Pattern of Closure of Velopharyngeal Valve in Normal Individuals

Thesis
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By

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بسم الله الرحمن الرحيم

وقُلِ اعْمَلُوا فَسَيَرَى اللَّهُ عَمَلَكُمْ وَرَسُولُهُ والْمُؤْمِنُونَ

صدق الله العظيم

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List of Abbreviations

AC	: Auditory Comprehension
AP	: Antero-posterior
APA	: Auditory perceptual assessment
CT scan	: Computerized tomography
EC	: Expressive Communication
EMG	: Electromyograph
F1	: First formant
F2	: Second formant
F3	: Third formant
LPW	: Lateral pharyngeal wall
LVP	: Levator veli palatine muscle
MRI	: Magnetic resonance imaging
MVF	: Multiview videofluoroscopy
PERCI	: Palatal Efficiency Rating Computed Instantaneously
PLS-4	: Modified preschool Language scale 4
PPW	: Posterior pharyngeal wall
SARS	: Speech Aerodynamic Research System
TVP	: Tensor veli palatine muscle
T	: Tesla
VPD	: Velopharyngeal dysfunction
VPI	: Velopharyngeal insufficiency
VPV	: Velopharyngeal valve

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DOZ : Double opposing Z-palatoplasty

DSP : Dynamic sphincter pharyngoplasty

VCFS : Velocardiofacial syndrome

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Introduction

The soft palate (or velum) separates the nasopharynx from the oropharynx. During quiet breathing the soft palate suspends between the nasal and oral cavities allowing air to freely moves through the mouth or the nose. During active breathing through the mouth only, the soft palate elevates to touch the posterior pharyngeal wall to close the opening between the oropharynx and nasopharynx. This velar closure is known as velopharyngeal or palatopharyngeal closure and it is important for swallowing, speech and blowing **(Rodenstein and Stãnescu, 1984).**

Speech sounds are mostly oral sounds i.e. they are produced and resonated in the buccal cavity only. Some speech sounds as /m/ and /n/ have to resonate in nasal cavity as well. One may get a disturbance of nasality if the nasal resonance is reduced (hypo-nasality) or if the nasal resonance is excessive (hyper-nasality) **(Hirschburg, 1986).**

Velopharyngeal closure is critical for production of vowels and oral consonants and thus, has a profound impact on speech intelligibility. Several clinical populations, for example, children with a history of a cleft palate or individuals with dysarthria, have impairments in velopharyngeal function that contribute to problems with speech production **(Watterson and Emanuel, 1981; Mayo et al., 1993**; **Warren et al., 1994).**

The velopharyngeal port is bounded anteriorly by the soft palate (velum), laterally by the lateral pharyngeal walls, and posteriorly by the posterior pharyngeal wall. Closure of the velopharynx during speech is a voluntary action that is mediated by the motor cortex and that requires the coordinated action of the velopharyngeal musculature. The muscles of the soft palate include the levator veli palatini, the tensor veli palatini, the palatoglossus, the palatopharyngeus, and the musculus uvulae **(Seaver and Kuehn, 1980; Moon et al., 1994).**

The velopharynx is a complex, three-dimensional valve which serves to uncouple the oropharynx and nasopharynx during speech and swallowing. It is widely accepted that the levator veli palatini is the muscle that is primarily responsible for velar motion and, hence, for velopharyngeal closure. Fine motor control of velar position may also be governed by the palatoglossus and palato-pharyngeus. The paired musculus uvulae may play an important role in velar stretch and in filling the gap between the velum and the posterior pharynx during velopharyngeal closure. The relative contribution of the levator and of the superior pharyngeal constrictor to lateral pharyngeal wall movement has been the subject of some debate (**Peterson-Falzone et al., 2001).**

Velopharyngeal dysfunction (VPD) is a general term describing the condition where the velum, lateral and posterior pharyngeal walls while in function fail to separate the oral cavity from the nasal cavity during speech and deglutination. It is used to describe different disorders of the velopharyngeal valve including velopharyngeal insufficiency (VPI) referring to anatomical causes and velopharyngeal incompetence referring to physiological defects. VPD results in articulatory problems and hypernasality of the speech which is unintelligible and less pleasant causing a negative impact on the social life of the patient. Children with hypernasality of the speech are often considered less intelligent, less pleasant, and less attractive. Such perceptions can seriously affect the social life of children **(Kummer, 2001).**

Clinical evaluation of velopharyngeal function often relies heavily on the clinician's auditory perceptual judgment. For example, a clinician might judge a client's speech to be hyper-nasal or hypo-nasal and assign a severity rating to it (e.g. mildly hyper-nasal). However, auditory perceptual judgments are known to be unreliable, subjective and are not necessarily well-correlated to velopharyngeal status. Therefore, auditory perceptual judgments of velopharyngeal function are often supplemented with instrumental evaluation. The instrumental approaches to evaluating velopharyngeal function during speech production that are commonly used in clinical settings include selected acoustical, visual imaging, and aeromechanical approaches. These Instrumental approaches have both clinical and research value **(Watterson and Emanuel, 1981; Mayo et al., 1993; Warren et al., 1994).**

An acoustical approach to velopharyngeal evaluation is attractive because the data are generally easy to record, requiring only a microphone and a recording device. Analysis of the speech signal often involves **spectrographic analysis** with an emphasis on selected acoustic features; for example, formant bandwidth (coupling of the velopharyngeal-nasal pathway to the oral pathway is associated with wider bandwidths) and formant frequencies (coupling of the velopharyngeal-nasal pathway to the oral pathway usually introduces a low-frequency "nasal formant" into the spectrum). Nevertheless, this type of analysis can be difficult to carry out and interpret without substantial experience and expertise. Another more widely used acoustical technique for evaluating velopharyngeal function is **nasometry**. Nasometry requires the use of two microphones, one positioned in front of the lips and one positioned in front of the anterior nares. A cumbersome, horizontally oriented plate is positioned between the microphones to isolate the sound energy from the two sources. Nasometry allows for the calculation of nasalance, which is the quotient of nasal sound pressure level to nasal + oral sound pressure level. Although nasalance values have been found to be strongly associated with perceptual judgments of nasality (at least when specified cut-off scores are used), they have been found to be weakly correlated with estimated velopharyngeal orifice area. The weak correlation between nasalance values and velopharyngeal orifice size is likely due, at least in part, to the effects of variables such as turbulent nasal air flow and degree of mouth opening on nasalance (**Daltson et al., 1991; Hoit et al., 1994)**.

Visual imaging is another common approach in evaluating velopharyngeal function in clinical practice. One type of imaging is **videonasendoscopy**, which involves passing a flexible endoscope posteriorly through the nasal pathways and viewing the velopharynx from above. Another type is **video-fluoroscopy**, which involves the use of x-ray to view oral, nasal, pharyngeal, and laryngeal structures from both sagittal and coronal perspectives (though not simultaneously). These two imaging techniques permit direct observation of the velum and pharyngeal walls as they move in relation to one another during speaking and swallowing. A major motivation for using a visual imaging approach is to examine contributions of the velum and lateral and posterior pharyngeal wall to velopharyngeal closure, information that is often critical in planning medical management, including surgical and prosthetic interventions. However video-fluoroscopy can be expensive, invasive, and poses safety risks and is, therefore, applied selectively (**Daltson et al., 1991; Hoit et al., 1994).**

An aeromechanical approach is also used frequently to evaluate velopharyngeal function during speech production. The most powerful aeromechanical method involves obtaining simultaneous measures of nasal airflow, oral air pressure and nasal air pressure. By entering these measures into an equation developed by Warren and DuBois, it is possible to estimate the size of the velopharyngeal port during running speech production. By knowing the size of the velopharyngeal port, the clinician will be able to determine if medical management is necessary or if behavioral management alone may be appropriate **(Warren and DuBois, 1964).**

Nasal airflow is relatively well correlated to velopharyngeal port size, but only at small sizes, the correlation decreases as velopharyngeal size increases. Nevertheless, nasal airflow provides an excellent means of determining if the velopharynx is open or closed during speech production. For example, if nasal airflow is detected during oral sound production, it can be inferred that the speaker has a velopharyngeal leak **(Warren, 1967).**

Velopharyngeal closure patterns may be classified as follows: coronal, where there is predominant soft palate movement toward the posterior pharyngeal wall; sagittal, where there is predominant movement of the lateral pharyngeal walls toward the pharynx midline; circular, where balanced movements of lateral pharyngeal walls and soft palate are observed; circular with Passavant's ridge, where the circular closure is associated with the development of a mucosal fold named Passavant's ridge on the posterior pharyngeal wall **(Skolnick et al., 1973)**.

Aim of the Work

This work aims to identify the variable patterns of closure of velopharyngeal valve (VPV) in normal subjects in order to further understand the nature of VPV closure and generalize information for future researches.