Delivery of intensive voice therapy for vocal fold nodules via telepractice: A pilot feasibility and efficacy study

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ABSTRACT

Summary: Objectives. This pilot study examined voice outcomes and patient perceptions following intensive voice therapy for vocal fold nodules via telepractice.

Study Design. Pilot: within-subjects experimental trial

Methods. Participants included 10 women diagnosed with bilateral vocal fold nodules who received intensive voice treatment via a free videoconferencing platform Skype, (Microsoft Corp., Redmond, WA).. All participants completed 1 vocal hygiene session in person, followed by 8 sessions of therapy via telepractice over 3 weeks. Before and immediately after treatment, patients attended a clinic in person to complete perceptual, stroboscopic, acoustic and physiological assessments of vocal function. Analyses were performed by a speech-language pathologist and an otolaryngologist independent to and blinded to the study. Participants also completed the Voice Handicap Index and a telepractice satisfaction questionnaire, or an anticipated satisfaction questionnaire, before and after treatment.

Results. Significant improvements were found in perceptual, vocal fold function, acoustic and physiological parameters as well nodule sizes and patient perceptions of voice-related quality of life post treatment**.** Participants were highly positive about their first experience with telerepractice. Results were similar to those from a separate study investigating the effects of an intensive voice therapy delivered in conventional

face-to-face format.

Conclusions. This study is consistent with possible benefits of telepractice in the delivery of intensive treatment for vocal fold nodules. Pending final verification with a face-to-face comparison group, telepractice could be recommended as an alternate treatment modality for patients with vocal fold nodules.

Keywords: Telepractice - Vocal fold nodules – Perception – Physiology – Acoustic – Aerodynamic – Participant Satisfaction

INTRODUCTION

The primary etiologic factor for vocal fold nodules is proposed to be cumulative perpendicular impact stress between the vocal folds over time, which increases with voice use.[1] Certain forms of voice use, such as pressed voice, appear to increase the risk of injury.[1] It has been well established that the presence of vocal fold nodules can lead to lost time at work, reduced productivity and impaired quality of life.[2]

Many people with vocal fold nodules work in professions which have high vocal demands, therefore, it is essential that they recover their vocal function so that their ability to perform their jobs is not compromised.[2] Several studies have been conducted on the efficacy of treatment for vocal fold nodules, with voice therapy recommended as first-line treatment.[3-11] Although it has been established that voice therapy is often effective[3-5,10,11], it has been noted that rates of therapy completion can be poor.[12-15] This presents a challenge for clinicians and a critical barrier for full voice recovery in this patient population.

As with other behavioural intervention, it is noted that effective delivery of oice therapy is impacted by problems of resistance to change, therapy dropout and lack of follow-through outside the therapy session.[13-15] Numerous factors contribute to therapy non-compliance. However, ready access to services is a key factor. In many settings internationally, individuals work long hours with sometimes inflexible work

conditions, or hold occupations that do not allow them to easily take time off work, which impact their ability to attend regular voice treatment sessions. For others who live in more regional or rural areas, the travel time associated with sometimes large distances needed to access clinicians experienced in voice disorders also can limit therapy attendance. Ultimately issues of access can contribute to missed appointments and a high dropout rate in the clinical population of individuals with vocal fold nodules. Such non-adherence to voice therapy not only affects treatment success, but also results in unnecessary extensions to treatment, and repeated examinations without sufficient behavioural change to effect improvement which lead to excess costs to healthcare and third-party payers. There is also a cost of cancellations and no-shows to healthcare.[15] Furthermore, there may be loss of revenue or loss of employment as patients are unable to meet the vocal requirements of their occupations.[12,15] Consequently, there is a need to explore ways to facilitate greater access to voice therapy to maximise attendance and ultimately enhance outcomes for people with vocal fold nodules and other conditions affecting voice.

Recent research[16] supports the efficacy of intensive voice therapy for vocal fold nodules. However, the ability to undertake such high intensity therapy programs (total program included 9 sessions over 3 weeks) in a traditional face-to-face (FTF) clinical model may not be possible for many patients due to the access issues previously

discussed. Therefore, alternate modes of delivery for voice treatment need to be considered. One possible service delivery mode is telepractice, in which services are provided at a distance.[17] A growing body of evidence is available to support the use of telepractice in speech pathology.[18] Speech pathology services in general appear to be well-suited to telepractice delivery due to the audio-visual nature of the patient-clinician interaction in most consultations.

A number of studies have explored the use of telepractice with various types of voice disorders. The majority of these have focussed on the assessment and treatment of voice disorders associated with Parkinsons Disease and revealed very positive outcomes.[19-23] Only one investigation, however, has explored the use of telepractice with a group of patients with voice disorders of various aetiologies, including some patients with vocal fold nodules.[24] Participants were treated via either conventional therapy or telepractice. All of the therapy sessions for the remote group were delivered in adjacent rooms via a real-time audio-video monitoring system. The system consisted of Sony Hi-8 video cameras with remote lapel microphone and colour monitors. In addition, FTF contact between patient and clinician was minimised as much as possible during the course of the conventional treatment protocol. The study found that both groups demonstrated improvements in voice quality, acoustic and physiological parameters post voice treatment. Furthermore, no

significant differences were found between the extent of change in either group, indicating that voice therapy delivered via telepractice was as effective as conventional therapy.[24] The authors suggested that the use of telepractice would be helpful in overcoming the barrier of geographic distance and eliminating the commute time to the clinic. In a later discussion article about this service published two years later, Mashima et al[25] commented on their telepractice service model and its potential to increase accessibility and availability for patients with voice disorders.

Although there is preliminary evidence supporting the use of telepractice in the management of various voice disorders, to date, no investigations have been conducted with a cohort of patients with vocal fold nodules, specifically, in telepractice. In addition, no studies have been performed with patients with vocal fold nodules receiving telepractice at home or in the workplace. Therefore, the aim of this pilot study was to investigate the feasibility and efficacy of telepractice in delivering intensive voice therapy to individuals with vocal fold nodules in their own homes or workplace. It is hypothesised that telepractice will be a service delivery mode which is both feasible and effective in improving voice outcomes for patients with vocal fold nodules.

METHODS

This study was approved by ethics committee at the Taipei Veterans General Hospital and a human research ethics committee at The University of Queensland.

Participants

Participants were recruited from the outpatient clinic at the Department of Otorhinolaryngology, Taipei Veterans General Hospital, Taiwan. For inclusion, participants had to present with bilateral vocal fold nodules, as determined by an otolaryngologist under stroboscopic examination, with planned behavioural management of the nodules by a speech-language pathologist (SLP). Participants were excluded from this study if they: 1) were not aged between 18 years and 55 years; 2) had articulation, resonance, or language disorders; 3) had hearing impairment as determined by a screening test at 20 decibels hearing Level (dB HL) at 500, 1000, 2000 Hz; 4) had previous professional singing or speaking training; 5) had previous voice therapy or laryngeal surgical treatment; 6) used prescription medication which may cause changes in laryngeal function, mucosa or muscle activity (list provided by National Center for Voice and Speech [NCVS][26]); 7) had psychiatric or neurologic conditions; 8) had a history of allergies, lung disease, or other concomitant vocal pathology (e.g., vocal polyp and vocal cyst); 9) presented with bamboo nodules, or; 10) had no access to internet and Skype™.

Ten women (mean age = 33.7 years, range =19 - 49 years) with vocal fold nodules and mild-moderate vocal impairments in perceptually evaluated voice quality were included in the study. Severity of dysphonia was determined from a recorded speech sample (a standard Mandarin passage) and rated using the "Grade" scale from the GRBAS (Grade, Roughness, Breathiness, Asthenia, Strain) scale[27] (where 0 = normal, 3 = severe). A single SLP experienced in the assessment and treatment of voice disorders but blind to the study purpose conducted the severity ratings. The participants' occupations were categorised into non-professional voice users (eg., factory worker, student, catering, clerical worker, home carer, and unemployed) and professional voice users (eg., teacher, health professional, and sales personnel). The decisions on the extent to which various professions constituted professional voice use were made somewhat arbitrarily. All participants were diagnosed before treatment with bilateral broad-based nodules with surrounding oedema. The nodules were located at the midpoint of the membranous, vibrating vocal folds for all participants. None had had any previous experience with telepractice. Demographic information of the 10 participants is detailed in Table 1.

[Table 1 near here]

Procedure

Following recruitment, each individual attended the hospital clinic in person for a comprehensive baseline assessment of their voice and speech production. They then completed one vocal hygiene session in person, followed by eight sessions of intensive voice therapy delivered via telepractice from either their home or workplace (detailed in full below). Re-assessment at the clinic took place within 24 hours following completion of the final session of online therapy.

Baseline and post treatment assessments

Auditory perceptual ratings, stroboscopic assessments, acoustic and physiological measurements as well as patient perception questionnaires were completed before and after therapy. All auditory perceptual ratings, acoustic and physiological analysis was performed by one SLP experienced in voice disorders and blinded to this study, while all stroboscopic ratings were performed by one otolaryngologist independent and blinded to this study.

Auditory perceptual ratings

At each assessment interval, the participants were asked to read a five-sentence Mandarin passage. All voice samples were recorded with a Shure SM48-LC microphone (Shure, Niles, IL, USA) in a sound-treated room and stored in the

Computerised Speech Laboratory system (CSL; model 4500, Kay Elemetrics Co.) at a 4.41 KHz sampling rate. The desktop microphone was placed in front of each participant's mouth at a distance of 15 cm. The microphone-to-mouth distance was established and maintained with a 15 cm ruler taped next to the microphone. The microphone was moved for each participant to be level with their mouth.

All speech samples were subsequently analysed perceptually by one SLP with 15 years experience assessing voice disorders. Voice quality was assessed using the GRBAS scale[27] which consists of five perceptual parameters: grade (G), roughness (R), breathiness (B), asthenicity (A) and strain (S). Paired comparison ratings of GRBAS parameters were conducted using the Comparison Mean Opinion Score (CMOS) process.[28] The order of the voice samples were randomised with respect to time points (pre versus post treatment) within each participant's paired samples to reduce potential expectation bias prior to the rater listening to and comparing the paired speech samples. A clinician independent of the rating process created 10 pairs of recorded speech samples for each participant relating to the assessment time points and the five GRBAS perceptual parameters (ie, pre and post voice therapy, with a total of 20 samples or a total of 100 voice ratings). After listening to each pair of speech samples, the rater then rated sample 2 in relation to sample 1 on a scale of -3 to +3, in which 0 indicates the samples are equal. If the value is positive, it indicates

that sample 2 is better than sample 1 (+1 mildly better; +2 better and +3 much better). However, if the value is negative, it indicates that sample 2 is worse than sample 1 (-1 mildly worse; -2 worse and -3 severely worse). The SLP was able to listen and compare the speech samples as often as needed. Once the paired samples were rated, the principle investigator revealed the order of the two samples and transposed the scores to ensure data accurately reflected perceptual differences relative to the time of speech sample recording such that any positive score indicated an improvement and negative values indicated a decline in function.

To validate the reliability of the primary rater, a second SLP with nine years experience assessing voice disorders listened to and rated a random set of 20 voice ratings (20% of the total voice ratings). Inter-rater reliability was calculated using direct calculation of the Percent Exact Agreement (PEA) and the Percentage of Close Agreement (PCA - where raters differed by no more than 1 scale point). Findings revealed an overall PEA was 80% and the PCA was 100%. Intra-rater reliability was calculated by having the primary rater re-rate 20% of the sample a second time, at no sooner than four weeks following initial assessment. The mean PEA was 80% and PCA was 100%.

Stroboscopic evaluation –vocal fold function and lesion ratings

The stroboscopic recordings were performed during the sustained phonation of the vowel /i/ produced at a comfortable loudness and pitch. The examination procedure was conducted by any one of four otolaryngologists at any assessment point. The recorded stroboscopic samples were then subsequently rated by one primary otolaryngologist with 10-year experience in assessing voice disorders, blinded to the assessment points.

The stroboscopic ratings were performed in two stages. The first stage was to complete ratings of vocal fold function and lesion including: the symmetry of vocal fold abduction and vibration; the regularity and amplitude of the vocal fold movement; vocal fold edge smoothness; mucosal wave characteristics and glottal closure (0 = normal; 1 = mild; 2 = moderate; 3 = severe); nodule location (very front, front, mid, back of the vocal fold membranous portion); nodule shape (narrow-based, broad-based) and surrounding oedema (yes/no). The 20 samples (10 participants by two samples per participant) were randomized prior to presentation to the otolaryngologist for rating in order to reduce any potential bias. The otolaryngologist was able to review each stroboscopic sample for as long as required to complete the ratings. The stroboscopic samples were viewed and rated without sound.

The second stage of the stroboscopic rating process used the paired sample comparison process (as described previously) to rate paired samples (pre and post

voice therapy) using a questionnaire adapted from Holmberg, Hillman, Hammarberg, Sodersten, and Doyle.[5] Ratings of sample two compared to sample one were rated for changes in: (1) nodule size (difference between the two recordings, -1 larger; 1 smaller; 0 no difference), and; (2) surrounding oedema (difference between the two recordings: -1 larger; 1 smaller; 0 no difference). Once the samples were rated, the order of the samples was revealed to the principle investigator who then transposed the scores to ensure data accurately reflected differences relative to the time of videostroboscopic sample recording (pre-voce therapy and post-voice therapy).

The reliability of the primary rater was determined using a second otolaryngologist with ten years experience assessing voice disorders who rated a random set of four samples (20% of the total stroboscopic samples). Inter-rater reliability of the ratings in first and second stage was calculated using PEA and PCA. Findings revealed PEA was 65% and PCA was 97.5% respectively for stroboscopic parameters. Intra-rater reliability of the ratings in first and second stage was calculated by having the primary rater re-rate 20% of the sample a second time, at no sooner than four weeks following initial assessment. The PEA calculated for intra-rater reliability was 92.1%, while PCA was 100%.

Physiological assessment

Measures of maximum phonation time (MPT), mean airflow rate (MFR) and subglottic pressure were included in the aerodynamic assessment. MPT was measured with a stopwatch while participants were asked to produce the sustained vowel /a/ for as long as possible at a comfortable loudness and pitch level on a single breath, three times. The MFR and subglottic pressure were obtained and analysed using the Aerophone II (Model 6800, Kay Elemetrics Co., Lincoln Park, NJ). For MFR measurement, each participant was asked to produce a sustained vowel /a/ for as long as possible at a comfortable intensity and pitch level with a face mask, sealed over the nose and mouth connected to a pneumotachograph- based flow system, three times. The middle portions of each sustained vowels were used for analysis. Subglottal pressure was estimated indirectly using an intraoral pressure probe positioned behind the lips and resting on the tongue. The participants were asked to repeat at least five /ipi/ at a comfortable pitch and loudness, however with constant loudness once initiated, with the face mask and probe in place at a rate of 1.5 syllables/second, three times. Results for each parameter were averaged to generate one single value which was used in the statistical analyses.

Acoustic assessment

The participants were asked to produce a sustained vowel /a/ on one breath at a comfortable pitch and loudness level, three times. Vowel productions were recorded via the desktop microphone of the Computerized Speech Lab (CSL) (Model 5105; Kay Elemetrics, Co., Lincoln Park, NJ, USA). The microphone was positioned in front of the participant with a mouth-to-microphone distance of 15 cm. The microphone-to-mouth distance was established and maintained with a 15 cm ruler taped next to the microphone. The microphone was moved for each participant to be level with their mouth. Each participant's production of sustained /a/ was analysed using the Multi-Dimensional Voice Program (MDVP) software in the CSL. All acoustic recordings were conducted in a sound-proof room. The middle 3-second segment from each of the sustained vowels was selected for acoustic analysis. Detailed acoustic measures included: vocal fundamental frequency (F_0) (Hz), mean percentage vocal jitter and shimmer, and noise-to-harmonics ratio (NHR) (dB). Results across the three vowel phonations were averaged to produce a single value for each measure. Furthermore, participants' vocal intensity (dB) for the three prolonged vowels /a/ and additional conversational speech samples were simultaneously measured using Sound Level Meter (320 series, Center Technology Corp., Taiwan) which was also positioned in front of the participant with a mouth-to-microphone distance of 15 cm. Vocal intensity recorded for the prolonged vowel phonations and

conversational speech samples were also averaged to produce a single value for each measure.

Voice handicap index

The Chinese version of the Voice Handicap Index (VHI)[29] was used to quantify self-assessment of voice-related quality of life. The VHI is a 30-item instrument consisting of three domains: emotional (VHI-E), physical (VHI-P), and functional (VHI-F) aspects (each 10 questions). A total score (ranging from 0 to 120) and each individual VHI subscale scores (ranging from 0 to 40) were generated. A lower total score represents less perceived voice-related quality of life problems.

Participant satisfaction questionnaires

To evaluate the patients' perceptions of the telepractice sessions, a 16-item questionnaire modified from Sharma et al[30] was administered both immediately prior to and after voice therapy. In the pre-session questionnaire, the questions were worded in the future tense while the post-session questionnaire contained the same questions, only with grammatical modifications to reflect past tense (i.e. I *will have/had* no difficulty in seeing online speech pathologist). All participants responded to all

questions using 5-point Likert scale (1 = strongly disagree, 3 = neutral/unsure, 5 = strongly agree).

The telepractice system

The telepractice system used to conduct the therapy sessions consisted of two computers (one at clinician end and one at participant end) that were equipped with videoconferencing software (Skype™; a peer-to-peer Internet telephony network), a web camera and microphone (Fig. 1). Although it is acknowledged that Skype™ may have security issues, it was nevertheless used as this technology was the only readily available platform for use in Taiwan for this population. All participants were fully informed of this limitation and gave consent to the use of Skype™ for the voice treatment. Videoconferencing was established over a broadband internet connection with at least 2M/64K (download/upload) speed between the clinic and the participant's home or workplace. Participants were required to have an account with Skype™, and e-mail contact with the clinician. All aspects of treatment were delivered remotely by the principal investigator. To ensure there was satisfactory visual and auditory information exchanged between the participants and clinician, specific equipment was used. Visual information was optimised through the use of web cameras (5 million pixels; Ktnet Enterprise, Co., Ltd., Taichung, Taiwan). The

web camera was clipped on the computer screen and the camera head could be moved and adjusted according to the participant and SLP's position and height. There were six LED lights on the web camera which could be switched on if a better light source was required. To enhance the auditory signal, and reduce background noise, a freestanding/desktop microphone (Jazz-005; Intopic International, Co., Ltd., Taipei, Taiwan) was used at both the clinician and participant sites. The microphone was fixed on an adjustable mobile platform that allowed the participant and clinician to move and adjust the microphone position and height accordingly.

Therapy program

All participants completed 9 sessions of intensive therapy delivered across three therapy sessions per week over a 3 week period. This intensive therapy model was previously reported by Fu et al (in press) and found to provide comparable outcomes to a traditional non-intensive therapy model. In week 1, for the first session participants attended in person for a session on vocal hygiene (adapted from Weinrich[31], Verdolini Abbott[32], and NCVS[33]) and also to receive information regarding the technology requirements and set-up for the subsequent eight online voice therapy sessions. The remaining 2 sessions in week one, and then all 3 sessions in weeks 2 and 3 were conducted via telepractice (8 telepractice sessions). In addition

to the therapy sessions, all participants were required to complete homework activities using written resources provided via email. Participants were instructed to complete this homework practice in two 15-minutes sessions per day on a non-treatment day and in a one 15-minute session on a treatment day.

The online voice therapy was provided by the principle investigator who was not involved in assessment of the participants. The principle investigator was trained and certified to provide the therapy program which was adapted from the Lessac-Madsen Resonant Voice Therapy (LMRVT) program developed by Verdolini Abbott[32,34]. Components of the Vocal Function Exercises (VFE) program developed by Stemple[35] were also incorporated in the speech tasks. Full details of the therapy program are published elsewhere.[16] In summary, it contained relaxation exercises[32] followed by basic training gestures as described by Verdolini Abbott[34] and Roy et al.[36] The sessions of direct facilitation of speech tasks proceeded in stages to a conversational level and real-life applications outside the therapy room. All resource materials used during therapy (ie., words, phrases, sentences and reading passages for speech tasks) were provided via email prior to each session.

Statistical analysis

The Statistical Package for the Social Sciences (SPSS) version 20 (SPSS, Inc.,

Chicago, IL) was used for all statistical analysis and level of significance was set at $p<0.05$. Although multiple statistical analyses were conducted, due to the preliminary nature of the study, more stringent alpha levels to protect inflation was not adopted. Paired comparison ratings (between pre to post treatment) conducted for the perceptual parameters of grade, roughness, breathiness, asthenia, strain and also for the static parameters of nodule size and oedema were analysed using a series of one sample *t*-tests (one-tailed) where 0 was taken to indicate no difference between the sample pairs. For the vocal fold functions ratings of the symmetry of vocal fold abduction and vibration; the regularity and amplitude of the vocal fold movement; vocal fold edge smoothness; mucosal wave; and glottal closure, analysis were conducted using Wilcoxon signed rank tests to explore extent of change across the two time points (baseline and post voice treatment). To determine whether significant changes occurred in acoustic and physiological parameters after therapy, paired sample *t*-tests were performed.

Analysis of VHI data pre post treatment was conducted using Wilcoxon-Signed Ranks test. Participants' responses to the telepractice questionnaire were collapsed from a 5-point scale to three groups (i.e., strongly disagree + disagree = "disagree", unsure = "unsure", and agree + strongly agree = "agree"). The Friedman test was then used to analyse the extent of change in perceptions of telepractice pre to post

treatment.

RESULTS

All participants completed the full telepractice voice program, with 100% attendance. One of the sessions had to be re-scheduled due to technical difficulties with webcam connection. This could not be solved during the session and the elderly participant required assistance from a family member. The problem was solved within 24 hours and the session continued as normal. The participant completed the rest of the treatment with good attendance. Five out of the eighty sessions (6.25%) had delays between audio and visual images during sessions but these delays did not affect the integrity of the treatment. Three out of the eighty sessions (3.75%) experienced loss of connection but reconnected straight away. In addition, participants demonstrated high compliance with homework activities, reporting that they practiced at least once a day as recommended during the course of treatment.

Auditory perceptual ratings

Comparison between baseline and post treatment perceptual ratings demonstrated significantly ($p < 0.05$) improved ratings of overall voice quality, roughness, and weakness of voice (Table 2). Individual analysis revealed all participants were rated

as having better voice post treatment in overall voice quality and roughness, six had reduced weakness and three had reduced strain post treatment. Breathiness did not change in any participant.

[Table 2 near here]

Stroboscopic ratings – vocal fold function and lesion ratings

Vocal fold function assessment revealed statistically significant ($p < 0.05$) improvements across the group from baseline to post treatment for ratings of mucosal wave, vocal edge smoothness and glottal closure (Table 3). No significant change was found for symmetry of vocal fold abduction, amplitude of vocal fold movement and regularity of vocal fold movement.

[Table 3 near here]

The paired comparison ratings for nodule size and oedema (baseline and post treatment) were analysed using a series of one sample *t*-tests. Post-treatment results revealed all ten of the participants were rated as having smaller nodule size when compared to pre-treatment. Ratings of vocal fold oedema was shown to have significantly improved ($t = 4$, df = 9, $p = 0.003$, mean diff = 0.800) following treatment.

Physiological and acoustic assessments

A series of paired sample *t*-tests were conducted to examine the impact of intervention on each physiological parameter. Results revealed significant increase in MFR, while no changes were found in MPT and subglottal pressure following treatment (Table 4). Individual analysis demonstrated that post treatment eight participants had an increase in MFR, five had an increase in MPT and seven increased their subglottic pressure.

Paired-samples *t*-tests revealed a significant increase in mean F_0, and significant reductions were shown in jitter, shimmer and NHR following treatment (Table 5). Results of vocal intensity of prolonged vowel /a/ and conversation demonstrated no significant differences between baseline and post treatment. Individual analysis showed post treatment all participants had an increase in F_0, all had reduced jitter, and nine had reduced shimmer and NHR. With regards to vocal intensity post treatment, eight had an increase during the prolonged vowel /a/ and five demonstrated an increase in vocal intensity during conversation.

[Tables 4 & 5 near here]

Voice handicap index

Significant improvement in patient perceptions of voice function was observed following treatment (Table 6). Almost all of the participants had lower total scores

after treatment (Figure 2). With regard to the individual VHI subscales, results for the VHI-P showed significant improvement post treatment, while VHI-F and VHI-E showed no significant differences before and after treatment (Table 6).

[Insert Table 6 and Figure 2 near here]

Participant satisfaction questionnaires

Pre-treatment some of participants were uncertain about their anticipated level of comfort with telepractice, the visual and audio quality, comprehensiveness of instructions, sufficient time to execute instructions given, opportunity to clarify doubts, replacement of FTF consultation with telepractice consultation, accessibility to healthcare with telepractice, and preference of telepractice over FTF consultation (Table 7). However, post treatment these aspects had significantly improved. No significant changes were observed on Questions 3, 12, 13, 15 and 16, with post-treatment opinions similar to pre-treatment. Even before treatment they agreed with these statements.

[Insert Table 7 near here]

DISCUSSION

The aim of the present study was to examine the feasibility and efficacy of delivering

intensive voice therapy via telepractice. Overall the results revealed positive treatment effects which are quantitatively comparable to previous research[16,37,38] on conventional FTF voice therapy for vocal fold nodules, and a high level of patient satisfaction. Sessions were well attended and delivered with minimal technical difficulty. Consequently, this investigation provides a preliminary indication that telepractice is a viable service delivery mode for providing intensive voice therapy for people with vocal fold nodules.

In the current investigation, it was found that after therapy there were significantly improved ratings on perceptual parameters of voice quality, specifically overall voice quality, roughness, and weakness of voice. These changes were parallel to positive changes in vocal fold function, with stroboscopic ratings showing improvements in mucosal wave, vocal fold smoothness, and glottal closure. In addition, positive changes in acoustic parameters were also observed. These findings are consistent with the patterns of the positive change observed following intensive therapy delivered in the traditional FTF manner. [16] They were also similar to the positive outcomes in perceptual, vocal fold and acoustic function observed by Mashima et al[24] in their larger group of patients with voice disordered treated by telepractice. Unlike prior research by Fu et al[16] additional positive changes were also observed in physiological (aerodynamic) functions across the group. There was a

significant increase in MFR post online voice therapy, which may reflect improved regulation of the mean resistance of the glottal airway and possibly, an overall improvement in vocal fold function in this cohort. This premise was supported by the fact that vocal fold function tended to improve across all stroboscopic parameters post-treatment (See Table 3), although mucosal wave, vocal fold edge smoothness, and glottal closure were the only parameters found to be significantly altered. A possible explanation for the difference in outcome between the current study and that of Fu et al [16] may be due to the individual variability in such a small cohort of participants, therefore, further research on a larger number of study group may be needed for clarification. Overall, the current findings provide further evidence to support the positive effects of delivering voice treatment via telepractice.

Apart from the positive outcomes shown in perceptual, vocal fold function, acoustic and physiological measures, participants' perception of changes in vocal function post treatment is an important indicator of the efficacy of treatment. It is recognised that how a patient feels about his/her voice-related quality of life is one of the determining factors in treatment seeking, compliance, and discharge.[39] The results of this study showed that the total VHI score decreased significantly, indicating that the participants had better perception of their voice-related quality of life after treatment. These results are similar to previous research[37,38] which has reported

improvements in total VHI score following voice therapy delivered in the traditional FTF modality. Overall the current results support that patients perceived a positive benefit from the therapy they received via telepractice.

Exploring participant perception is an important component in the evaluation of any novel service delivery model. The satisfaction questionnaire conducted to explore participant perceptions of the telepractice service confirmed that participants were highly positive about their first experience with telepractice. Pre-treatment it was noted that patient expressed some concerns about using telepractice particularly regarding audio/visual issues, however these were resolved post-treatment. Similar data were reported by Sharma et al[30] from their patient cohort who were to undergo dysphagia assessment remotely. As discussed by those authors,[30] identification of any patient concerns pre-treatment can enable clinicians to address these concerns prior to sessions commencing. Pre and post treatment, the majority saw telepractice as a way to improve access to healthcare, save time and money and believed telepractice to be a viable option to FTF therapy. These findings are consistent with much of the literature, [19,30,40,41] with patients' perception of telepractice services in general to be very positive. The results also align with the comments made by Mashima et al[25] about the benefits of delivering voice therapy via telepractice.

Although the results of the current trial were generally positive, some technical

difficulties impacted the quality of some sessions. In a few sessions occasional delays between audio and visual images during the therapy sessions were noted. Furthermore, in a few sessions the Skype™ connection was lost and reconnected. There was only one session where there was complete inability to reconnect and the session was cancelled. Contributing to technical difficulties experienced in this study were the sometimes low and varying bandwidth connections into the individual's homes/workplace. However, these issues did not appear to have a negative impact on treatment outcomes in the current study. This finding is consistent with previous telepractice research[24,42] using low bandwidth connections where outcomes were not substantially affected by audio and visual quality loss. Further research is necessary however in order to establish appropriate technical standards and guidelines for the use of telepractice in the management of voice disorders.

Despite evidence of therapeutic benefits, there are limitations in this study. One limitation was the use of Skype™, the free consumer-based voice and video over the Internet Protocol (VoIP) software system. Whilst the participants were fully informed and gave consent to use this software and felt comfortable using the program for therapy, several studies[43-45] have expressed concerns for privacy and security of the therapy sessions. Future investigations, using more secure, low cost systems would enable public health privacy and security regulations to be optimised. Another

limitation of the study was that only a small cohort was included in this pilot study. Future studies should be conducted on a larger number of participants to ensure the magnitude of outcome effect is not over-estimated. Including a parallel group treated via FTF would also enhance the strength of the research design by enabling validation of the online treatment mode. It would also be of benefit to conduct long-term follow-up on the investigated measures to examine whether the treatment effects were maintained. Finally, it is acknowledged that the vocal hygiene session may have been a contributing factor to the positive outcomes observed in the cohort. In a larger study[16] of conventionally delivered voice therapy no significant differences in perceptual, acoustic or physiological (aerodynamic) parameters were observed from pre to post vocal hygiene session. However, the therapeutic benefit of the FTF vocal hygiene session cannot be completely discounted.

CONCLUSION

This pilot study provided evidence that supports telepractice as feasible and potentially effective in delivering intensive voice therapy to individuals with vocal fold nodules. In this investigation, significant improvements were found in perceptual, vocal fold function, acoustic and physiological parameters post therapy. There were positive changes in participants' perception of their voice and the effects of their voice

on their life after voice treatment. Overall, the participants were satisfied with the intensive voice therapy provided through telepractice delivery. These results may possibly indicate the effectiveness of treatment was not reduced by the distance mode. This service delivery mode could be recommended as one of the treatment options for patients who are unable to attend conventional FTF voice therapy and have urgent need to recover their voice within a short period of time. There is also a need for future studies involving the management of voice disorders via telepractice which utilize secure standards-based technologies.

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REFERENCES

1. Titze IR. Mechanical stress in phonation. *J Voice*. 1994;8:99-105.
2. Kunduk M, McWhorter AJ. True vocal fold nodules: the role of differential diagnosis. *Curr Opin Otolaryngol Head Neck Surg*. 2009;17:449-452.
3. Holmberg EB, Doyle P, Perkell JS, Hammarberg B, Hillman RE. Aerodynamic and acoustic voice measurements of patients with vocal nodules: variation in baseline and changes across voice therapy. *J Voice*. 2003;17:262-282.
4. Blood GW. Efficacy of a computer-assisted voice treatment protocol. *Am J Speech Lang Pathol.* 1994;3:57-66.
5. Holmberg EB, Hillman RE, Hammarberg B, Sodersten M, Doyle P. Efficacy of a behaviorally based voice therapy protocol for vocal nodules. *J Voice.* 2001;15:395-412.
6. Hogikyan ND, Appel S, Guinn LW, Haxer MJ. Vocal fold nodules in adult singers: regional opinions about etiologic factors, career impact, and treatment: a survey of otolaryngologists, speech pathologists, and teachers of singers. *J Voice.* 1999;13:128-142.
7. Hufnagle J, Hufnagle K. An investigation of the relationship between speaking fundamental frequency and vocal quality improvement. *J Commun Disord.* 1984;17:95-100.

8. Lancer M, Syder D, Jones AS, Le Boutillier A. The outcome of different management patterns for vocal cord nodules. *J Laryngol Otol.* 1988;102:423-432.

9. Lockhart MS, Paton F, Pearson L. Targets and timescales: a study of dysphonia using objective assessment. *Logoped Phoniatr Vocol.* 1997;22:15-24.

10. Murry T, Woodson GE. A comparison of three methods for the management of vocal fold nodules. *J Voice.* 1992;6:271-276.

11. Verdolini-Marston K, Burke MK, Lessac A, Glaze L, Caldwell E. Preliminary study of two methods of treatment for laryngeal nodules. *J Voice.* 1995;9:74-85.

12. Portone-Maira C, Wise JC, Johns MM III, Hapner ER. Differences in temporal variables between voice therapy completers and dropouts. *J Voice.* 2011;25:62-66.

13. Behrman A. Facilitating behavioral change in voice therapy: the relevance of motivational interviewing. *Am J Speech Lang Pathol.* 2006;15:215-225.

14. Hapner ER, Portone-Maira C, Johns MM. A study of voice therapy dropout. *J Voice.* 2009;23:337–340.

15. Portone C, Johns MM, Hapner ER. A review of patient adherence to the recommendation for voice therapy. *J Voice.* 2008;22(2):192-196.

16. Fu S, Theodoros DG, Ward EC. Intensive versus traditional voice therapy for vocal nodules: perceptual, physiological, acoustic and aerodynamic changes. J Voice. Published online 11 October 2014, http://dx.doi.org/10.

1016/j.jvoice.2014.06.005.

17. American Speech-Language-Hearing Association. Professional issues: telepractice. http://www.asha.org/Practice-Portal/Professional-Issues/Telepractice/. Accessed August 14, 2014.

18. Keck CS, Doarn CR. Telehealth technology applications in speech-language pathology. *Telemed J E Health.* 2014;20(7):653-659.

19. Constantinescu G, Theodoros D, Russell T, Ward E, Wilson S, Wootton R. Assessing disordered speech and voice in Parkinson's disease: a telerehabilitation application. *Int J Lang Commun Disord.* 2010;45:630-44.

20. Constantinescu G, Theodoros D, Russell T, Ward E, Wilson S, Wootton R. Treating disordered speech and voice in Parkinson's disease online: a randomized controlled non-inferiority trial. *Int J Lang Commun Disord.* 2011;46:1-16.

21. Howell S, Tripoliti E, Pring T. Delivering the Lee Silverman Voice Treatment (LSVT) by web camera: a feasibility study. *Int J Lang Commun Disord.* 2009;44(3):287–300.

22. Tindall LR, Huebner RA, Stemple JC, Kleinert HL. Videophone-delivered voice therapy: a comparative analysis of outcomes to traditional delivery for adults with Parkinson’s disease. *Telemed J E Health,* 2008;14(10):1070-1077.

23. Theodoros D, Constantinescu G, Russell TG, Ward EC, Wilson SJ, Wootton R.

Treating the speech disorder in Parkinson's disease online. *J Telemed Telecare.* 2006;12:88–91.

24. Mashima M, Birkmire-Peters D, Syms M, Holtel M, Burgess L, Peters L. Telehealth: voice therapy using telecommunications technology. *Am J Speech Lang Pathol.* 2003;12:432-439.

25. Mashima PA, Holtel MR. Telepractice brings voice treatment from Hawaii to Japan. *ASHA Lead*. 2005;10:20–21.

26. National Center for Voice and Speech. Frequently prescribed medications and effects on voice and speech. http://www.ncvs.org/e-learning/rx2.html. Accessed June 26, 2009.

27. Hirano M. *Clinical Examination of Voice*. New York: Springer-Verlag; 1981.

28. ITU-T. P.800. Methods for Subjective Determination of Transmission Quality. Geneva, Switzerland: International Telecommunication Union (ITU): Recommendation; 1996. P. 800.

29. Lam PK, Chan KM, Ho WK, Kwong E, Yiu EM, Wei WI. Cross-cultural adaptation and validation of the Chinese Voice Handicap Index-10. *Laryngoscope.* 2006;116(7):1192-1198.

30. Sharma S, Ward EC, Theodoros D, Russell T. Assessing dysphagia via telerehabilitation: patient perceptions and satisfaction. *Int J Speech Lang Pathol*.

2013;15:176-183.

31. Weinrich, B. *Vocal hygiene: maintaining a sound voice*. [Videotape]. Gainesville, FL: Communicare Publishing; 2003.

32. Verdolini Abbott K. *Lessac-Madsen Resonant Voice Therapy Patient Manual*. Oxfordshire: Plural Publishing Inc.; 2008

33. National Center for Voice and Speech. Self-help for vocal health. http://ncvs.org/e-learning/strategies.html. Accessed June 6, 2009.

34. Verdolini Abbott, K. *Lessac-Madsen Resonant Voice Therapy Clinician Manual.* Oxfordshire: Plural Publishing Inc.; 2008

35. Stemple JC, Lee L, D'Amico B, Pickup B. Efficacy of vocal function exercises as a method of improving voice production. *J Voice*. 1994;8:271–278.

36. Roy N, Gray SD, Simon M, Dove H, Corbin-Lewis K, Stemple JC. An evaluation of the effects of two treatment approaches for teachers with voice disorders: a prospective randomised clinical trial. *J Speech Lang Hear Res.* 2001;44:286-296.

37. Behrman A, Rutledge J, Hembree A, Sheridan S. Vocal hygiene education, voice production therapy, and role of patient adherence: A treatment effectiveness study in women with phonotrauma. *J Speech Lang Hear Res.* 2008;51:350-366.

38. Niebudek-Bogusz E, Kotylo P, Politanski P, Sliwinska-Kowalska M. Acoustic analysis with vocal loading test in occupational voice disorders: outcomes before

and after voice therapy. *Int J Occup Environ Med.* 2008;21:301-308.

39. Gillespie AI, Gooding W, Rosen C, Gartner-Schmidt J. Correlation of VHI-10 to voice laboratory measurements across five common voice disorders. *J Voice.* 2014;26(4):440-448.

40. Brennan D, Georgeadis A, Baron C, Barker L. The effect of videoconference-based telerehabilitation on story retelling performance by brain-injured subjects and its implications for remote speech-language therapy. *Telemed J E Health.* 2004;10,147-154.

41. Mashima PA, Doarn CR. Overview of telehealth activities in speech–language pathology. *Telemed J E Health.* 2008;14(10):1101-1117.

42. Ward E, White J, Russell T, Theodoros D, Kuhl M, Nelson K. Assessment of communication and swallowing function post-laryngectomy: a telerehabilitation trial. *J Telemed Telecare.* 2007;13:388–391.

43. Hall JL, McGraw D. For telehealth to succeed, privacy and security risks must be identified and addressed. *Health Aff (Millwood).* 2014;33(2):216-221.

44. Watzlaf VRM, Moeini S, Firouzan P. VOIP for telerehabilitation: a risk analysis for privacy, security, and HIPAA compliance. *Int J Telerehabil.* 2010;2(2): 3-14.

45. Watzlaf VR, Ondich B. VoIP for Telerehabilitation: a pilot usability study for HIPAA compliance. *Int J Telerehabil.* 2012;4(1):25-32.

Table 1. Demographic Information of Participants

Demographic variables	
Total number of participants	10
Mean age	33.7
Severity of dysphonia	
Mild-moderate	8
Moderate	2
Occupations	
Professional voice user	6
Non-professional voice User	4

Table 2. Results of the One Sample *t*-tests and the Proportion of Change in Perceptual Ratings

Parameter	Rating	n (%)	Mean difference	*t* Test	*P* Value
Grade	Post-treatment better	10 (100)	1.2	9.00	<0.001*
	No change	0 (0)			
Roughness	Post-treatment better	10 (100)	1.2	9.00	<0.001*
	No change	0 (0)			
Breathiness	Post-treatment better	0 (0)	N/A	N/A	N/A
	No change	10 (100)			
Asthenia	Post-treatment better	6 (60)	0.6	3.674	0.005*
	No change	4 (40)			
Strain	Post-treatment better	3 (30)	0.3	1.964	0.081
	No change	7 (70)			

Abbreviation: N/A, not available.

* Significant at $P < 0.05$.

Table 3. Results of Analysis of Strobosopic Ratings

Parameter	Pre-treatment, Mean (SD)	Post-treatment, Mean (SD)	Z	*P* Value
Symmetry	1.3 (0.675)	1.0 (0.471)	-1.732	0.83
Amplitude	1.4 (0.699)	1.0 (0.667)	-1.265	0.206
Mucosal wave	1.8 (0.919)	1.1 (0.738)	-2.111	0.035*
VF edge smoothness	1.5 (0.527)	1.1 (0.316)	-2.000	0.046*
Regularity	1.4 (0.516)	1.2 (0.632)	-0.707	0.480
Glottal closure	1.4 (0.516)	0.8 (0.422)	-2.449	0.014*

Abbreviation: VF = vocal fold.

* Significant at $P < 0.05$.

Table 4. Results of Analysis of Physiological Parameters

Parameter	Pre-treatment, Mean (SD)	Post-treatment, Mean (SD)	*t* Test	*P* Value
MPT	6.21 (1.76)	6.63 (2.55)	-0.681	0.513
MFR	131.97 (77.16)	167.00 (80.38)	-2.469	0.036*
Subglottic pressure	9.30 (1.93)	9.81 (1.18)	-0.993	0.347

Abbreviation: MPT, maximum phonation time; MFR, mean airflow rate; SD, standard deviation.

* Significant at $P < 0.05$.

Table 5. Results of Analysis of Acoustic Parameters

Parameter	Pre-treatment, Mean (SD)	Post-treatment, Mean (SD)	*t* Test	*P* Value
F_0	186.03 (30.48)	232.01 (44.16)	-7.437	<0.001*
Jitter	1.81 (0.91)	1.09 (0.75)	3.181	0.011*
Shimmer	4.95 (1.30)	3.74 (1.04)	3.700	0.005*
NHR	0.17 (0.03)	0.13 (0.14)	3.246	0.010*
VI of prolonged /a/	72.73 (5.56)	77.74 (8.72)	-1.973	0.080
VI of conversation	69.84 (3.28)	69.96 (4.95)	-0.110	0.915

Abbreviation: F_0, fundamental frequency; NHR, noise-to-harmonic ratio; VI, vocal intensity; SD, standard deviation.

* Significant at $P < 0.05$.

Table 6. Summary of VHI Scores Before and After Treatment

Subscale item	Pre-treatment, Mean (SD)	Post-treatment, Mean (SD)	Z	*P* Value
VHI-F	15.3 (7.379)	12.8 (6.763)	-1.011	0.312
VHI-P	25.3 (8.233)	17.6 (6.883)	-2.807	0.005*
VHI-E	13.4 (9.559)	11.4 (0.879)	-0.869	0.385
VHI total score	54 (21.965)	41.8 (22.075)	-2.199	0.028*

Abbreviation: VHI, Voice Handicap Index; VHI-F, functional domain; VHI-P, physical domain; VHI-E, emotional domain; SD, standard deviation.

* Significant at $P < 0.05$.

Table 7. Results of Participants Perception of Telepractice Service Pre- and Post- Voice Therapy which have been Concatenated from a 5-point Likert Scale to a 3-point Likert Scale to Reveal Basic Groups of "disagree", "unsure", and "agree".

Questions	Pre-treatment			Post- treatment			Z	*P* Value
	Disagree, n (%)	Unsure, n (%)	Agree, n (%)	Disagree, n (%)	Unsure, n (%)	Agree, n (%)		
1. I *will be comfortable* (am comfortable) to use telepractice if it is available in the hospital or healthcare facility nearest to my place of residence.	0 (0)	5 (50)	5 (50)	0 (0)	0 (0)	10 (100)	-2.309	0.021*
2. I *am (*was) comfortable to undergo voice therapy via telepractice.	1 (10)	4 (40)	5 (50)	0 (0)	0 (0)	10 (100)	-2.640	0.008*
3. I would rate the online treatment as being equal to a treatment provided	1 (10)	7 (70)	2 (20)	2 (20)	1 (10)	7 (70)	-1.667	0.096

	traditionally in the face-to-face method.								
4.	The instructions given during the online voice therapy *will be* (were) clear and easy to follow.	0 (0)	8 (80)	2 (20)	0 (0)	0 (0)	10 (100)	-2.762	0.006*
5.	I *will have* (had) no difficulty in seeing the online speech pathologist.	0 (0)	5 (50)	5 (50)	0 (0)	0 (0)	10 (100)	-3.051	0.002*
6.	I *will have* (had) no difficulty hearing the online speech pathologist.	0 (0)	6 (60)	4 (40)	0 (0)	0 (0)	10 (100)	-2.649	0.008*
7.	I *will have* (had) sufficient time to execute the instructions given	0 (0)	6 (60)	4 (40)	0 (0)	0 (0)	10 (100)	-2.598	0.009*

	during the treatment.								
8.	I *will have* (had) opportunities to clarify any doubts I may have during the online treatment.	0 (0)	6 (60)	4 (40)	0 (0)	0 (0)	10 (100)	-2.972	0.003*
9.	I *will be* (was) comfortable being online and would consider using the internet for the rehabilitation of my voice problems.	0 (0)	1 (10)	9 (90)	0 (0)	0 (0)	10 (100)	-2.121	0.034*
10.	Telepractice can replace a face-to-face voice therapy.	1 (10)	4 (40)	5 (50)	0 (0)	1 (10)	9 (90)	-2.041	0.041*
11.	Telepractice will allow easy access to healthcare.	0 (0)	1 (10)	9 (90)	0 (0)	0 (0)	10 (100)	-2.00	0.046*
12.	Telepractice will save me travelling	0 (0)	0 (0)	10 (100)	0 (0)	0 (0)	10 (100)	-1.732	0.083

	time & money.								
13.	Telepractice may benefit all patients alike.	1 (10)	6 (60)	3 (30)	0 (0)	6 (60)	4 (40)	-1.134	0.257
14.	I would prefer to have a telepractice consultation with the speech pathologist over a face-to-face consultation.	0 (0)	3 (30)	7 (70)	0 (0)	0 (0)	10 (100)	-2.070	0.038*
15.	I would prefer to have a face-to face consultation with the speech pathologist over a telepractice consultation.	0 (0)	7 (70)	3 (30)	5 (50)	2 (20)	3 (30)	-1.027	0.305
16.	I would prefer to have a combination of face-to-face and	0 (0)	1 (10)	9 (90)	1 (10)	1 (10)	8 (80)	-1.633	0.102

	telepractice consultations with the speech pathologist.

Notes: The italics and brackets indicate pre-/post- wording changes between the pre- and post-therapy conditions.

* Statistically significant difference.

Figure 1. Illustration of the telepractice system equipment and setup

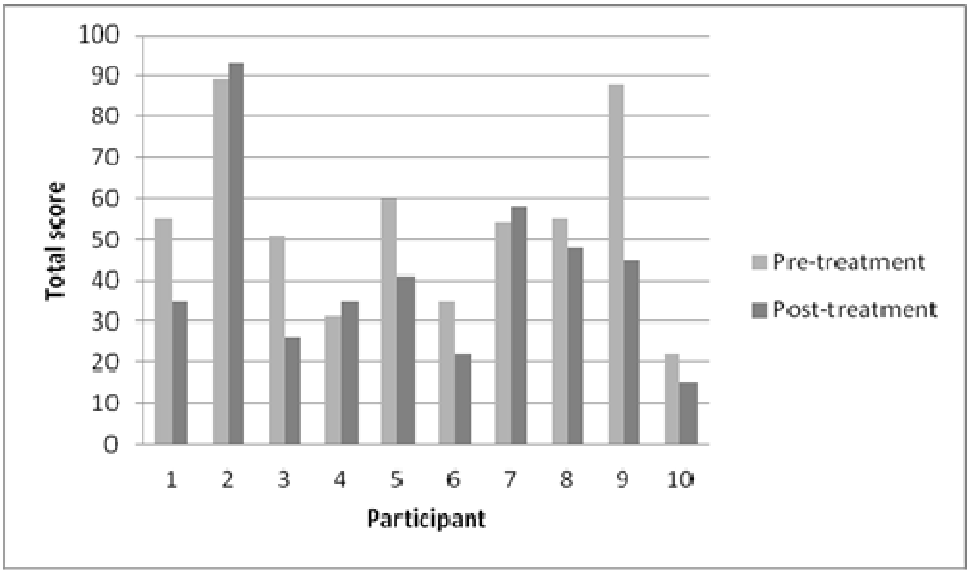

Figure 2. Individual results of Voice Handicap Index scores preand post-treatment.