it can be speculated that vocal changes after massaging tense muscular regions could be related to the CM technique and its ability to reduce tension. They suggest that changes due to CM and other tension reduction techniques may be due to reducing laryngeal muscle tension, but results are inconclusive as other factors seem to play a role when considering long-term treatment. However, it seems more likely that the positive outcome reported in a single treatment session (Roy & Leeper, 1993), including this client, can be attributed to the reduction of musculoskeletal tension alone. Chronic, unresolved psychological difficulties in certain clients seem to impede decreased tension using CM as opposed to others who seem to resolve their psychological issues and benefit from the approach (Roy & Leeper, 1993).

Figure 2. Perturbation measures taken during a sustained /a/ production before, after, and 1 year after treatment.



Note. CM = circumlaryngeal massage, TX = treatment.

*Indicates statistical significance at $\alpha \leq .05$ when compared to pretreatment measures.

In the current study, although there was some evidence of increased stress and anxiety in some situations, overall, this child did not report excessive stressful events that would have been severe enough to cause this vocal response. In addition, it was reported that the client's voice had not changed since vocalization began at a very young age. These results can lead us to conclude that muscular tension may have been the main cause of the FD, not psychological issues. Certainly, there is a complex relationship between psychological states and physiological responses that contribute to FD, but in this case, there were more indicators leading us to an etiology of muscle tension rather than psychological issues.

Future Studies

In order to identify the causes of FD, more controlled studies are necessary to identify the precursors of FD before acquisition of symptoms and identify life stressors that induce laryngeal tension. Roy, McGory, et al. (1997) cited other complicating factors in recent manual reduction treatment studies as a lack of control groups, objective measures of laryngeal muscle tension, psychological effects of treatment including placebo effect, increased confidence and experience with the clinician, and the treatment protocol. Aronson (1990) indicated that an assessment of laryngeal tension through palpation of the larynx should be undertaken for each client to determine the presence of muscle tautness/tension and be a focus of treatment. He further described that improvements in vocal quality are directly proportional to a reduction in laryngeal musculoskeletal tension and lowering of the larynx in the neck. Roy, McGory, et al. reported that evidence of this correlation was found in 88% of their clients through a reduction of laryngeal pain and tenderness after massage. This evidence is still debatable as objectifying measures were not taken. However, it does support the overall hypothesis of reduction of laryngeal tension directly improving symptoms of FD, including pain, tenderness, and dysphonia.

Further studies are required that objectively measure muscle tension, such as electromyography (EMG). Surface EMG has been used to determine muscle activity in vocal fold studies (Young, 2001). Young and Russell (2000) used surface EMG to study the effects of CM on singers with vocal fatigue and to measure changes in muscle activity before and after treatment. They found that surface EMG voltage decreased significantly after using CM in one session and further decreased after multiple treatment sessions, indicating that the treatment reduced muscle activity in the laryngeal region. Further studies using EMG to measure muscle activity are necessary with clients with FD. Lee and Son (2005) found that voice treatment improved vocal quality in their pediatric clients with MTD and altered their voice characteristics. Lee and Son further commented that pitch abnormalities may be caused by hyperfunctioning

vocal folds and excessive vocal effort during speaking.

There are other aspects to consider when performing manual tension reduction techniques on young children, such as the decreased size of the larynx, especially the thyrohyoid space. This space is occasionally so narrow that it is difficult to manipulate. The larynx is also normally elevated in children's necks until they grow older and the larynx descends. It is difficult to decide if the larynx height is normally positioned or elevated due to muscular tension. However, presenting dysphonia without visible organic lesions is a sign of muscular tension paired with elevated laryngeal height and a small thyrohyoid space. Another indicator that muscular tension is present is that through manual tension reduction, the thyrohyoid space increases in width and the larynx begins to descend naturally. The descent is typically very small and noticeable only to the clinician who completed the manipulation of the larynx. Overall, the improvements in the perceptual and acoustic parameters of voice indicate that the dysphonia was markedly reduced in the first evaluative session and was maintained over time.

Past studies have all demonstrated the value of CM in reducing dysphonia in children and adults with FD and MTD. Evidence to support the continued research of these techniques is warranted as control group studies as well as increasing the number of participants. Also, determining psychological anxiety and stress interactions to the presenting dysphonia seem important to determining the etiology of FD as well as the physical repercussions to voice. Although this study reviewed a single client's success using the CM approach, the results seem to agree with the current literature on the use of CM as a proven method of reducing the symptoms of FD in children.

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APPENDIX. CONSENSUS AUDITORY–PERCEPTUAL EVALUATION OF VOICE (CAPE–V) STIMULI SENTENCES FOR CONNECTED SPEECH TASKS

1. "The blue spot is on the key again."
2. "How hard did he hit him?"
3. "We were away a year ago."
4. "We eat eggs every Easter."

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