The Lubit Palatal Exerciser: A Preliminary Report

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Failure to effectively seal off the oropharynx from the nasopharynx during phonation, due to inadequate contact of the soft palate with the posterior and lateral walls of the pharynx, results in articulatory defects and hypernasality. These speech disorders cannot be corrected by extensive speech therapy of the traditional type and so either prosthetic or surgical procedures must be resorted to. However, these procedures fail to improve speech in at least one out of every ten children (*5, 10, 20*). This is a clear mandate for the development of additional therapeutic procedures to deal with the problem. In response to this challenge an appliance has been developed to mechanically exercise the soft palate. This appliance is called Lubit Palatal Exerciser[1], often referred to as LPE.

Description of the Exerciser

The Lubit Palatal Exerciser consists of three basic parts: an oral portion, a connecting air tube, and a hand bulb (Figure 1). The oral portion has an inflatable bag imbedded in an acrylic bite block (Figures 2 and 3). The inflatable bag is made of hand-dipped latex rubber, pleated on three sides, with a thin tube, six inches in length, extending from the fourth side. This thin tube is connected to a larger rubber tube, the end of which is connected to a rubber hand bulb with a lock-nut attachment. The acrylic bite block holds the exerciser in proper position within the mouth and supports the inflatable bag during its use (Figure 4). Air can be forced into or released from the bag, thus inflating and deflating it, by alternately squeezing and releasing the hand bulb while alternately closing and opening the lock-nut.

When the LPE is properly positioned and inflated, the soft palate will be displaced posteriorly and superiorly and pressure will be exerted against the posterior pharyngeal wall by the inflated bag (Figure 5).

The child is instructed to close the lock-nut, place the oral portion

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[1] Patent pending.

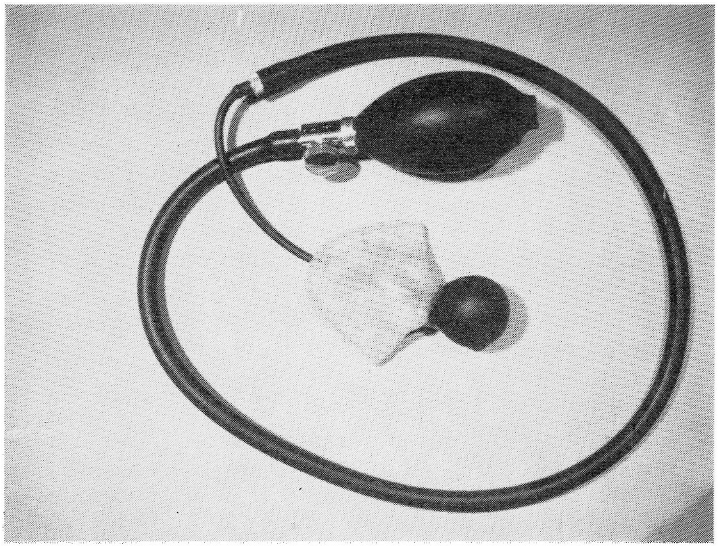

FIGURE 1. The Lubit Palatal Exerciser (LPE).

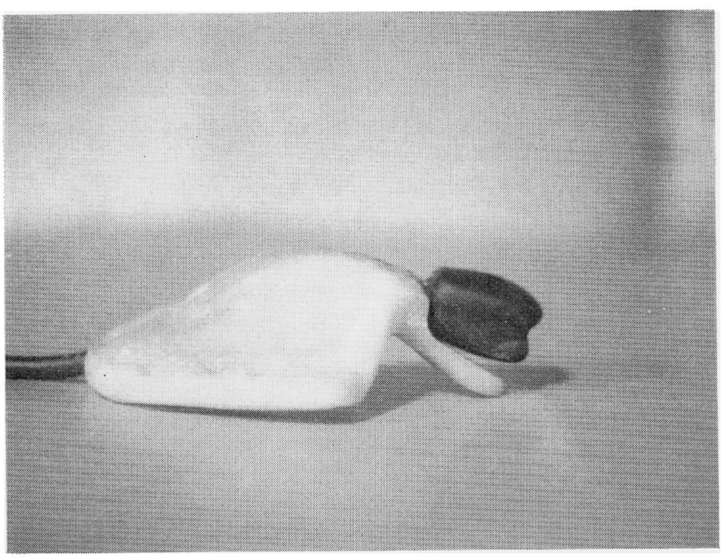

FIGURE 2. Side view of LPE with latex bag deflated.

into the mouth and bite down firmly upon the bite block. Then the hand bulb is squeezed several times, inflating the bag to the point at which any further inflation of the bag would displace the oral portion, forcing the child's mouth open. At this point the lock-nut is opened and, as the air escapes, the bag deflates. The bag is alternately inflated and deflated from 25 to 50 times during each exercise session, five to six such sessions taking place every day.

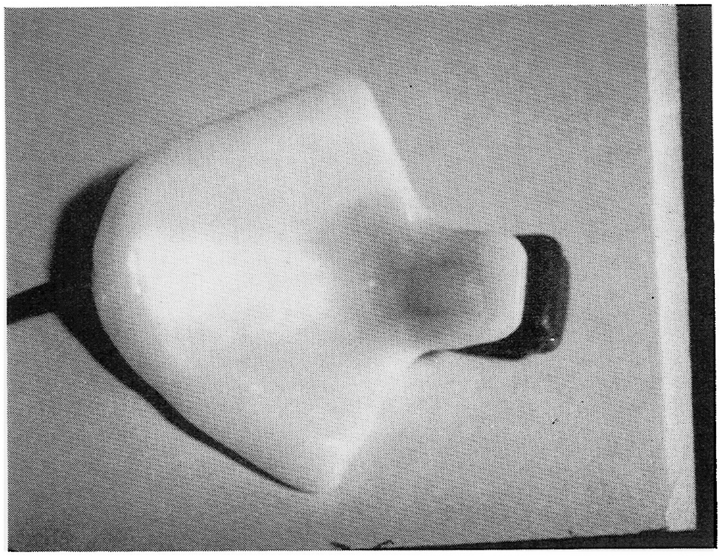

FIGURE 3. Inferior view of LPE. Note reinforcing wire in pharyngeal extension.

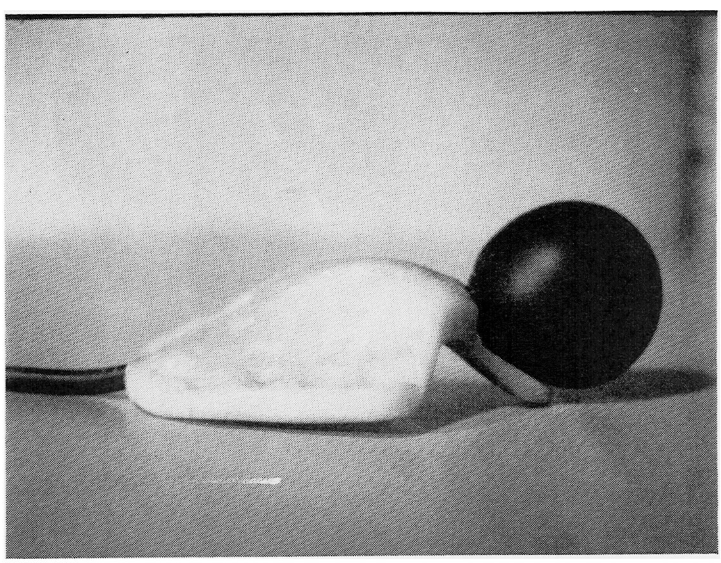

FIGURE 4. Side view of LPE, with latex bag inflated.

Evaluation Procedures

To help evaluate the changes produced by LPE therapy, the following four procedures were selected.

(*a*) *Cephalometric measurements*. Serial lateral roentgenograms were taken while the patient was phonating the high vowel sound "ee" (*4, 6, 9*), selected to demonstrate maximum movement during velo-

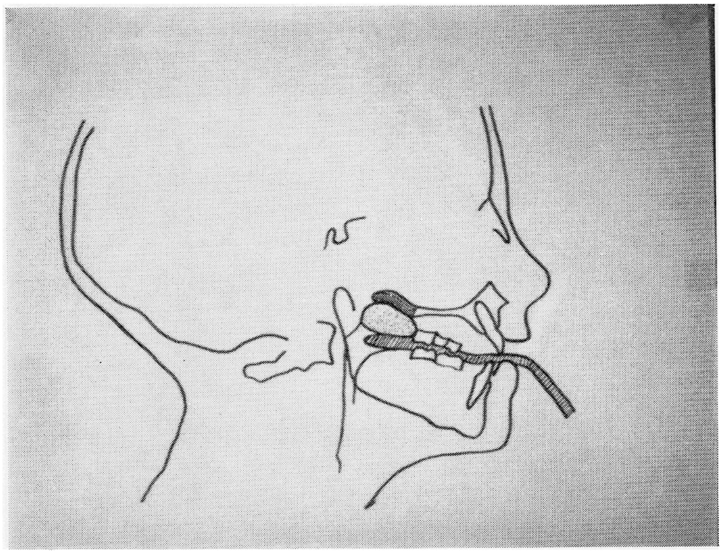

FIGURE 5. Tracing of cephalometric roentgenogram while patient is inflating the LPE. Note contact of the inflated latex bag with the posterior superior portion of the pharynx, and the displacement of the soft palate.

pharyngeal closure. The following anatomical landmarks were traced from the roentgenograms: sella turcica, nasion, pterygomaxillary fissure, posterior pharyngeal wall, soft and hard palate. A straight line representing the palatal plane was drawn connecting the anterior nasal spine with the posterior nasal spine and extended to the posterior pharyngeal wall (Figure 6). A perpendicular line was dropped from the pterygomaxillary fissure onto the palatal plane. A diagonal line was drawn, connecting the point of intersection of the perpendicular line with the palatal plane to the most inferior tip of the soft palate. The point of intersection of the perpendicular line with the palatal plane was labeled point A. The point of intersection of the palatal plane with the posterior pharyngeal wall was labeled point B. The point of intersection of the palatal plane with the posterior surface of the soft palate was labeled point C. The point of intersection of the diagonal line with the inferior tip of the soft palate was labeled point D. Measurements were taken of the distances in millimeters between the points A and B, A and C, and A and D. Line AB is used to represent the depth of the nasopharynx. Line AC is used to represent the horizontal length of the soft palate. Line AD is used to represent the vertical length of the soft palate.

(*b*) *Speech ratings*. Tape recordings of connected speech samples were taken at monthly intervals, using a Roberts, model 400, four channel tape recorder with a Shure, model 545S, dynamic microphone. For the purposes of articulation testing we used a speech sample con-

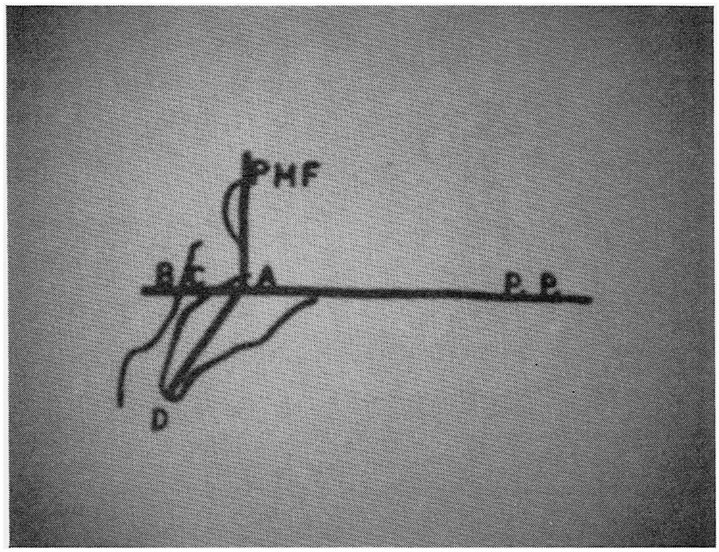

FIGURE 6. PMF, pterygomaxillary fissure; PP, palatal plane; points A, B, C, D, described in text; AB, depth of nasopharynx measured in millimeters along the palatal plane; AC, horizontal length of soft palate measured in millimeters along the palatal plane; AD, vertical length of soft palate measured in millimeters along the palatal plane.

sisting of thirteen sentences containing a total of 149 consonant sounds devised by Van Demark (*18*), so constructed as to approximate the relative frequency of occurrence of the various consonant sounds in the English language. Articulation was judged on a right-wrong basis by a panel of five experienced speech therapists (*14*). A rating of proficiency of articulation was obtained by computing the number of misarticulations of the total number of consonant sounds within the sample. The judges rated nasality by listening to the backward playing of the speech samples. Hypernasality was rated on a rising five point scale (*15, 17*).

(*c*) *Pressure ratios.* Oral manometer ratios, taken with a constant bleed, were obtained in the conventional way (*16*).

(*d*) *Spectrographic analysis.* This analysis was used to obtain a quantitative acoustical analysis of the physical properties of speech before and after LPE therapy (*2, 7, 11*). The sound spectrograph is a visible pattern of the power components of speech. Its horizontal axis shows the dimension of time, its vertical axis the frequency component, and the blackness of print represents intensity. Cross sectional cuts of the tracings allow the relative intensity of different frequencies at a specific instant in time to be quantitated. As pharyngopalatal competency increases, the intensity of the high frequency bursts, principally the plosives, fricatives and affricates, also increases (*1, 11*). The spectrographic pattern depends upon functional interplay of the speaker's articulators and vocal cavities. Changes in the functional use of the articulators and the shape and size of the resonating cavities will change the spectrographic pattern of the individual. The spectrographic analysis was performed by Voiceprint Laboratories.[2]

Case Report. At the present time we have 28 patients under active LPE therapy. We have noted many beneficial changes in both the palatopharyngeal structures and the speech in each and everyone of these patients. However, for the purpose of this introductory paper on LPE therapy, we have selected one patient, Karen, to show in detail the changes we have obtained with just six months of exclusive LPE therapy.

Karen is an attractive, alert, nine-year-old white female, who was born with an incomplete cleft of her secondary palate, extending throughout the entire soft palate and into the posterior third of the hard palate. At three and one-half years of age a Wardill surgical procedure was performed which left her with a movable but somewhat short soft palate. Speech evaluation, including the Henja Articulation Test, indicated many articulatory distortions and severe hypernasality. Cephalometric roentgenograms showed an isthmus of three millimeters between the posterior pharyngeal wall and the soft palate during the phonation of the high vowel sound "ee". Audiometric pure tone sweep check tests, Rutgers Drawing Test, Peabody Picture Vocabulary Test, and Binet Test, all revealed the patient to be within normal limits. After five years of speech therapy it was felt that no further gains could be made, so we decided to place her on LPE therapy prior to considering surgical or prosthetic procedures. When the LPE therapy was instituted, all speech therapy was discontinued.

The following results were obtained.

Serial Lateral Roentgenograms. The serial cephalometric tracings showed the following results. The depth of the nasopharynx, as measured by line AB, remained constant at ten millimeters. Since point A is relatively constant, any decrease in the AB measurement would represent an anterior movement of the posterior pharyngeal wall. We can therefore state that in this patient there was no additional anterior movement of the posterior pharyngeal wall during phonation.

The horizontal length of the soft palate, as measured by line AC, increased. At the onset of therapy, it measured five millimeters in length. After one month of therapy, it measured eight millimeters in length. After three months of therapy, it measured ten millimeters in length, making it equal to the depth of the nasopharynx. Once the measurement of AC equaled that of AB, it could no longer increase, since the length of the soft palate was now equal to the depth of the nasopharynx. As the length and thickness of the soft palate continued to increase, the contact of the soft palate with the posterior pharyngeal wall changed from a point contact to a broad surface contact. After three months of therapy, we merely had a point contact, while after five months of therapy, we found a broad surface contact. This broad surface contact extended for a distance of nine millimeters (Figure 7).

While the horizontal length of the soft palate was increasing, its vertical length was decreasing. This represented a change in the contour of the soft palate during phonation. The soft palate was now elevating superiorly and extending posteriorly to a much greater extent during function (Figure 8). A clear picture of this change can be seen by superimposing the tracings of the roentgenograms taken before and after six months of LPE therapy (Figure 9). This composite tracing was made by superimposing the palatal planes and the

[2] Voiceprint Laboratories, Inc., Somerville, New Jersey.

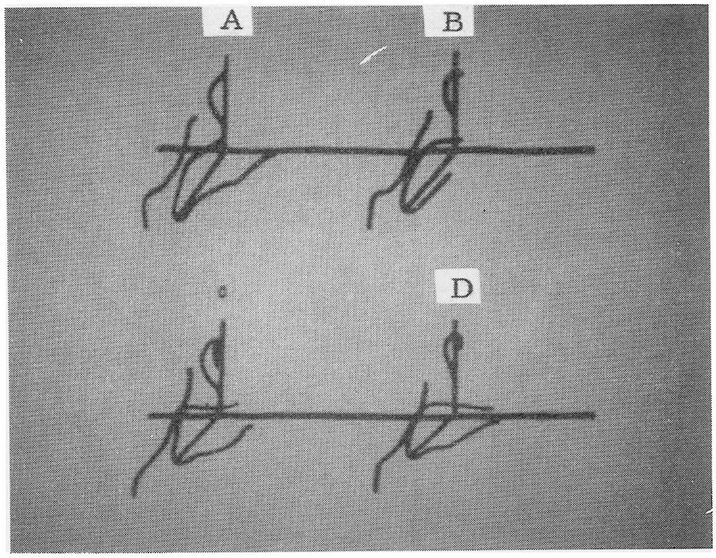

FIGURE 7. Lateral cephalometric roentgenogram tracings of Karen phonating the high vowel sound "ee", showing changes in the relationship of the soft palate to the posterior pharyngeal wall. A represents pre-LPE therapy; B, after one month of therapy; C, after three months; and D, after five months.

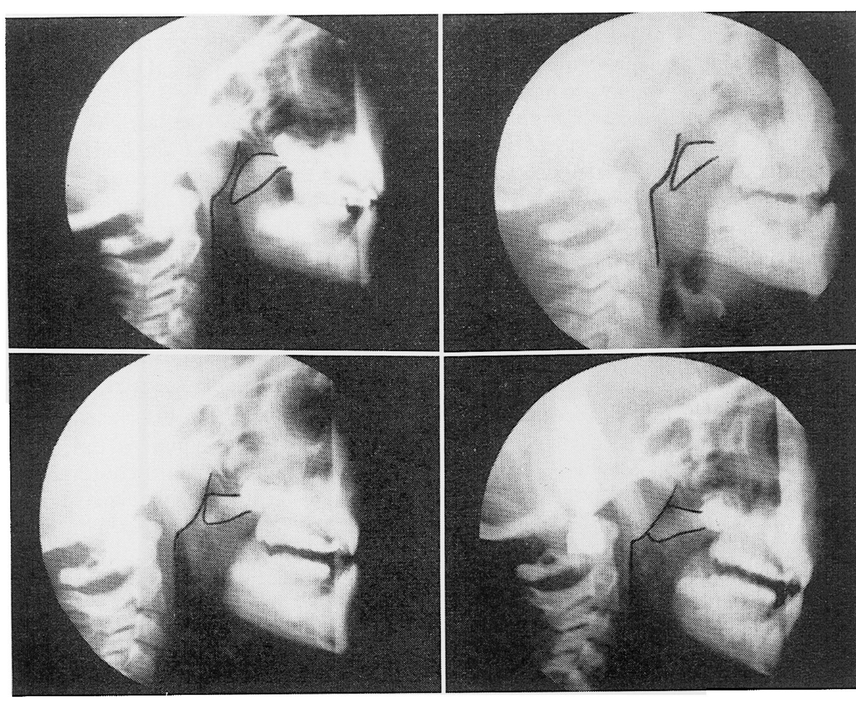

FIGURE 8. Lateral cephalometric roentgenograms of Karen, phonating the high vowel sound "ee", showing changes in velopharyngeal closure. Upper left, before LPE therapy; upper right, after one month of therapy; lower left, after three months; and lower right, after five months.

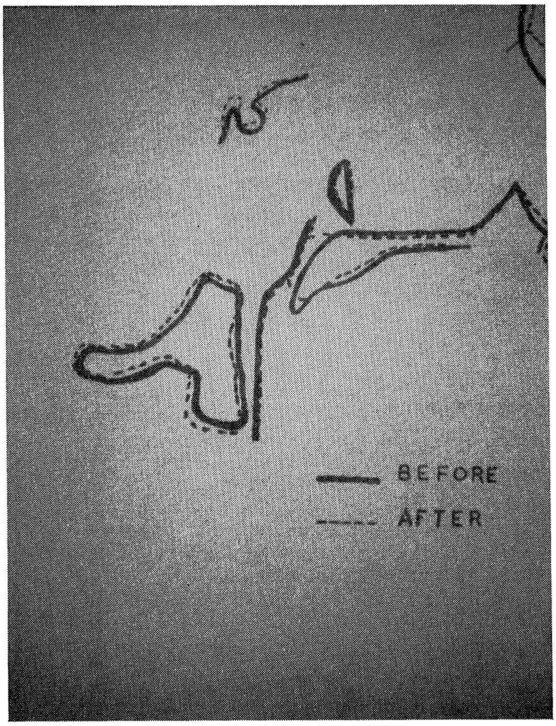

FIGURE 9. Superimposed tracings of lateral cephalometric roentgenograms of Karen, phonating the high vowel sound "ee", before and after five months of LPE therapy. Tracings are superimposed on palatal plane and pterygomaxillary fissure.

pterygomaxillary fissures of the individual tracings. The posterior pharyngeal wall remained in the original position and velopharyngeal closure was effected by the changes in the soft palate.

Speech Ratings. All the judges were in close agreement on the percent of improvement of articulatory proficiency. The mean rating demonstrated a 41% improvement. Three of the five judges rated the percentage of improvement of articulatory proficiency within one percent of this mean value. However, the nasality ratings showed no statistically significant difference. We must interpret these results by stating that the method we used for testing nasality was a highly inaccurate and subjective system (*3*). The reason we obtained such random results was probably due to the fact that each judge had his own interpretation of the meaning of nasality and we failed to pretrain our judges. In the future, we shall pretrain our judges and perhaps incorporate other means of testing nasality.

Oral Manometer Readings. Our original readings showed fifteen ounces of pressure with the nostrils open, against twenty ounces with the nostrils occluded. After six months of therapy the readings showed the same twenty ounces of pressure with the nostrils open and occluded, demonstrating a definite improvement in velopharyngeal valving. Even though the oral manometer readings indicate no nasal leakage, it does not necessarily follow that all hypernasality during speech will be attenuated. It is quite possible for the patient to show adequate velopharyngeal function while blowing and yet be unable to use her full valving potential during speech activities. Nasality is not the result of mere velopharyngeal functioning. Other factors, such as articulatory movements, pharyngeal structure and pharyngeal surface characteristics, relative laryngeal positioning and the acoustic nature of the glottal sound source, can all affect perceived nasality (*12*).

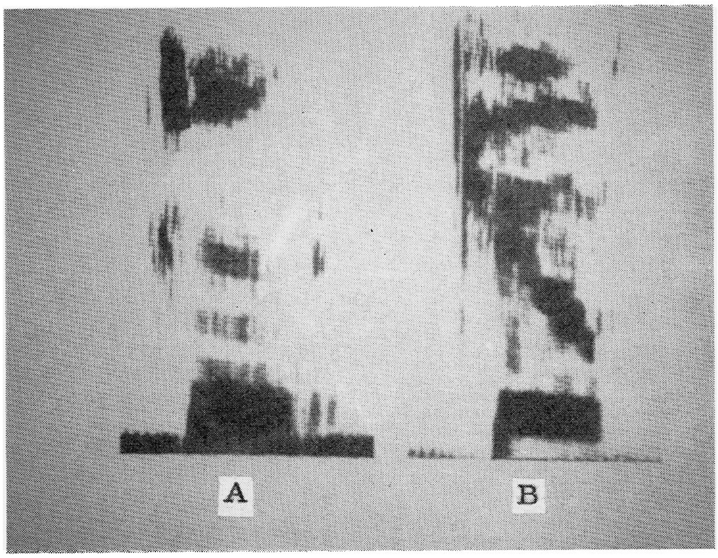

FIGURE 10. Broadband spectrogram of the word *to*, before and after six months of LPE therapy.

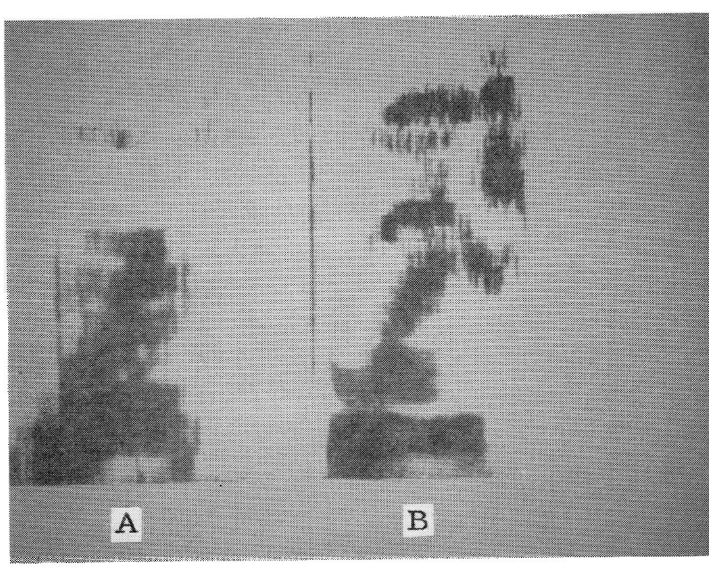

FIGURE 11. Broadband spectrogram of the word *boys*, before and after six months of LPE therapy.

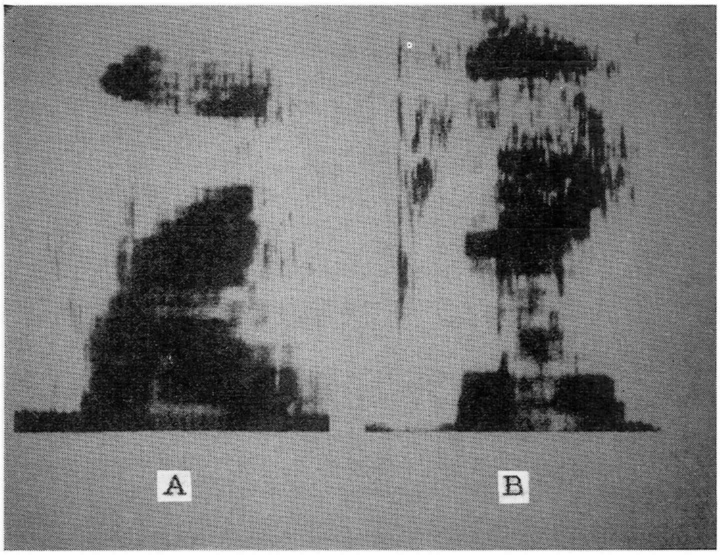

FIGURE 12. Broadband spectrogram of the word *play,* before and after six months of LPE therapy.

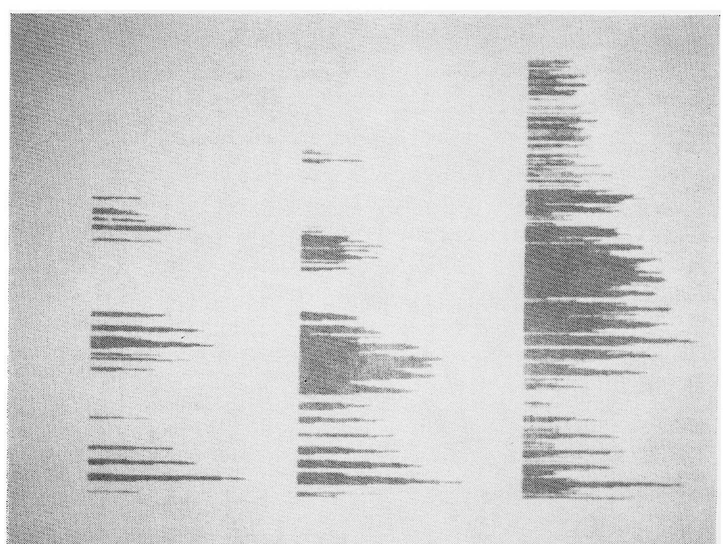

FIGURE 13. Narrowband spectrogram of the sound "e" (in the same phonetic context), before, after two months, and after six months of LPE therapy.

Spectrographic Analysis. A remarkable improvement in the spectral pattern was evident. The "after" speech showed a notable departure from the flat speech formants of the "before" speech (Figures 10, 11, 12, 13). The increased dynamic excursions of the "after" speech were more descriptive of normal sounding speech.

TABLE 1. Analysis of speech spectrograms. Items are recording date, formant rate change/time, pitch in cps, and syllabic rate.

Recording date	*FR/t*	*Pitch*	*Syl. rate*
11/65	8.9	275	1.73
4/66	13.5	305	2.28
12/66	15.3	308	2.72

The time rate change in speech formants steadily increased. The "after" speech formants progressed smoothly through each word utterance. In the "before" speech, the formants were often interrupted and changed slope during word utterance quite abruptly. These changes were interpreted to indicate better speech mechanism facility which allows the patient to change from one articulator pattern to another more rapidly, resulting in improved speech (Table 1).

The syllabic rate showed improvement with time, indicating greater confidence in changing from one phonetic element to another. This was another indication of improved facility for forming and uttering successive phonemes.

Discussion

Beneficial changes in velopharyngeal closure and speech, comparable to those reported for Karen, have been found in all 28 patients in our LPE program at the present time. The beneficial changes that the LPE therapy produced were obvious, but the means by which the LPE produced these changes was a matter of speculation. Many hypotheses have been suggested, and it is quite possible that various combinations of these may account for the improvements in any one patient.

It has been suggested that the LPE exerciser may be capable of producing the following beneficial effects: a) increasing the blood supply to the tissues, thus decreasing muscular fatigue; b) improving muscular tonicity, resulting in improved muscular functioning; c) stretching the soft palate, thus increasing its length; d) causing hypertrophy of the muscle fibers, resulting in a thickening of the muscle tissue; e) releasing adherent scar tissue from the underlying tissue, resulting in freer movement of the soft palate; f) decreasing adhesions that may be pulling or pressing on nerves, resulting in improved neuromuscular control of the soft palate; g) causing a feedback to the central nervous system, setting up a reflex arc, resulting in improved patient control of the soft palate; h) breaking up adhesions that may be present in the palatine aponeurosis, resulting in a freer movement of the soft palate.

Massaging muscles increases the blood supply to the area and carries away the by-products of muscular contraction. The effects of muscular fatigue are more rapidly dissipated and the power of spontaneous action is revived (*8*).

Muscle tonus is the state of continuous mild contraction of muscles. Muscle tonicity increases as the number of muscle fibers that are able to contract at one time increases. Exercises, in the form of muscular contraction and relaxation, are able to increase the number of muscle fibers that can contract at one time, resulting in increased muscular tonicity (*8, 19*). When a patient follows our instructions to inflate the latex bag to the point at which any further inflation would force the mouth open, he is actively resisting displacement of the LPE by the contraction of the muscles of the soft palate and pharynx. Thus, the LPE forces patients to actively contract the muscles involved in velopharyngeal closure, resulting in an increase of muscle tonicity and an improvement of muscle functioning.

That tissue can readily be stretched is well known. Many primitive societies have practiced physical deformations by stretching tissues. The best known of these are the Ubangi women of Africa, with their "duck-billed lips", stretched to as much as eight inches in diameter, and the Padaung women of Upper Burma, with their "giraffe necks", stretched to seven or eight inches in height. It is easy to understand, that as we inflate the latex bag and force the soft palate posteriorly and superiorly, the palatal tissues are stretched and elongated (Figure 5). This increase in the length of the soft palate improves velopharyngeal closure, resulting in improved speech.

Biochemical analysis has shown that myosin, the primary contractile element of muscle, increases in response to increased muscular activity (*19*). This increase in myosin is probably responsible for the cellular hypertrophy that occurs as a result of increased function. Exercising is a means of increasing muscle function, and muscles enlarge in response to it. The LPE, by forcing the muscles involved in velopharyngeal closure to contract and relax, exercises these tissues. The end result of these exercises is probably muscular hypertrophy with a thickening of the palatal tissues. A thickening of the soft palate allows better velopharyngeal contact and improved speech.

Direct massaging of scarred tissue can result in the freeing of the adherent scar tissue from the underlying tissue. This procedure is frequently used with amputee patients prior to fitting an artificial limb. The alternate inflation and deflation of the latex bag against the tissues produces an action which can be described as a "massaging of the soft palate". It is conceivable that in some cases, this massaging action is capable of freeing adherent scar tissue from the underlying tissue, resulting in a freer movement of the soft palate.

Minute adhesions which pull or press upon nerves can cause chronic and persistent motor neuron disturbances. Because of these disturbances, muscles may be unable to react normally to stimuli, manifesting weakness or paralysis (*8*). Through massage, it is possible to relieve these adhesions in selected cases, resulting in improved neuromuscular control of the soft palate.

When we stimulate the soft palate with the LPE, we may initiate a stimulus that is present in normal individuals, but may be dormant in others. Stretching a muscle can cause the stretch receptors or spindles to discharge, sending an impulse to the central nervous system, initiating muscular contraction (*13*). Repeated stimulation of the soft palate may cause a feedback to the central nervous system, setting up a reflex arc. Repeated stimulation reinforces the reflex arc, resulting in improved patient control of the soft palate. It must be remembered, however, that normal muscular contraction is dependent upon the integrity of the efferent and afferent nerves and their central connection. In the presence of permanent nerve damage, normal muscular contractions cannot take place.

The palatal aponeurosis, which is found in the anterior portion of the soft palate, gives attachment to the fibers of the levator veli palatinis and pharyngopalatinus, and to the tendon of the tensor veli palatini muscle. It is composed primarily of bundles of collaginous fibers with a small admixture of elastic tissue. It is possible that adhesions in the palatal aponeurosis would so stiffen it, that it would resist the normal pull of the muscles decreasing the functioning of the soft palate. If this were so, it would be easy to see how the LPE can break up these adhesions and allow a more normal functional movement of the soft palate.

The net result of these changes would be a more efficient velopharyngeal valving, resulting in an improvement of the patient's speech. It is also possible that other factors, of which we are presently unaware, have contributed to these changes. We are now initiating additional research studies, which we hope will shed light on this subject.

Summary

A new type of mechanical palatal exerciser, called the Lubit Palatal Exerciser (LPE), is described. A case report is presented to demonstrate the changes in the velopharyngeal structures and speech proficiency. There are now 28 patients in this therapeutic program and beneficial changes have been observed in all of them. At present a statistical analysis of the entire group is being made to be presented at a future date.

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