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PUSHING EXERCISE PROGRAM TO CORRECT GLOTTAL INCOMPETENCE

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Introduction

The pushing method is a voice therapy technique designed to reduce glottal inefficiency by increasing glottal closure. This method capitalizes on the mechanism of primitive closure and the well known principle that in order to build up thoracic pressure it is necessary to close the larynx. Thus the technique takes advantages of the responsive adduction of the vocal fold which takes place synchronously when the neck and the upper arm are consciously strained in any manner that requires in intrathoracic pressure build up. The method is said to have been used for the first time in 1955 when Froeschels applied to treat unilateral vocal fold paralysis. The method is now widely recommended as an effacious mode of treatment for incomplete closure of the glottis 1-5). Yet, data documenting how the technique works or its specific usefulness is scarce or non-existent. Moreover existent descriptions are frequently vague concerning objective measures for patient inclusion and determination criteria.

To date over a period of three years 29 patients (17 paralysis and 12 sulcus vocalis) have been treated with this technique. Treatment results with sulcus vocalis were poor. In cases of unilateral vocal fold paralysis pushing was generally combined with phonosurgery and was considered to be an effective form of treatment. The purpose of the present paper is to describe the evolved technique and to illustrate the changes that occur with three case studies.

METHODS

Subjects

Three cases with incomplete grottal closure and subsequent vocal dysphonia characterized by an asthenic breathy quality were selected for study The cases included: a 77-year-old male with a paramedian paralysis of the left vocal fold secondary to cancer of the lung; a 59-year-old female telephone operator with incomplete closure due to a sulcus vocalis; and a 45-year-old business man with recurrent laryngear nerve paralysis of unknown etiology.

Pre-and post-treatment examinations

Prior to the initiation of treatment a battery of tests of vocal function were administered. Tests included an audio recording which was subsequently used for perceptual and acoustical

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analysis, a stroboscopic examination, and a phono-laryngograph(PLG) to provide measures of flow rate, intensity, and fundamental frequency. For the audio recording the assessment tasks included oral reading of a short paragraph, maximum phonation time(MPT), physiological vocal range, and esey phonations of /e/ and /i/. The PLG recordings were made during phonation of loud, normal, quiet, high pitched and low pitched productions. The entire battery of tests was repeated every four weeks, and the PLG recordings during tasks of maximum loudness were repeated prior to every therapy session.

The therapy sessions were 20-30minutes in length and conducted once a week until consistent training effect was observed. Training effect was defined as increased intensity and increased glottal closure. If no training effect was observed after three months of voice therapy the subject was considered for phonosurgery. The training paradigm used here required a feedback or monitoring method by which the examiner could make an objective evaluation of the training effect and the subject could easily understand the objective and the target of training. Specific targets of increased closure or loudness were set for each stage of treatment(Table 1). The monitoring equipment included: a Sony Digital Voice Recorder (Model DTC-1000ES); a RION Phonolaryngograph (PLG model SH-01); a Kay Elemetrics 6095/6097 VISIPITCH; and a Kay Elemetrics laryngograph also referred to as an Electric Glottograph (EGG).

Table 1 SETTING TARGETS FOR PUSHINGEXERCISE PROGRAM

1) Establish intensity level during easy phonation
2) Establish intensity level with strained voice
3) Establish intensity level with digital manipulation
4) Synchronize timing of pushing with glottal closure with targets 10 dB greater than that achieved with easy phonation
5) Establish intensity level of phonation produced as loud as possible with pushing
6) Establish intensity level produced for syllables, words and sentences with hard glottal onset

The PLG was used to display in real time the intensity, frequency and flow rate. A scale on the screen assisted both the clinician and subject in making measurements of these parameters. The VISIPITCH displayed intensity and frequency of the voice on the screen. With the EGG, the pattern of the glottis could be inferred when electrodes were placed on both sides of the ala of the thyroid cartilage.

All treatment programs were initiated in the same manner. An outline of the major steps of the overall treatment program is shown in Figure 1 and an outline of the steps specific to the pushing exercise program in Table 1 and Figure 2. The first step of the treatment was to briefly explain the operations of the larynx to the subject by using anatomical illustrations. This was

MAJOR STEPS IN PUSHING EXERCISE PROGRAM FOR CASES OF INCOMPLETE GLOTTAL CLOSURE

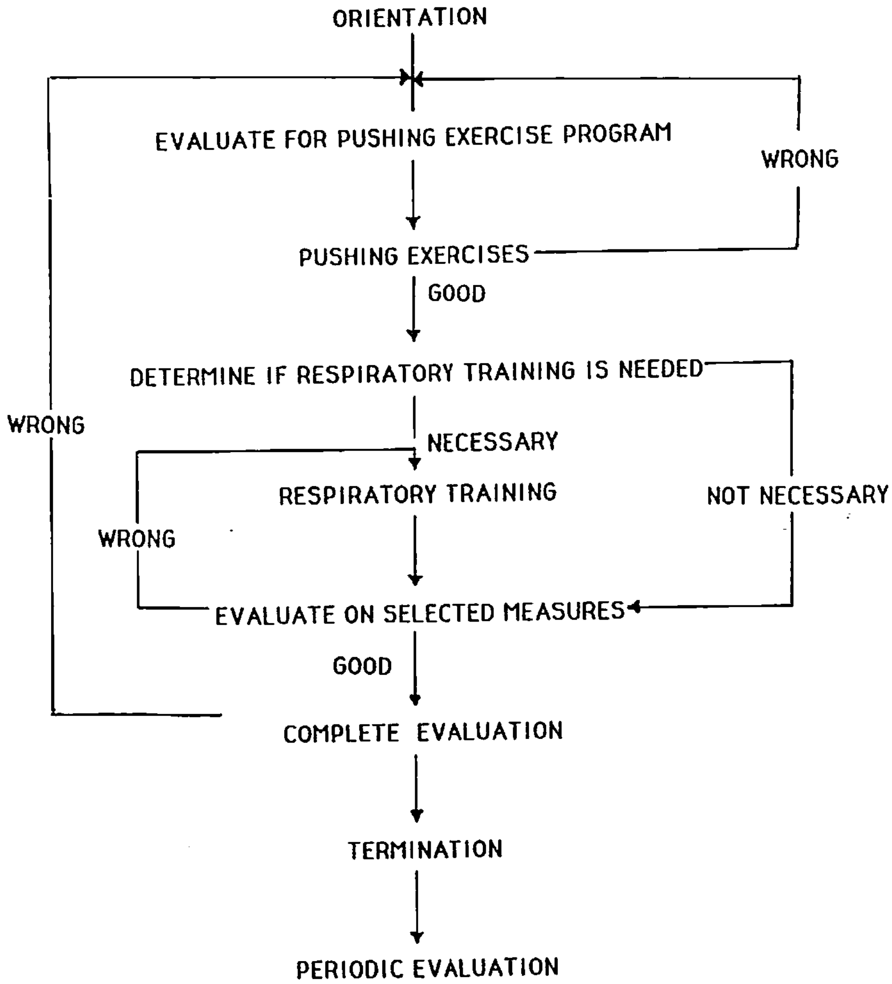

Figure 1. Block diagram depicting the major steps in pushing exercise procedures.

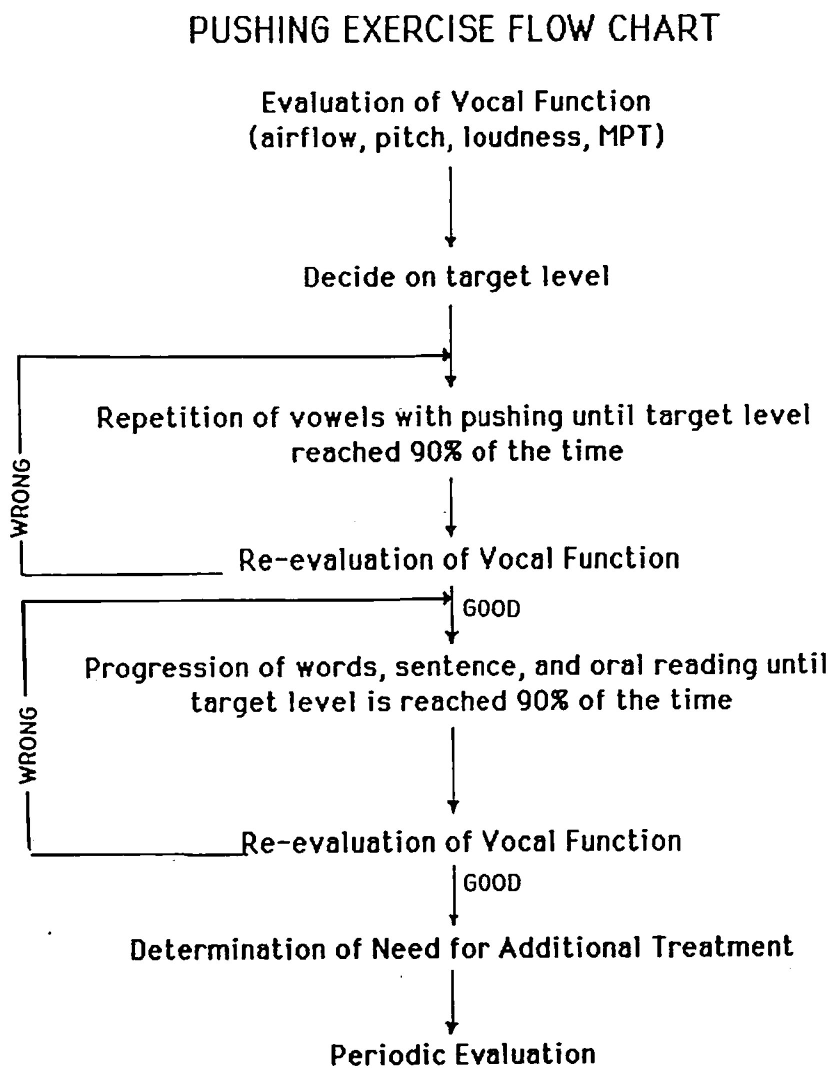

Figure 2. Flow chart of pushing exercises demonstrating the integral role of evaluation of vocal function in this treatment paradigm.

followed by an explanation of the objectives, and a demonstration of the equipment used for monitoring.

A RION contact microphone was placed on the external neck wall at the midline of the thyroid cartilage approximately at the level of the vocal folds. The subject was asked to produce an easy phonation at normal pitch and loudness levels. The intensity level prodused during this easy phonation was used as the baseline against which target levels and measurements of change could be made.

The first target level was established by determining the levels of loudness the subject was physiologically capable of producing without using any pushing technique. Determining this physiological level helped determine if the patient was a good candidate for voice therapy. First the subject was asked to produce a strained voice in the absence of any pushing motion. The intensity level produced during this strained condition was recorded. The examiner then asked the subject to phonate again while the examiner used digital manipulation to compress the thyroid ala. The greatest intensity level achieved, whether by digital manipulation or strain without pushing was used as the initial target level. The next step of treatment was conducted to synchronize the pushing motions of the upper limbs with the closing motion of the vocal folds. The purpose of this step was to facilitate reaching the target level without digital manipulation or strain. Subjects were shown four different ways to achieve the target closure. These methods included: pushing by interlacing hands and pulling outward; putting palms togetter and pushing inward with as much force as possible; sitting in a chair while grabbing the edge of the seat of the chair and pulling upward; pushing the head forward against the resistance provided by the examiners hands placed on the forehead of the subject. The subjects were asked to practice these techniques with the clinician in order to help them select the technique that seemed to work best and they felt most comfortable doing.

At this stage of treatment, emphasis was placed on synchronization of the pushing motion and the adduction movement of the vocal fold. The monitoring equipment was used to determine if there was synchronization of the pushing and vocal fold approximation. When the synchronization failed (determined by no change in EGG wave form, unchanged airflow, and unchanged intensity level) video endoscopic recordings were made for both good synchronization with the pushing motion and bad syncronization. These recordings were used to provide a visual explanation of the target goal until the subject appeared to be able to achieve some synchronization. After synchronization was achieved in at least 90% of the trials the subject was directed to increase the length of phonation. During this task the EGG wave patterns were used for reference. While the subject was pushing, he/she was asked to phonate short repeated productions of the vowel /a/. The subject monitored the duration of these productions and was asked to successively approximate longer and longer durations until the target length was achieved. Figure 3 illustrates samples of successive approximations of increased durations while maintaining a constant intensity level.

Finally, while pushing, the subject was asked to phonate as loudly aspossible. The target of the intensity level was 20 dB louder than the baseline recording. Once the subject was able to achieve this goal, training proceeded from sustained vowels, to dipthongs, syllable repetetion, oral reading of short sentences, and finally to connected speech.

RESULTS OF THREE CASES

Three cases are used to provide illustrative examples of the changes co-occuring with this treatment program. Data documenting these changes appears in Figures 3-7. In the first case of a 77-year old male with unilateral paralysis the baseline intensity level of 71 dB was unchanged with digital manipulation (even though the glottal waveform more closely approximated normal during this condition), and increased to 81 dB with rapidly produced short repetitions of /a/. Using 81 dB as the target level pushing exercises were initiated. After he demonstrated good synchronization with the pushing exercises, he was asked to produce /a/ as loudly as possible while pushing. During this loud repetitive condition the intensity level increased to 87 dB. This was practiced with pushing until the subject was able to consistently hit the target level. He was then asked to extend the length of phonation while maintaining the loudness. This portion of the treatment program took three months for this patient to achieve. At the end of this period, techniques for generalization of target levels to produce similer levels of loudness in connected speech was attempted by moving from sustained vowels to syllables and short phrases, and to increasingly difficult tasks. The final evaluation showed an overall change in intensity form the pre-treatment condition of 71 dB to a post-treatment condition of 93.7 dB. While this indicates a significant improvement it is noteworthy that the patient was unable to carry over the 93 dB level into conversational speech.

The second illustrative subject was a 59-year-old telephone operator for 30 years who complained of abreathy voice of 20 years duration. Laryngoscopic examination revealed aglottal gap secondary to bilateral sulcus vocalis. She was treated with pushing exercises for 10 months using the EEG and PLG for visual feedback. Over this period improvements were recorded in MPT (5 to 28 seconds), SPL (20dB), and glottal closure. Data documenntng differences co-occuring with training are illustrated in Figure 5. The top chart shows the voice wave pattern and the EGG wave pattern without pushing in contrast to the middle column with pushing where the waveform more closely approximates that of the normal speaker shown in the bottom graph. Without pushing, the peak is sharp and, compared to the normal speaker the duration of the glottal closure period is shorter. When pushing is applied, the glottal waveform more closely approximates normal as evidenced by a more rapid risetime, rounder peak, quicker glottal

Program for Pushing Exercise ①

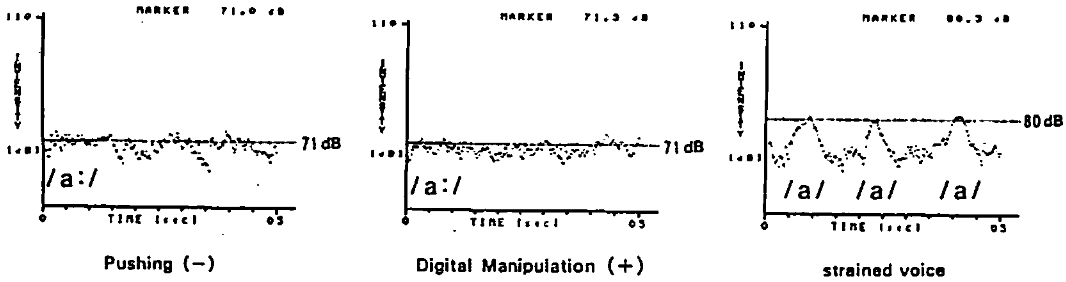

Figure 3. Intensity traces for the vowel /a / produced by the same 77-year-old male during a non-pushing task, digital manipulation, and during repetition of the vowel /a/ produced with a strained voice.

Program for Pushing Exercise ②

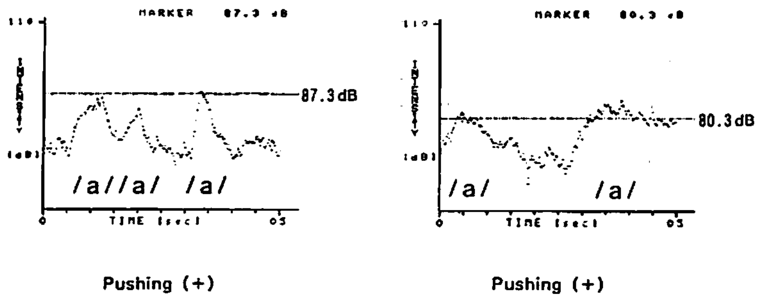

Figure 4. Intensity traces for a 77-year-old male after he demonstrated synchronization near the beginning of training on the traces on the right and on the left after several weeks of training producing as loud as sound as possible while pushing.

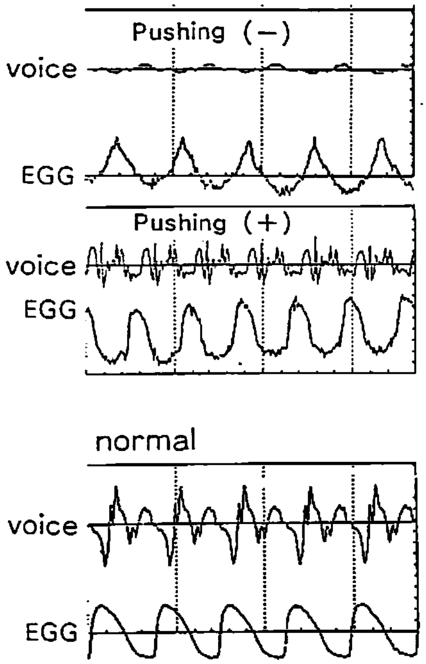

Figure 5. Voice and EGG tracings for a 59-year-old telephone operator are shown in the top four traces compared to the traces of a normal speaker in the lower two traces. Both the voice and EGG patterns approach normal after training during the pushing task-illustrated in the middle trace-and in the upper two traces demonstrate glottal incompetence during the non-pushing task.

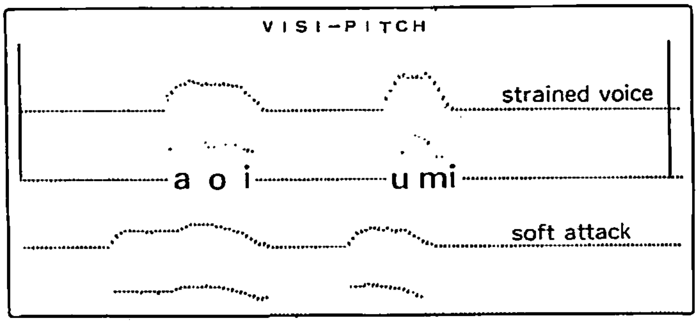

Figure 6. VISIPITCH tracing of a 45-year-old male producing dipthong and VCV utterances during a strained and soft vocal attack production.

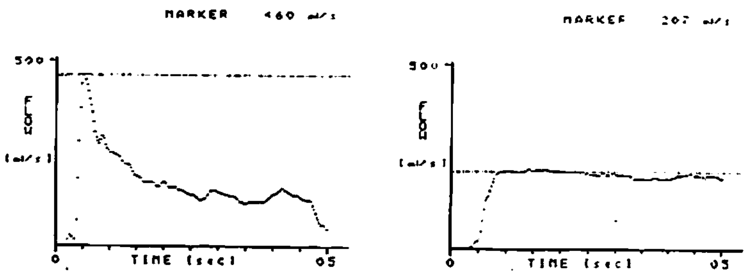

Figure 7. Airflow traces from a Phonolaryngograph produced while the patient was attempting to produce a steady exhalation. At the beginning of training the subject was unable to successfully complete the task as seen on the left hand side of the figure. The subject expended high airflow at the beginning of phonation and was unable to sustain phonation. After visual feedback training he achieved better exhalatory control and was able to sustain phonation longer using lower steady flow rates.

closure, and longer closed phase. In addition, the amplitude of the vocal wave pattern is suggestive that pushing exercise increased the vocal intensity. This was confirmed with PLG measures of vocal intensity demonstrating that the intensity level changed form the pre-treatment level of 73 dB to a post-treatment level of 93dB. In this subject the treatment took two weeks to reach the first target level, and 14 weeks to reach termination criteria. Termination criteria was defined as improved phonation and patient satisfaction. The voice was improved but not normal at the termination of treatment.

The third case was a 45-year-old male business man who had a congenital recurrent laryngeal never paralysis of unknown etiology. His voice was relatively high pitched and asthenic. Laryngoscopic examination revealed his left vocal fold was fixed in a paramedian position. He was unable to significantly increase his loudness with voice training. Radiographic examination revealed his left vocal fold was significantly thinner than the right (approximately 2:5mm). The left vocal fold was medialized with a transcutaneous silicone injection . Surgery improved glottal closure but his voice continued to be weak, high pitched and breathy. A pushing program using the PLG and VISIPITCH for visual feedback was initiated. It took this patient 7 months to reach tremination criteria. At the end of treatment he had increased loudness (an average intensity change of 7dB) and a lower pitched voice. He also exhibited better phonatory control as indicated indicated in the airflow traces shown in Figure 8.

DISCUSSION

The purpose of vocal training for the breathy and asthenic voice due to a large glottal chink it to recover the intrinsic potential of larynx, to encourage compensatory movements of, and to maximize the giottal closure so that the subject can learn how to produce louder, longer, less breathy and better quality voice production. Indications for this vocal training includes all of the glottal chink, incomplete closure, based voice disorders, namely, unilateral vocal fold paralysis, sulcus vocalis, vocal fold atrophy due to aging, and glottal chink due to unknown causes.

Naturally, not all the above mentioned indications realize voice improvements through voice training alone. Cases in which incomplete glottal closure remain unchanged after three months of vocal training are indications for phonosurgery including thyroplasty and vocal fold augmentation by teflon, silicon, collagen or some other suitable implant. Following surgery, depending on the condition of the voice, compensatory application of vocal training or other parallel vocal training technique, or further phonosurgery may be necessary.

In case of unilateral vocal fold paralysis, natural recovery may take place within three to six months after onset. Vocal training should be done during this period to recover the compensatory capcity of the healthy side of the vocal fold. Once it has been determined that incomplete glottal closure may not be improved further through vocal training, phonosurgery should be carried out. Again, vocal training is recommended for postoperative functioning as well.

Problems in voice training

The methods described here and illustrated by example of three subjects with incomplete glottal closure demonstrate improved adduction as evidenced by increased intensity and glottal waveforms that approximate normal. While this appears to provide some preliminary documentation of the efficacy of this technique and the value of using instrumentation to enhance treatment, it clearly needs further study to determine when the techniques would be most beneficial.

During the course of developing the vocal training program several problems were encountered that influenced the way the program was developed, and that should be taken into consideration in treating patients with incomplete glottal closure. These problem included: insuring that subjects recognized target levels early in the programs by appropriate use of feedback; carry-over to coversational levels was not attained by the pushing technique alone and additional carry over exercises had to be incorporated into the program; extraneous compensatory movements were developed; and in some instances inflammation developed secondary to the training because of excess effort necessitating modifying the program to be less strenuous. This latter point underscores the importance of careful monitoring of the laryngeal condition throughout the training program.

In the treatment paradigm described here emphasis was placed on synchronizing timing of the pushing motion and glottal closure. Glottal closure was enhanced in the initial stage of treatment with digital manipulation. Thus, initial productions were produced at a lower intensity level in order to work on the timing components of the phonatory gesture. Perceptual judgements of a louder less breathy voice could be used to determine whether or not closure was improved but when changes were small the validity of the judgements were questionable. Consequently, videoendoscopy and monitoring of EGG and PLG wave patterns were used to make objective evaluations. Regardless of the monitoring technique selected it was essential that the patient recognized whether or not he/she hit the appropriate target level (ie. when the timings of the pushing motion and the glottal closure were matched). Such recognition appeared to accelerate the improvement and subsequent generalization to more complex levels of phonation. Nevertheless, training frequently took several months to reach termination criteria. Ways to reduce the training time need to be investigated.

The carry-over or generalization while not focused directly on pushing was pertinent to the final results and centered on increasing intensity levels. The intensity level was monitored from the PLG screen while training proceeded from short vowels to dipthongs and then to sentence. When the patient reached the level of sentence reading training, the VISIPITCH indicator was used. The VISIPITCH screen was divided into two channels in order that the clinician could provide a visual model of the target level for the patient to match on the other channel.

Treatment was terminated when the patient was satisfied and/or able to phonate without pushing or obvious strain or after three months of training when no improvement was observed, or when no further improvement seemed likely to occur. This criteria may have contributed to the longer training time necessitated by this training paradigm compared to the short-term treatment described in the literature 1-5.

The treatment program was modified if the patient complained of laryngeal pain or if any inflammation of the laryngeal tissues was noted. Intensive training of strained voices may result in such side effects as pain accompanying phonation or a reactive inflammation. In such a case, training should be suspended, or the duration of training periods shortened. Generally these problems can be avoided by careful monitoring of the patient's performance and limiting home practice to no more than 10 minutes of training at any one session. Occassionally, the pushing seems to promote compensatory movements resulting in hyperfunction of the supraglottal structures and approximation of the ventricular folds. By using videoendoscopic feedback the patient can work to achieve closure without excessive effortful closure of the supra-glottal structures. Additionally, attempts to close the glottis with a loud laugh appears to help reduce the hyperfunction. In some instances the only means of achieving closure necessitates use of the ventricular folds. In these instances the patient generally must expend a substantial amount of effort to produce voice, and even though the voice may be improved the cost in effort is too high and phonosurgery may be indicated.

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