Laryngeal Manual Therapy: a preliminary study to examine its treatment effects in the management of muscle tension dysphonia

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Abstract

Objectives/Hypotheses
The objectives of this study were to determine appropriate acoustic and outcome measures for the evaluation of a method of laryngeal manual therapy (LMT) used in the treatment of patients with muscle tension dysphonia (MTD). The effects of this technique was also investigated. The study was based on the hypotheses that the vertical position of the larynx in the vocal tract would lower, that the quality of the voice would normalize, and that a reduction in any vocal tract discomfort would occur following LMT.

Study design
This was a small, prospective, repeated measures pilot study in which each member of the research team was 'blinded' to all other stages of the study and during which all data were anonymized until the final stage of data analysis.

Methods
Ten subjects presenting with MTD completed outcome measures and provided audiorecordings immediately before, immediately after and one week after LMT. The Kay CSL 4150 was used for acoustic and spectrographic measurements. A new perceptual, self-rating scale, the Vocal Tract Discomfort Scale, and a new proforma for use by the clinician for palpatory evaluation, were developed for the study.

Results
Relative average perturbation during connected speech was significantly reduced following LMT, indicating a reduction in abnormal vocal function. The severity and frequency of vocal tract discomfort was shown to have reduced following LMT.

Conclusions
This pilot study showed positive evidence for laryngeal manual therapy as a method of therapy in the treatment of hyperfunctional voice disorders. Its effects were shown to be measurable with both acoustical analysis and the Vocal Tract Discomfort scale.

Key words*:* laryngeal manual therapy, Vocal Tract Discomfort Scale, muscle tension dysphonia, palpatory evaluation

Introduction

Hyperfunctional phonation is characterized by excessive phonatory effort [1, 2]. The muscle effort involved can be apparent throughout the vocal tract so that the articulatory muscles, the extrinsic and intrinsic laryngeal muscles and the size and shape of the resonators are affected. This inappropriate vocal behaviour places undue physical stresses on the anatomy and physiology of the vocal tract, causing undesirable changes in its function and, in some cases, trauma to the vocal folds. The voice disorders arising from excessive phonatory effort are currently frequently referred to as muscle tension dysphonias (MTD). The resulting dysphonia can range from intermittent and mild to chronic and severe. MTD can be divided into two groups: 1) MTD without changes to the vocal fold mucosa and 2) MTD resulting in and presenting with vocal fold lesions[3].

It is also recognized that MTD can be both a primary and secondary feature of voice disorders[3]. Excessive phonatory effort, therefore, can be the initial cause of MTD with and without vocal fold lesions. The aetiology of primary MTD can be multifactorial, with some factors predominating. Contributory factors can include a vocally high-risk occupation or social life, psychosocial and sociolinguistic issues, vulnerability following a respiratory tract infection, inadequate vocal skills and anatomical and physiological issues. MTD is also evident as a secondary, and compounding, feature of a range of voice disorders of both behavioural and organic aetiology. Secondary MTD is usually the result of the speaker's attempts to compensate for vocal deficiencies affecting voice quality, volume and paralinguistic vocal features, all of which compromise communicative efficiency. In many instances, the speaker attempts to increase vocal loudness using excessive effort.

Laryngeal Manual Therapy

Aronson[4] described manual treatment for the reduction of musculoskeletal tension associated with vocal hyperfunction in 1990. Subsequently, a number of practitioners from various disciplines, including speech pathology [5,6,7,8,9,10], osteopathy [11] and physical therapy, have developed manual therapy techniques designed to be used in the treatment of voice disorders. As a result manual therapy is being used increasingly in the treatment of muscle tension dysphonia (MTD) and the emerging literature is beginning to provide an evidence-base for the effectiveness of these approaches. Inevitably, the methods of manual therapy employed by practitioners from different disciplines vary according to the professional backgrounds from which the techniques emanate. Observation suggests that the manual therapy for the treatment of voice disorders which is undertaken by osteopaths and physical therapists is more vigorous than the method described in this paper.

The primary aim of manual therapies in the perilaryngeal and laryngeal area is to relax the excessively tense musculature which inhibits normal phonatory function. Aronson[4] maintained that in cases of vocal hyperfunction resulting from musculoskeletal tension, the larynx and hyoid bone are elevated. This feature appears to predominate in individuals presenting with MTD but clinical observation suggests that this is not always the case. As Roy and Ferguson [12] have indicated, it can be presumed that the extrinsic laryngeal muscles that raise the larynx also affect the way in which the vocal folds vibrate [13,14]. These authors also make reference to the fact that vertical laryngeal position can be presumed to influence phonatory function by altering control over the length, tension and stiffness of the vocal folds, thus contributing to the disturbance of voice quality[15, 16.] Consequently, it can be deduced that strategies directed at relaxing the excessively tense perilaryngeal musculature might improve glottal source function. Laryngeal manual therapy(LMT), of which there is a detailed a description in Appendix B, is directed chiefly at the stenocleidomastoid muscles at the start of the intervention and, subsequently, at the supralaryngeal area. The rationale for targeting these areas, and in this order, is based on the clinical observation that in many patients presenting with muscle tension dysphonia the sternocleidomastoid muscles are excessively tense. Although these accessory muscles are not directly related to laryngeal function, patients frequently complain of stiffness and tenderness of these muscles which has developed in association with their voice disorders. Clinical experience suggests that massage of these muscles lateral to the larynx reduces this tension, thereby reducing the patient's discomfort, and consequently their distress and anxiety, at an early stage of the intervention. Intervention involving the supralaryngeal and laryngeal areas appears to be facilitated as a result. Subsequent kneading, and consequent softening, of the supralaryngeal area allows the high-held larynx to lower. It can also be observed that the normal range of laryngeal vertical excursions, which have been inhibited while the larynx has been held in a raised position, return during connected speech and singing.

Within the field of voice pathology, manual circumlaryngeal therapy[5,6,7,12] has been shown to result in consistent improvement in patients with "functional dysphonia" across perceptual and acoustic indices of vocal function, immediately after treatment and during the follow-up period. Based on the technique of laryngeal musculoskeletal reduction originally described by Aronson [4], manual circumlaryngeal therapy differs from the method of LMT described in this paper (Appendix B) in certain fundamental aspects, although there are also similarities in approach. The variations and similarities in the two techniques are summarized in Table 1. The main differences consist of whether or not a) patients self-rate their vocal tract discomfort prior to intervention, b) palpatory evaluation is conducted by the clinician before or during the procedure, c) the active intervention is carried out using chiefly both hands or one hand and d) whether or not the patient is asked to vocalize after or during manual therapy. A notable distinction between the approaches is that whereas Aronson's technique and manual circumlaryngeal therapy address a diminished thryohoid space by circular massage in that area, LMT does not. The rationale for not working on this area is that clinical experience suggests that following massage, kneading and stretching of the perilaryngeal musculature during LMT, as described in Appendix B, the thyrohyoid space enlarges spontaneously as the musculature becomes more relaxed and the larynx lowers.

INSERT TABLE 1 –LMT and MCT – ABOUT HERE

Massage of tense, painful muscles has long been recognized as a method of relaxing them and reducing discomfort [17]. The term Laryngeal Manual Therapy (LMT) has been employed throughout this study as it is an 'umbrella' term which can be used to refer to any therapeutic handling of the laryngeal and perilaryngeal structures by a clinician. In this study it is used to cover the massaging, kneading and stretching of the perilaryngeal musculature involved in this particular method of manual treatment. The term LMT is also used in order to avoid confusion with the techniques used in "manual circumlaryngeal therapy" [5,6,7,12] and in order to avoid the use of the word "manipulation", which falls within the vocabulary used to describe particular techniques employed by osteopaths. The LMT technique used in this study has been developed primarily for use by voice pathologists, with the intention that it should be minimally invasive and maximally effective. The pre-treatment palpatory evaluation and LMT are described in detail in Appendices A and B.

Vocal Tract Discomfort

Clinical experience suggests that a significant number of patients who present with MTD also experience vocal tract discomfort. Not only is this unpleasant in itself but it frequently gives rise to unfounded fears of serious underlying pathology, particularly laryngeal cancer. Pain has been defined by the International Association for the Study of Pain as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage". Pain, inevitably, is a subjective experience which is private to the sufferer. Consequently, it is difficult to assess and measure. It is reasonable to assume, however, that *discomfort* is low level pain on a scale of 'no pain' to 'unbearable pain'. Although the quantification of pain is complex, it can be presumed that most people can state reliably whether or not they are experiencing discomfort.

The Vocal Tract Discomfort Scale (VTD scale) (Fig.1) is being developed as a tool to quantify the severity and frequency of an individual's throat discomfort, using qualitative descriptors. It is a patient self-rating scale which is completed by the patient prior to the palpatory evaluation undertaken by the clinician and after LMT. Consequently, its findings reflect the patients' perceptions of their vocal tract discomfort, not the findings of the palpatory examination conducted by the clinician. (The palpatory evaluation described in Appendix A is used by the clinician to assess muscle resistance and not degrees of tenderness or discomfort.)

An earlier study was conducted in 1993 by the first author [18] in order to investigate the relationship between hyperfunctional dysphonia and vocal tract discomfort in a group of 36 patients (age range7-59 years, mean age 35years, 21 females, 15 males) who attended a combined ENT/voice pathology Voice Clinic over a 6-month period. Seventy-two per cent of the patients were diagnosed as exhibiting hyperfunctional dysphonia. This retrospective study sought to investigate a) the incidence of vocal tract discomfort in a group of patients presenting with hyperfunctional dysphonia, b) the qualitative differences in the discomfort experienced and c) the link between discomfort and vocal fold mucosa changes. Prior to treatment all patients had been asked to select items from a list of terms which had been found previously to be those used frequently by patients attending the voice clinic to describe their throat symptoms spontaneously. All patients were fluent speakers of English. The list of descriptors given to patients was: "tickling, burning, soreness, aching, tightness". The terms "choking", "pain" and "other" were also included. Sixty-two per cent of the survey group confirmed vocal tract discomfort by marking one or more of the first five terms; most patients ticked two descriptors. No member of the group ticked "choking","pain" or "other". Vocal fold mucosa changes were evident in 56% of the group while 44% exhibited no changes in the vocal fold mucosa. Most patients with discomfort experienced both "aching" and "soreness". Those with mucosal changes complained of "soreness" three times more frequently than those with no mucosal changes. This relationship was inverted for patients recording "aching"; those without mucosal changes complained of "aching" three times more frequently than those with mucosal changes. Eight per cent more patients with mucosal changes experienced coexisting "aching" and "soreness" than those without tissue changes. Following this study, further monitoring of the descriptors of throat discomfort used routinely by patients resulted in the terms "irritable", "dry" and "lump in the throat" being added to the list and "choking", "pain" and "other" being removed. An early version of the Vocal Tract Discomfort scale was published in 2001[3]. The current version (Fig 1) allows the patient to self-rate the frequency and severity of the symptoms separately.

INSERT FIGURE 1 Vocal Tract Discomfort Scale ABOUT HERE

It is can be surmised that the descriptors “dry, tickling, irritable, burning and sore” refer to sensations related to the mucosa of the larynx and hypopharynx; possibly inflammatory changes or tissue damage. The terms “tight, aching and ‘lump in the throat’” can be presumed to relate to musculoskeletal discomfort. Discomfort arising from tightening and bunching of muscle fibres through overuse or postural strain is well recognized [19]. It is also understood that such discomfort does not necessarily represent a symptom of tissue damage but that it is an essential feature of a disorder of function of the pain system as a whole, involving both peripheral and central mechanisms of the nervous system. Ergonomic considerations and physical therapies are regarded as the mainstay of intervention for this type of musculoskeletal discomfort. Massage of the perilaryngeal musculature, therefore, is directed at reducing the tightening and bunching of the muscles with the aim of reducing or eliminating discomfort and improving phonatory function. Clinical practice suggests that dealing with patietns’ discomfort effectively at an early stage of treatment increases their confidence in the clinician and facilitates their response to further intervention.

Acoustic measurements
A wide range of acoustic measures (Table 4) was used in this study in order to fulfil the aim of identifying which might be the most effective in evaluating LMT.

As changes in formant frequencies occur as a result of changes in vocal tract length, it was decided that these should be analysed and monitored over time. The frequency of all formants lowers as the length of the vocal tract increases [20] and it is possible that this would be reflected in instances where the larynx is lowered. The fact that oral (both anterior and posterior) and pharyngeal constriction can affect F1 and F2 simultaneously and individually needs to be considered in interpretation of the results. A study by Roy and Ferguson [12] investigated formant frequency changes following manual circumlaryngeal therapy for functional dysphonia. Roy had conducted previous studies supporting the efficacy of circumlaryngeal therapy[5,9] and was subsequently seeking to establish objective evidence to confirm physical changes, such as lowering of the larynx, which are associated with successful management of functional dysphonia. The study of 75 subjects showed, on formant frequency analysis, that there was lowering of the first three formants, thus confirming the hypothesised decrease in laryngeal height and lengthening of the vocal tract following intervention.

Hypotheses
The study was based on the hypotheses that:

1. LMT results in a change in the vertical position of the larynx in the vocal tract. Change, if any, in vocal tract length following LMT will be reflected in the frequencies of the vowel formants.
2. the quality of the voice (that is, the glottal source) will normalize following LMT and that the changes will be apparent in various parameters on acoustic analysis.

3. LMT reduces or eliminates the vocal tract discomfort (VTD) which can accompany MTD.

Aims
The aims of the study were:
1. to determine appropriate measures that would enable the authors to establish or refute the benefits of a method of LMT which clinical experience suggested might be effective in the treatment of patients with MTD.
2. to assess the effectiveness of the intervention which used a method of LMT which is within the knowledge base and skill set of speech-language pathologists who specialize in the treatment of patients with voice disorders.

Methods
Design and Participants
This repeated measures pilot study involved 10 patients, 2 males and 8 females, whose ages ranged from 19–55years, with a mean age of 30.3 years. All presented with MTD which had been diagnosed in a multidisciplinary voice clinic by a consultant ENT surgeon using videostrobolaryngoscopy. The subjects presented with primary MTD; there was no evidence of laryngeal lesions nor of neuropathology affecting the larynx. Each patient's dysphonia was rated by the ENT surgeon as mild, moderate or severe. The subjects were selected sequentially as they presented in the clinic and all had a negative history for senescent frailty, cervical injury, cardiovascular disorder. None had received any voice therapy previously nor was any other method of intervention undertaken either prior to or concurrently with LMT Each participant completed outcome measures and individual audiorecordings were made by a research assistant immediately prior to each patient's LMT session, immediately after this session and then one week later.

Each member of the team conducting this study was 'blinded' to all other stages of the study and all data were anonymized until the final stage of data analysis.

INSERT TABLE 2 LMT study subjects ABOUT HERE

Acoustic measurement protocol
One of the aims of the study was to determine which measures, including acoustic measures, might be most useful in evaluating LMT. Consequently, a range of acoustic measures was used. Although not well-validated, the belief has clinical currency that these measures reflect different types of phonatory dysfunction. As that belief has currency in the vocology world, it was decided that examination of a range of measures would identify the best measures.

Subject recordings were made in a quiet room with a consistent gain recording level using a headset-mounted AKG 420 MC Phantom microphone (mouth-microphone distance of 15cms) and the Kay CSL 4150 analysis system. Some acoustic measurements were accomplished with the Laryngograph with Speech Studio software. Subjects were instructed to a) "sustain /ɑ:/ at a comfortable pitch for as long as you can"; b) read a shortened (approximately 60 seconds) version of the standard passage, "Arthur the Rat".

Formant frequency analysis

INSERT FIGURE 2 ABOUT HERE

A 0.25 s segment of the sustained /ɑ:/ beginning at 1 s after vowel onset was selected for formant quantification using Praat [21]. Delaying analysis until a second after the start of the vowel avoided transient phenomena commonly associated with phonatory initiation. Quality of the sound pressure material was evaluated by visual inspection of an oscillogram and a sound spectrogram using 6 dB/octave pre-emphasis (low frequency 3 dB point = 50 Hz) and a 50 Hz filter bandwidth (Figure 2). All samples were anonymized to conceal both subject name and sample type (pre- or post-therapy) from the technician. Acceptability criteria included stability of mean sound pressure and F_0 for the duration of the segment, and minimal variability of the estimates of each of the first two formant frequencies (the only ones used in the present study) derived by Praat's "Burg" algorithm within the selected segment. If the analysis window beginning at 1.0 s did not meet these criteria the analysis was performed for the nearest 0.25s segment that did comply.

For the formant analysis, the Praat system was set for a window length of 0.025 s, with an automatic time step determination (the default condition for Praat). A maximum number of 5 formants was permitted, with a maximum formant frequency of 5.5 kHz. Formant frequency resolution was calculated to be approximately 52 Hz. Praat computes the formant frequencies for every time step within the selected analysis segment. These values were saved to disk and the means and standard deviations derived.

Vocal Tract Discomfort Scale

Subjects completed the Vocal Tract Discomfort Scale immediately before LMT, immediately after and then one week later. The frequency section was not completed immediately post-LMT as no change in frequency could be judged at this stage.

The VTD scale is a self-rating scale which enables patients to record the frequency and severity of their vocal tract symptoms. Patients complete the VTD scale on their own, without comment from the clinician. (The VTD scale is entirely separate from the palpatory evaluation which is the clinician's record of his or her findings concerning muscle resistance, prior to intervention with LMT.)

Laryngeal Manual Therapy

Palpatory evaluation of the perilaryngeal musculature was carried out prior to LMT. This process is described in detail in Appendix A. The purpose of the palpatory evaluation is to determine the degree of muscle resistance and the height of the larynx in the vocal tract, prior to embarking on laryngeal manual therapy. Its findings guide the clinician embarking on intervention. It is not related to the terms used in the patient self-rating scale of Vocal Tract Discomfort. As expected, all patients within the study group experienced some discomfort on palpation which they reported in response to questioning as each area was palpated. In these subjects, higher levels of discomfort related to higher levels of muscle resistance. Clinical experience indicates that this is not always the case.

The resistance of the sternocleidomastoid muscles, the supra laryngeal area and of the larynx to lateral digital pressure was rated on a scale of 1-5, with 5 representing the greatest resistance. In addition, the height of the larynx in the vocal tract was noted. A proforma has been created to record the palpatory findings (Fig.3)

INSERT FIGURE 3 Laryngeal Manual Therapy Palpatory Evaluation ABOUT HERE

The clinical session for each patient lasted for 45 minutes. The patient described his or her voice problem briefly to the speech-language pathologist (the first author) who was to carry out LMT. Explanations were given to the patient about the possible bases of the symptoms. A detailed account of LMT is given in Appendix B. In summary, during the palpatory examination and LMT, each patient was seated on an upright chair with a straight, low back with the clinician standing behind the patient. The LMT consisted of bimanual circular massage of the sternocleidomastoid muscles and kneading of the supralaryngeal area with the fingers of one hand. Circular massage was applied to the hyoid bone, along its length. When the supralaryngeal muscles were less resistant to digital pressure, the larynx was depressed by pressure applied bimanually to the superior edge of the thyroid cartilage. Changes in tension of the perilaryngeal musculature, if any, were monitored by application of alternate lateral digital pressure to the thyroid cartilage. The period of time during which the massage was given varied from patient to patient according to the response to LMT. Massage was terminated when the perilaryngeal musculature had softened and when the larynx could be moved easily from side to side by the application of lateral digital pressure. The time for this stage to be reached ranged from approximately from 5 to 10 minutes of direct LMT, including brief pauses for patients to rest, if necessary.

Statistical Analyses
The SPSS for Windows (v14.0) software package was used for the statistical analyses. Changes in measures over time were tested using repeated measures ANOVA with the Greenhouse-Geisser correction (used as a relatively conservative method of correcting for violations of sphericity in the repeated measures ANOVAs). the Significance levels for p values were set at 0.05, and measures of the strength of association between variables are provided through partial eta-squared (η_p^2) where appropriate. ($\eta_p^2 \approx 0.01$ is a small association, $\eta_p^2 \approx 0.06$ is a medium association, $\eta_p^2 \approx 0.14$ is a large association). Cronbach's alpha was used to evaluate VTD scale reliability at each time point. Cronbach's alphas were calculated separately for the symptom frequencies and symptom severities.

Results
Formant frequency changes over time are shown in Table 3. Figure 4 represents the changes in formants and their standard deviations (SD). Analyses show no changes in any of the four measures which are displayed. However, the effect sizes for the second formant mean, in particular, are quite large and suggest the value of further probing in this direction. The SD graph shows that although there was a fairly large variance in the scores before therapy, this has reduced after LMT and is sustained over time. It is possible that the SD changes are an effect of the treatment.

INSERT TABLE 3 Formant frequency changes over time ABOUT HERE

INSERT FIGURE 4 Formant changes and their standard deviations ABOUT HERE

The first aim of the study, to determine appropriate measures for evaluating LMT, produced promising results in the analysis of connected speech samples(Table 4) The results for the relative average perturbation (RAP) measure show a significant effect and very large effect size. The superscript letters near the mean indicate which scores are significantly different from each other and which are not. Means sharing the same letter denote that they are not significantly different. Thus the RAP measures before and immediately after LMT do not differ but after 1 week the score is significantly lower than both pre- and immediately post-LMT. Although no other variable was significant, the effect sizes for the noise-to-harmonics ratio (NHR), soft phonation index (SPI) and perturbation irregularity (PI), and to a lesser extent DQx1&2, hold promise.

INSERT TABLE 4 – Acoustic changes over time - ABOUT HERE

Cronbach's alphas for the VTD scale symptom frequencies (based on all symptoms) were 0.890 at baseline and 0.893 at one-week follow-up. Cronbach's alphas for the VTD symptom severities (based on all items) were 0.886 at baseline, 0.929 immediately after LMT and 0.935 at one-week follow-up. Table 5 (symptom changes over time) shows that the frequency of throat dryness, tickling, soreness, tightness and irritability changed significantly from pre- to one week post-LMT, as a result of therapy. The severity of tight, dry, tickling and sore sensations are shown to be significantly reduced after LMT. There is a tendency towards recurrence of tightness.

INSERT TABLE 5 Symptom changes over time ABOUT HERE

Table 6 shows mean scores from the palpatory evaluation. The scores for the left sternocleidomastoid muscle, the right sternocleidomastoid muscle and for the supralaryngeal area, and for laryngeal resistance all show significant changes from pre- to post- LMT indicating that muscle resistance was reduced by the intervention. The laryngeal position score is not significantly changed over the therapy session, although the trend indicates that the trend is from relatively high held to neutral.

INSERT TABLE 6 Palpatory evaluation changes over time ABOUT HERE

Discussion

This small pilot study aimed to demonstrate that changes in acoustic and outcome measures might occur as a result of LMT, thus demonstrating the treatment outcomes of this therapy. The results have shown that certain acoustic measures, particularly relative average perturbation in connected speech, can change markedly following LMT. The particular acoustic measures which demonstrated sensitivity to change following LMT are also likely to be generally sensitive to changes occurring in dysphonia following other types of treatment. An aim of this study, however, was to identify acoustic measures which might be most useful in assessing the treatment effects of LMT. As LMT was the only method of intervention used, the investigation satisfied the aim of identifying these measures.

An apparent anomaly is evident in that the palpatory evidence shows changes in the laryngeal position following treatment but the formant data show contradictory evidence. This might be explained by the fact that the palpatory evaluation is undertaken when the patient is at rest and not vocalizing. As the formant data is acquired while the patient is vocalizing, it is possible that patients had a tendency to revert to habitual laryngeal positions during phonation following this initial intervention. The subjective nature of the palpatory evaluation also has to be taken into account and raises the issue of continuing to refine this process.

It should be noted that analysis of formant frequencies over time (Table 3) shows that the F2 mean was elevated following treatment, although the F1 mean was lowered. Baken and Orlikoff[20] attribute a lowered F1 in association with a raised F2 to anterior oral constriction, by elevation of the front of the tongue. The effects on formants of tongue raising (both posterior and anterior), lip rounding and pharyngeal constriction, therefore, must be taken into consideration when considering vocal tract length in relation to strategies designed to lower laryngeal position.

Although the formant frequency data showed no change after treatment, this measure will be included in further studies investigating the effects of LMT because of its apparently sound theoretical base and the trend in this small study which merits further investigation. This view is supported by the larger study carried out by Roy and Ferguson [12], the results of which showed that Aronson's contention that laryngeal position is lowered by manual therapy in the treatment of functional dysphonia was reflected in the lowering of the first three formants.

Future studies might also need to consider the fact that there are a small number of patients with hyperfunctional dysphonia who present with their larynxes held in a forced lowered position. Clinical experience suggests that this tendency generally appears to reflect either sociolinguistic or physiological aetiological factors. The speaker tends to use an unduly low vocal pitch and maintains a pressed lowered mandible, thus forcing the larynx to a lowered position, when talking. These features occur mainly in males; observation suggests that this vocal behaviour is associated with an attempt, of which the speaker is frequently unaware, to convey status and gravitas. During the past two decades, an increasing number of females have been presenting in our clinic with similar features of vocal behaviours. Our experience also suggests that some individuals presenting with laryngopharyngeal reflux (LPR) maintain a similar head posture with forced lowered larynx in an attempt, of which they are frequently unaware until the matter is discussed, in order to inhibit the sensation of gastric reflux. Consequently, investigations of vocal tract discomfort and the treatment effects of manual therapy might need to identify two subgroups: those patients whose larynxes are high-held and those with forced lowered larynxes. In the event of successful intervention, formant frequencies would be expected to lower in the first group, as the larynx is lowered and the vocal tract lengthens, and to rise in the second group as the larynx rises and the vocal tract shortens.

The Palpatory Evaluation protocol will be the subject of further research with the aim of developing it as a useful method for teaching palpatory skills and for use in further investigations. The findings are inevitably subjective but they do not influence the outcome measures of this study of the treatment effects of LMT. It is intended that further research with two or more clinicians undertaking the palpatory evaluation, appropriately ‘blinded’, will investigate inter-rater reliability. Investigations of the appropriate pressure to be used by the clinician during the palpatory procedure will also be considered. Unlike the palpatory procedures employed by physicians in order to assess points of muscle tenderness, as in fibromyalgia, the LMT palpatory evaluation protocol is directed at ascertaining the degree of muscle resistance. The interpretation of resistance will be influenced, among other things, however, by the clinician’s strength. A study of the evaluation of points of tenderness in fibromyalgia, for example, addresses the issue of attempting to train examiners to deliver a 4kg force, monitored by observing the amount and pattern of blanching beneath and around the thumbnail[22]. Although the aim of this examination is different, the refinement of the palpatory process prior to laryngeal manual therapy merits further study.

As this study’s sample size was relatively small, the analyses are under-powered to detect statistically significant changes in the measures taken. Nevertheless the few significant results detected and the effect sizes that correspond with each analysis show the potential clinical significance of LMT on each index. Further sufficiently powered research (that is, with larger samples) is required to enable these measures to demonstrate statistical significance if true changes are occurring.

The Vocal Tract Discomfort Scale (VTD Scale) has been shown to be a useful tool for monitoring change. Consequently, further work will be carried out, *on a larger sample size*, in order to validate this scale which patients found easy to use and which contained the words they required to describe their sensory symptoms. In addition, it is possible that these qualitatively sensitive and specific terms used by fluent speakers of English in England might not be appropriate either in direct translation for speakers of other languages or for speakers of English in other cultures. This aspect of the scale requires further investigation.

As this study and clinical experience suggest that LMT is a useful clinical tool, it follows that it is important that it should be demonstrated that palpation and this LMT technique is a teachable skill. It would be unsatisfactory to show that a technique can be effective in the hands of one clinician without showing that it can be taught, and then used effectively, by other clinicians. Consequently, a small group of voice pathologists has been trained in this method of LMT with the intention of conducting a larger study in which they are the treating clinicians. In addition, 2-day courses are being run on a regular basis in order to train further voice pathologists in the use of LMT.

Conclusions

This pilot study showed positive evidence for laryngeal manual therapy as a method of therapy in the treatment of hyperfunctional voice disorders. Its effects were shown to be measurable with both acoustical analysis and the Vocal Tract Discomfort scale.

Although the formant frequencies showed no changes in this study, formant frequency analysis would appear to be a theoretically sound method for assessing change in the vertical position of the larynx in the vocal tract. The results indicate that further investigation using a larger sample size is merited. The results also indicate that RAP, measured during connected speech might be a sensitive indicator of acoustic change following LMT.

The Vocal Tract Discomfort Scale proved to be a useful perceptual indicator of sensory changes before and after LMT. It demonstrated that the method of LMT used in this study can reduce the vocal tract discomfort experienced by patients with MTD. In addition, this method of LMT resulted in measurable acoustic changes in the voices of the patients participating in this study.

Appendix A

Palpatory evaluation of the perilaryngeal area prior to LMT

Palpatory evaluation of the perilaryngeal area is an essential prerequisite to LMT in order to determine sites and levels of muscle tension and resistance in the perilaryngeal musculature. It is not intended as assessment of tenderness or discomfort although the examining clinician will inevitabley become aware of the patient's discomfort from comments or responses. The findings on palpation dictate the pressure and location of the subsequent intervention with Laryngeal Manual Therapy In most cases the higher the score on palpation in one or more areas, the more gentle the applied digital pressure should be on intervention. This is because clinical experience suggests that higher levels of muscle resistance are associated with higher levels of discomfort when digital pressure is applied. Consequently, unnecessary discomfort by unduly vigorous intervention can be avoided. For example, massage of the sternocleidomastoid muscle is usually started at the point of least resistance along the length of the muscle. In some patients this will be at the mastoid or sternal attachment, while in others it is at the mid-point or belly of the muscle. We take the view that unnecessary pain or significant discomfort should be avoided during palpation and LMT whenever possible, particularly as many patients are apprehensive about having their necks handled. The palpatory scoring proforma (Fig. 3) is designed to enable clinicians to develop a systematic method of palpation. It is a subjective method of evaluation, inevitably, but early work involving the training of voice pathologists in the use of this scoring system suggests that inter-rater reliability increases markedly when each clinician has palpated eight subjects. Further investigation will be undertaken into the teaching of perilaryngeal palpation and into developing inter-rater reliability during use of this scale.

During this procedure, the examining clinician stands behind the patient who is seated in a low-backed chair. The clinician ensures that the subject is seated well back on the seat of the chair, that the spine is straight and that the head is in a neutral position, so that the chin is not raised, depressed, retracted nor protruded. The patient is encouraged to relax his or her shoulders and to ensure that the mandible is relaxed, thus avoiding teeth-clenching. The clinician also asks the patient to ensure that his or her tongue is relaxed and not making strong contact, if any, with the hard palate. Palpation is carried out by the clinician using the pads of the index, second and third fingers of both hands. (The number of fingers used might vary according to the size of the clinician's hands and patient's neck size) As some patients experience exquisite tenderness on even very light touch, initial exploration is conducted with the lightest contact pressure of which the clinician is capable. The aim is to minimise the patient's discomfort. In part this is to maintain the patient's confidence in the process but also to try to avoid making the patient increasingly tense and thus invalidating the results of the examination.

The LMT Palpatory evaluation scale (see Fig 3) can be used to record the findings of the examination. Resistance of the areas palpated is rated on a scale of 1-5, with 5 representing the greatest resistance. The height of the larynx in the vocal tract is also noted. Palpation of the perilaryngeal area is conducted in the following stages:

- Palpation commences with bimanual examination of the sternocleidomastoid muscles, starting at the point of attachment of the sternocleidomastoid muscles to the mastoid processes. (The thumbs of each hand can be rested lightly on the back of the patient's neck.) Initially, the pressure is the lightest touch of which the clinician is capable. As the patient becomes accustomed to the sensation of the clinician's touch, this pressure is increased steadily until the muscle can be palpated firmly but without causing the patient distress. Manual pressure is applied throughout the length of both muscles, ending at the sternal attachment.
  Comment: Excessively tense sternocleidomastoid muscles are taut and well-defined. On both visual and palpatory examination, there is usually high definition of the muscle. Tense muscles are tender and the patient might 'start' or 'jump' when the area is palpated. The examining clinician should be careful to distinguish between well-defined muscles that are due to tension and those which are the product of physical exercise. Together with the case history, the differentiating factor is that the markedly prominent sternocleidomastoid muscle in the 'toned' subject is not as tender as a muscle of similar prominence in those who do less exercise. The clinician's experience in palpating a large number of necks is important in this instance.

- The supralaryngeal area is palpated using the clinician's dominant hand. The other hand cradles the patient's occiput so that the head does not move backwards as pressure is applied to the supralaryngeal area. Pressure is applied upwards and backwards from the mid-point of the mandible towards the hyoid bone. The entire supralaryngeal area is then palpated.
  Comment: An accurate assessment of the resistance of the supralaryngeal muscles depends on distinguishing adipose tissue in the area from the underlying muscles. It might be necessary to apply greater pressure than when palpating the sternocleidomastoid muscles in order to ensure that the underlying muscles are being evaluated, rather than adipose tissue.

- Pressure is applied alternately to the thyroid cartilage laminae, again using the pads of three fingers. When the perilaryngeal musculature is tense, the larynx is frequently highly resistant to lateral digital pressure. The clinician should not attempt to increase this pressure in an attempt to overcome the resistance. To do so will be extremely uncomfortable for the patient and it is unnecessary to carry out a forceful manoeuvre in the process of this evaluation.When the perilaryngeal musculature is relaxed, the larynx moves easily in response to this lateral digital pressure.

- Laryngeal height is assessed by placing the fingers of one hand, held horizontally, with the lowest finger at the level of the clavicles (Rubin: personal communication)) A high-held larynx usually allows the examiner to place three fingers between the clavicles and the lower edge of the cricoid cartilage, depending on the size of the examiner's hands and the dimensions of the patient's neck. A neutral position allows two fingers and a lowered larynx, one finger. The forced lowered larynx might compress this space completely.

- During this examination, the hyoid bone is palpated gently in order to find out if it is tender. Experience suggests that an exquisitely tender hyoid bone is associated with high levels of general tension in the perilaryngeal musculature.

The palpatory evaluation process generally takes approximately 3 or 4 minutes but will be shorter if the extrinsic laryngeal muscles are not unduly tense and can be longer, including breaks, if they are extremely tense and the patient experiences marked discomfort.

Appendix B

Laryngeal Mnaual Therapy

Laryngeal Manual Therapy (LMT) is carried out following palpatory evaluation of the perilaryngeal musculature.The positions of the patient and clinician are similar for both the palpatory evaluation and LMT. During this procedure, the examining clinician stands behind the patient who is seated in a low-backed chair. The clinician ensures that the subject is seated well back on the seat of the chair, that the spine is straight and that the head is in a neutral position, so that the chin is not raised, depressed, retracted nor protruded. The patient is encouraged to relax his or her shoulders and to ensure that the mandible is relaxed, thus avoiding teeth-clenching. The clinician also asks the patient to ensure that his or her tongue is relaxed and not making strong contact, if any, with the hard palate.

LMT consists of rotational massage, kneading and stretching of the perilaryngeal muscles.

- The procedure is usually started on the sternocleidomastoid muscles, simultaneously (Figs 5, 6) It is carried out by the clinician using the pads of the index, second and third fingers of both hands. (The number of fingers used might vary according to the size of clinicians' hands and patients' neck sizes) The site of the start of the massage is either the mastoid or sternal points of attachment of the SCMs or the belly of the muscles, whichever have been found to be least tense on palpatory evaluation. Experience suggests that working from the area of lesser tension to that of greater tension is the most comfortable for the patient and achieves a reduction in overall muscle tension most rapidly. It is advisable to ensure that the movements of the massaging finger tips of each hand are not exactly synchronous; equal pressure on the SCMs simultaneously, on either side of the neck, might exert undesirable pressure on the carotid sinuses. Similarly, for this reason, the clinician must ensure that the SCMs are accurately identified and that the massage does not waver from the course of the muscle. As the massage progresses along the length of the SCM, and is repeated in the same area, the muscle can be felt to change gradually from being tense and cord-like to a much softer structure with much less definition. When this point has been reached, attention can be directed to the supralaryngeal area.

INSERT FIGURE 5 Massage of the sternocleidomastoid muscles ABOUT HERE
INSERT FIGURE 6 Massage of the sternocleidomastoid muscles (lateral view) ABOUT HERE

- The supralaryngeal area is kneaded using the clinician's dominant hand (Fig. 7). The other hand cradles the patient's occiput so that the head does not move backwards as pressure is applied to the supralaryngeal area. A kneading action is applied upwards and backwards from the mid-point of the mandible with the pads of the fingers of the index, second and third fingers. (In practice, the majority of the pressure tends to be applied by the second finger because it is the longest.) It is helpful to remind the patient to relax the mandible, avoid teeth-clenching and to allow the tongue to rest in the floor of the mouth so that unnecessary tension is minimized. After working in the midline, kneading is also carried out from a more lateral position on the mandible, towards the larynx. As tension of the supralaryngeal muscles is reduced, the area softens so that it is possible to increase pressure, without causing the patient discomfort, until the fingertips can be pressed beyond the border of the mandible.

INSERT FIGURE 7 Massage of the supralaryngeal area ABOUT HERE

- The first two stages can be repeated until the clinician feels that maximum reduction in muscle tension has been achieved, without causing the patient undue discomfort. If the larynx was high-held on palpatory evaluation, it is at this stage that bilateral pressure can be applied to the superior edge of the thyroid cartilage so that the larynx is firmly, but gently depresse (Fig.8)

INSERT FIGURE 8 Laryngeal depression ABOUT HERE

- Finally, when the perilaryngeal musculature is more relaxed than at the onset of LMT, bilateral digital pressure is applied to the thyroid laminae. Increased lateral movement of the larynx in response to this pressure, in comparison with pre-LMT status, is an indication of reduction of tension in the perilaryngeal musculature (Figs 9a, 9b)

INSERT FIGURES 9a and 9b ABOUT HERE .

- The patient is asked to swallow and then to vocalize, frequently in response to the question, "How does that feel?"

The patient does not vocalize throughout the process of LMT. The rationale for this requirement has evolved as a result of observations made while using the technique in clinical practice. It appears that many patients with MTD develop an habitual posture of the muscles associated with phonation. Consequently, if they vocalize during the treatment, the authors' experience is that there is a tendency for them to use habitual phonatory patterns which might slow or regress the effects of the intervention. Vocalization is not requested from the patient during LMT until after the larynx responds easily to lateral digital pressure in the final stage of intervention. Counting, days of the week, vocal glides and spontaneous speech are then encouraged. The rationale for this is that the patient's phonatory patterns are hyperfunctional and the muscle postures associated with the dysphonia have become habituated. Waiting until maximum relaxation of the laryngeal musculature has been achieved allows phonation to be attempted with optimum muscle tone and reduced or eliminated discomfort. Following LMT, patients commonly make the comments, "It's easier to swallow." or "My throat feels more open." Many individuals then also comment on the kinaesthetic changes related to phonation as well as improvements in vocal quality.

The time taken for this process of LMT varies according to the patient's response to the procedure. It is not necessarily the case that higher levels of muscle tension require a longer period of treatment. In most cases, the LMT process alone takes approximately 10 minutes. The process can be repeated within the session.

Aronson stated that many patients find manual therapy extremely tiring. This appears to be an emotional as well as a physical response. Patients should also be informed that tenderness in the areas where manual pressure has been applied might become apparent during the day following treatment.

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