

Prosthetic Approach of Rehabilitating Patients with Velopharyngeal Insufficiency

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ABSTRACT

The subject of this case study was a 43-year-old male with a hypernasality problem due to a right hemiparesis of the velum (soft palate) following a Cerebro-Vascular Accident (CVA). The patient was subjected to videofluoroscopic assessment of the soft palate and the posterior pharyngeal wall to detect and measure the existing gap causing hypernasality. The ultimate goal was to design a palatal lift to function as a static mechanical prosthesis. The existing gap was measured and a palatal lift was designed accordingly, then modified to achieve the best possible vocal resonance quality.

Nasometric evaluation (measurement of the nasalance scores) was conducted pre and post palatal lift fitting. Perceptual judgment of the patient's vocal resonance quality was also conducted pre and post palatal lift fitting by three speech-language pathologists, one dentist and two M.A. students of speech-language pathology. Post palatal lift results showed that Nasometric readings were within normal limits. Also, vocal resonance was checked and the patient achieved normal resonance. Optimal prosthetic management of the palato-pharyngeal port requires close interaction between a number of professionals (e.g. the dentist and speech pathologist and the x-ray specialist) in the use of videofluoroscopy for design, placement and modification of the prosthesis.

Keywords : Palatal lift, velopharyngeal insufficiency, prosthesis, measured gap, real gap.

INTRODUCTION

One of the most active articulators is the velum or the soft palate. The velum serves several functions such as controlling resonance quality through coupling of the oral and nasal cavities during speech. This coupling serves as an essential means of forming a seal that allows the build up of intra-oral pressure necessary for the production of oral sounds (Main, Kelly and Manely, 1999). Without this seal, the perception of hypernasal vocal quality will result. Hypernasality is caused by Velopharyngeal Insufficiency (VPI). VPI is defined as inability to make adequate velopharyngeal closure, i.e. it is a deficit in the coupling mechanism of the velopharyngeal port. This deficit may result from structural, neurological or functional dysfunctions (Albery and Russell 1990). Some of these dysfunctions include, but are not limited to, cerebral palsy, cleft palate, trauma causing damage to the

velum or to the cranial nerves that supply it (Vagus, Trigeminal and Accessory nerves), CVA and progressive neurological diseases. Also, adenoidectomy and tonsillectomy has been found to carry some amount of risk of developing VPI (Bradley, 1997). Speech with an existing VPI is characterized by compensatory articulation, such as substitution of oral stops by glottal stops or pharyngeal fricatives, deletion of oral stops, weak plosives, nasal air escape and/or hypernasality (Rampp, Pannbacker and Kinnebrew, 1984).

The evaluation and treatment of patients with VPI has called considerable attention in recent years. Investigators direct attention to the relationship between Velopharyngeal Port (VP) closure and normal speech. They are also concerned with defining the site, height and amount of closure in normal VP valving. To achieve this goal, the single exposure x-ray technique has been utilized in speech research and clinical studies. Most of the information known today about site, height, amount of closure and interrelationship of structures involved in VP valving is driven using this technique (Turner and Williams, 1991). The advantage of the single exposure x-ray technique lies mainly in the study of structural

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integrity as it relates to dynamic function of VP, provided that a clear resolution of image is available. Some limitations of the technique are that the movement patterns of soft tissues structures are not easily achieved. The fact that the articulatory structures are held immobile whether the exposure is made while the subject produces a sustained speech sound or during rest limits the clinician's ability to assess VP function during normal continuous speech (Turner and Williams, 1991). Although normal speakers do not achieve complete VP closure during the production of continuous speech, it was found that they achieve complete VP closure while repeating oral Consonant-Vowel (CV) syllables such as /pi/, /pa/ and /pu/. Thus, it appears that the production of isolated sustained sounds is not predicative of VP function during continuous speech. Consequently, the functional adequacy of the VP port for speech can only be determined when the patient produces a sample of connected speech while being viewed with videofluoroscopy (Williams, Henningson and Pegoraro-Krook, 1997).

Videofluoroscopy involves radiographic recording of anatomical structures in motion. Thus, videofluoroscopy provides an efficient way of providing multiple frames that help determine the best possible VP closure during a speech task. Videofluoroscopy allows visualization of articulatory placement for the production of speech and makes visible the sequencing and timing of the movement of the structure (Peterson-Falzone, Hardin-Jones and Karnell, 2001).

Treatment options for VPI include surgical, prosthetic and behavioral procedures. Several surgical procedures have been developed to address the problem of VPI. Some of these techniques are pharyngeal flaps, palatal pushbacks, Furrow double opposing Z-plasties and posterior pharyngeal wall implants (Peterson-Falzone, Hardin-Jones and Karnell, 2001). Although surgical techniques provide a wide array of solutions for patients with velopharyngeal insufficiency, prosthetic speech appliances remain important adjuncts to this patient category management (Light, Edelman and Alba, 2001; Gibbons and Bloomer, 1958; Mazaheri and Mazaheri, 1997). Turner and Williams (1991) suggested that prosthetic speech appliances are considered a better option over surgery when the patient has opted against surgery, when there is a limited viable velar-pharyngeal tissue, or because of the patient's health and medical concerns. Prosthetic speech appliances produce a more

favorable outcome if there is little velar elevation or movement and if there is lateral and/or posterior pharyngeal wall movement (Turner and Williams, 1991).

The purpose of speech appliances is to make possible the rapid alternate closing and opening of the velopharyngeal port in the speech mechanism that is accomplished by the velopharyngeal function of the mobile soft palate against the lateral and posterior walls of the velopharynx (Morton and Bzoch, 1997). Palatal lift appliance, first described by Gibbons and Bloomer (1958) can be of help, particularly in individuals with minimal velopharyngeal insufficiency or with borderline neurogenic disorders affecting primarily velopharyngeal function (Mazaheri and Mazaheri, 1976). The lift of the appliance extends posteriorly fitting under the velum and elevating it into a more functional position with the posterior pharyngeal wall. Figure (1) shows a palatal lift appliance (Williams, Henningson, and Pegoraro-Krook, 1997).

By elevating the velum, the size of the portal into the nasopharynx is reduced, as well as the remaining distance the velum has to elevate to make contact with the posterior pharyngeal wall. Criteria for selection of a palatal lift includes the existence of a structurally or anatomically intact velum (no cleft, fistulas or scarring which would limit velum elevation), little or no movement of the velum, lateral pharyngeal wall movement, which would increase the likelihood of improved obturation and patient capability of producing more than vowels or single syllables. Patients who are likely to benefit from a palatal lift include those with neurological dysfunction, closed head injury, or in an early stage of a progressive neural disease. Lifting the velum into approximation with the posterior pharyngeal wall results in improved intelligibility. Individuals with strong velar mobility are typically not good candidates for a palatal lift (Morton and Bzoch, 1997).

METHODOLOGY

Subject

The subject of this case study was a 43-year-old male with hypernasality during speech due to a right side hemiparesis of the velum (soft palate) following a Cerebro-Vascular Accident (CVA). The velum was anatomically intact, but showed weak movement on the right side. History review of the subject's medical reports

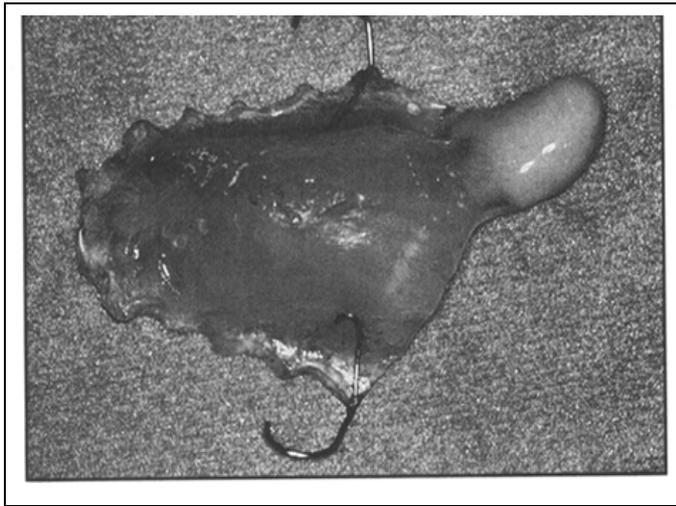


Figure 1. A palatal lift appliance (Williams, Henningsson and Pegoraro-Krook, 1997).



Figure 2.: One frame revealing maximum VP closure achieved.

revealed a history of disseminated intravascular COAGULATION (COA). During oral and dental examination, a dentist detected dental caries in multiple teeth. Dental history is important to evaluate since the palatal lift should be fitted to both the teeth and the hard palate. A speech sample was recorded pre and post palatal lift fitting for purposes of vocal resonance comparison and documentation. Videofluoroscopic evaluation was also conducted. At the time of recording the speech sample and the videofluoroscopic evaluation, the patient had no cold, allergy or flu symptoms.

Pre and post Nasometric evaluation was conducted using the Nasomere™ Model 62300-3 (Kay Elemetrics Corp. NJ). A Nasometer is a hardware/software system that detects nasality through two directional microphones coupled to a head set. One of the microphones detects the oral signal and the other detects the nasal signal. The Nasometer then compares the amplitude of the nasal signal with the amplitude of the oral signal. The ratio is calculated as follows : nasal / nasal+oral signal (Baken and Orlikoff, 2000).

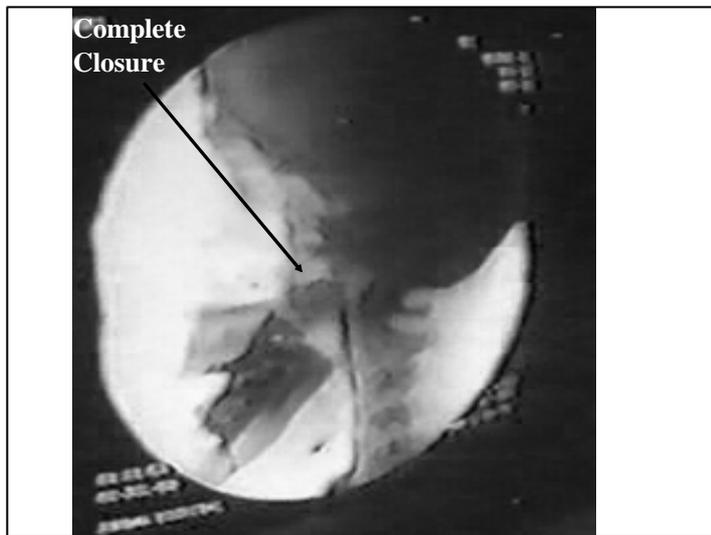
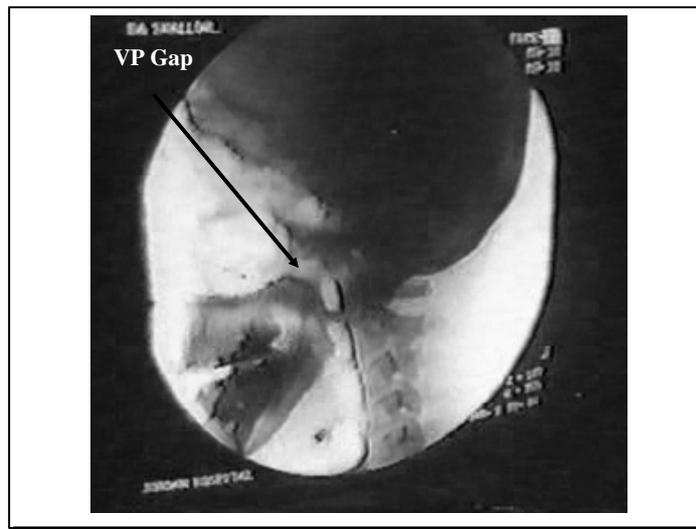


Figure 3 a-b. A videofluoroscopic frame showing the patient's VP without the palatal lift (a) A videofluoroscopic frame showing the patient's VP with the palatal lift in place (b).

Nasometric evaluation was conducted using three speech tasks: six trials of a vowel (/a:/), six trials of a sentence loaded with non-nasal sounds (/ba:ba beddo bukra burdæ: je/) and six trials of a sentence loaded with nasal sounds (/ma: ma men masʔarha mar mu: ra/). The subject produced all speech tasks with habitual pitch and loudness.

Perceptual evaluation of the patient's speech was conducted pre and post palatal lift fitting by three speech-language pathologists, two M.A. students of speech-language pathology and a dentist. A 5-point severity scale was used, with 1. representing normal vocal resonance, 2. representing mild hypernasality, 3. representing moderate hypernasality, 4. representing moderate-to-severe

hypernasality and 5. representing severe hypernasal vocal resonance. The raters were trained using recorded samples representing each of the scale points.

Equipment and Procedures

Pre palatal lift fitting nasality scores for this patient were as follows: 34.8 for the vowel task, 48 for the sentence loaded with non-nasal sounds and 62 for the sentence loaded with nasal sounds. Nasalance score was compared to the normal limits based on studies of English speaking individuals. The norms for English speaking 38-63 year old males are: 18 for the vowel task, 15 for the sentence loaded with non-nasal sounds and 38.2 for the sentence loaded with nasal sounds) (Dalston,

Table 1. Results of quantifiable measurements conducted.

Length of the velum at physiological rest	36 mm
Thickness of the velum at physiological rest	9 mm
Depth of the nasopharynx	25 mm
Velopharyngeal gap	11.48 mm

Based on (Subtelny, 1957).

1997; Baken and Orlikoff, 2000). Thus, the patient's results fall within the category of moderate-to-sever hypernasality according to Dalston (1997).

Using the above-mentioned 5-point scale, the three speech-language pathologists and the dentist pre-rated the patient's vocal resonance quality as moderate-to-severe hypernasal (4), while the two students rated it as severe (5).

An x-ray machine (Prestige, General Electric Inc., USA), was used to obtain multiple lateral and frontal videofluoroscopic views of the patient's oral and nasal cavities. Filming rate was set at eight frames per second as it provides a considerable amount of frames showing the velopharyngeal gap during speech. A ruler locally designed with holes separated by a distance of 10 mm was used to calculate the distortion factor following Williams, Henningsson and Pegoraro-Krook (1997).

Although the risk from radiation exposure is minimal, protective shielding was used to protect the examiner and the speech sample during exposure was relatively short but enough to allow the speech-language pathologist to complete evaluation. To prepare the patient for evaluation, 2 cc of Barium Sulphate (contrast material) (E-Z-HD, E-Z-EM, Inc., New York, USA) was added to water and introduced through the patient's nostrils. Also, the posterior pharyngeal pillars were painted with thick Barium Sulphate using a Q-tip for improved visualization of the soft palate and related structures such as the hard palate. The patient was then comfortably seated in a normal upright position and was instructed to hold his head stable. Soft tissue was checked for adequate delineation. The patient was then instructed to vocalize an /a:/, (/ba:ba beddo bukra burdæ:je/) and (/ma:ma men masyarha marmu:ra/). The patient was also instructed to whistle and blow to evaluate VP closure during non-speech sounds. Subjective assessment of lateral videostroboscopic view revealed minimal velar mobility of the right side, minimal appropriate velar elevation of the right side and the existence of a velar gap. No Passavant's pad was detected. A Passavant's pad is a muscular

bulging across the posterior pharyngeal wall at or near the point of VP approximation. The existence of a Passavant's pad would have helped improve VP-posterior pharyngeal wall approximation.

Subjective assessment of frontal videofluoroscopic views revealed minimal lateral pharyngeal movement of the right side but good lateral pharyngeal movement of the left side, asymmetrical mesial movement of the two sides and reduced range of movement toward the midline.

Figure (2) shows a single frame selected for measurement after examining several frames for the maximum VP closure achieved. Accordingly, the speech language pathologist drew in a best-fit estimate of the length and position of the palatal lift.

Quantifiable measurements made of the VP port were the length of the velum in its physiological rest as measured from the posterior nasal spine (PNS), i.e. the posterior end of the hard palate, to the tip of the uvula. The thickness of the velum was measured across its thickest point while at physiological rest. The depth of nasopharynx and the anterior-posterior gap between the velum and the posterior pharyngeal wall were also measured. Table (1) provides the resulting measurements.

The existing gap was measured according to the following formula:

$$\frac{\text{Real Distance Between the Holes}}{\text{Measured Distance Between the Holes}} = \frac{\text{Real Gap}}{\text{Measured Gap}}$$

$$\frac{30}{47} = \frac{?}{18}$$

$$\text{VP Gap} = 30 * 18 / 47 = 11.48$$

The dentist was provided with a blue print along with the necessary measurements in order to manufacture the appropriate palatal lift. The speech-language pathologist and the dentist agreed that the resulting measurements guided the dentist in designing the required lift. A dental impression was taken with an ulginate impression material from the patient for the purpose of comparison

with the estimated measurements, and for the fabrication of the appliance. The palatal lift measured 22 mm in length from the posterior nasal spine. The palatal lift was fabricated accordingly, then was modified using medical wax. Only the right side of the velum was lifted in order to achieve complete closure of the palatal port for speech. The whole process was videotaped for documentation. Permission of videotaping the whole process was obtained from the patient.

RESULTS AND DISCUSSION

Results of quantifiable measurements, i.e. length and thickness of the velum and depth of nasopharynx, were within normal based on normative data provided by Subtelny (1957); however, the velopharyngeal gap was not, as shown in Table (1).

After manufacturing the appropriate palatal lift, it was fitted in the patient's mouth and vocal resonance quality was checked. Figure (2) shows two videofluoroscopic frames revealing the existing gap; first without the palatal lift (Figure 3-a), then with the palatal lift in place (Figure 3-b).

Post palatal lift Nasometric evaluation was conducted. The results of the nasalance scores for the patient were as follows: 15.5 for the vowel task (pre palatal lift fitting: 34.8), 17 for the sentence loaded with non-nasal sounds (pre palatal lift fitting: 48) and 38 for the sentence loaded with nasal sounds (pre palatal lift fitting: 62). These scores are considered within normal limits (Dalston, 1997; Baken & Orlikoff, 2000).

Post palatal lift fitting perceptual rating results were as follows: the two speech-language pathologists, the two students and the dentist rated the patient's vocal resonance quality as normal, one speech-language pathologist rated the it as mildly hypernasal. The differences in rating between the two speech-language pathologists, the two students and the dentist on one hand and the third speech-language pathologist on the other hand may be due to the fact that the latter had more years of experience working with voice and resonance disorders. It is documented in the literature that training and experience cause individuals to differ more, not less, in how they perceive vocal quality (Kreiman, Gerratt, Precoda and Berke, 1992; Kreiman, Gerratt and Precoda, 1990).

Two days post fitting the prosthesis, ulceration occurred posteriorly in the area tangent to the prosthesis.

To avoid repeated ulceration of the soft palate a soft layer of self curing soft chairside reline material (Softline-Schein, USA) was added to the posterior part of the prosthesis. The dentist rechecked the patient's mouth in two weeks; no ulceration was detected.

CONCLUSION

Although surgical techniques provide a wide array of solutions for patients with velopharyngeal insufficiency, prosthetic speech appliances remain important adjuncts to this patient category management. In this particular case, the patient achieved normal nasalance scores. Additionally, the patient's vocal resonance quality was perceived as satisfying to the professionals involved and, most importantly, to the patient himself in addition to his wife and his parents. Perceptual subjective judgment of the patient's hypernasality is extremely important because it resembles the true judgment of the how effective everyday communication is.

This patient category requires a teamwork approach. Combined clinical skills of the speech-language pathologist and the dentist as well as the x-ray technician were essential for the resulting rehabilitative success of this particular hypernasality case. Each professional brings his own line of experience as well as his personal perspective to resolving a number of multidisciplinary issues. Furthermore, the integration of such professional experiences would be of benefit to the clinical process. Exchanging expertise was one of the valuable outcomes of this study.

Suggestions for Further Research

This study was a case study; i.e. it was conducted utilizing the speech samples of one patient. The evaluation of the patient's vocal resonance was conducted acoustically using Nasometry and also perceptually. Further research may increase the number of participating patients and utilize multiple speech samples to better represent therapy outcomes for this patient's category using this approach. Furthermore, the patient's data was compared to the Nasometric readings from English speaking individuals. Unfortunately, there is little normative Nasometric data of hypernasality ratings for Arabic speaking individuals. Language differences are known to have some influence on Nasometric results (See Baken and Orlikoff, 2000). No aerodynamic data was obtained pre or post palatal lift fitting because no

aerodynamic speech analysis system was available at the time of conducting this study. To support the conclusions

of the current study, further research may incorporate aerodynamic reading to acoustic nasometric readings.

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