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# Speech Production Patterns Following Management of Velopharyngeal Inadequacy

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THESIS APPROVAL

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# ABSTRACT

An abstract of the thesis of Debra Lynn Childs for the Master of Science in Speech Communication: Speech and Hearing Science presented July 17, 1998.

Title: Speech Production Patterns Following Management of Velopharyngeal Inadequacy.

This descriptive study investigated the pattern of speech sound production before and after surgical management of velopharyngeal inadequacy in two subjects. The research questions asked were: (a) What type of speech patterns do subjects referred for surgical management of velopharyngeal incompetence demonstrate presurgically? (b) What changes in the speech patterns of the subjects are observed in the immediate month following surgery for velopharyngeal incompetence? (c) Do these changes settle into a stabilized pattern of speech production by 4 months postsurgery?

The subjects' speech productions were audio recorded for analysis using the Broen CVC Probe to obtain imitated single word elicitations at 1 month prior to surgery, 1 month postsurgery, and 4 months postsurgery. The principal investigator transcribed the 2 subjects' Broen CVC results when data collection was completed. Twenty-five percent of the subjects' speech samples were transcribed independently by a second examiner. Inter-rater reliability for phonetic transcription was at .98 for initial and final phoneme transcription. The subjects' initial and final consonant productions were scored as correct or incorrect

according to place, manner, voicing, and diacritic errors. Percentage of error in production was calculated. Error rates were compared over the three data collection periods.

Presurgically, Subject #1's percentage of error for placement, manner, voicing, and diacritics ranged from 0% to 49%. Errors included nasality, partial de-voicing, breathiness, and interdentalization. Error rates 1 month postsurgery ranged from 0% to 38%. Errors included partial de-voicing, hyponasality, and interdentalization. Error rates 4 months postsurgery ranged from 0% to 24%, and included partial de-voicing and interdentalization.

Presurgically, percentage of error for Subject #2 in terms of place, manner, voicing, and diacritics ranged from 0% to 52%. Errors included nasality, weak consonant production, and partial de-voicing. One month postsurgery, error rates ranged from 0% to 35% and included hyponasality, excessive aspiration, and partial de-voicing. Four months postsurgery, error rates ranged from 0% to 30%, including partial de-voicing and excessive aspiration. Velopharyngeal competence had improved, as had accuracy of speech productions, but neither subject had achieved normal speech at 4 months postsurgery.

# SPEECH PRODUCTION PATTERNS FOLLOWING MANAGEMENT OF VELOPHARYNGEAL INADEQUACY

by

DEBRA LYNN CHILDS

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# DEDICATION

I would like to dedicate this study to my parents. Your love and support are the constants in my life that keep me going. Thanks for everything.

I would also like to dedicate this study to the memory of Elroy Farah whose wonderful friendship is sorely missed.

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# INTRODUCTION AND STATEMENT OF PURPOSE

## Introduction

The *velopharyngeal mechanism* consists of the soft palate, and posterior and lateral pharyngeal walls. During speech sound production, the soft palate and pharyngeal walls at times produce a sphincter-like valve to separate the oral and nasal cavities. The ability to couple and uncouple the oral and nasal cavities results in the production of nasal versus oral sounds and is referred to as *velopharyngeal closure*.

*Velopharyngeal inadequacy* refers to the inability of the components of the velopharyngeal mechanism to approximate closely enough when needed to separate the oral and nasal cavities. Velopharyngeal inadequacy can result from either anatomical or neurological conditions.

The effects of velopharyngeal inadequacy on speech include hypernasality, nasal air loss, and impaired speech intelligibility. Pressure consonants, referred to as *obstruents*, are often weak due to reduced intra-oral pressure. Pressure consonant phoneme classes include stops, affricates, and fricatives. At times, the individual with velopharyngeal inadequacy may substitute *sonorants*, which are phonemes that do not require a build-up of intra-oral pressure. Sonorants include such phoneme classes as nasals and glides. In cases of persisting velopharyngeal inadequacy, individuals can develop compensatory patterns such as over tension in the vocal mechanism and/or articulatory backing in an effort to control airflow.

Individuals with velopharyngeal inadequacy often benefit from physical management of the mechanism, either via surgery or prosthetic means. Typically, surgical or prosthetic management of the velopharyngeal mechanism is followed by (re)enrollment in speech therapy to promote optimal speech outcome. Previous studies have documented that management of velopharyngeal inadequacy improves the speech characteristics of individuals with velopharyngeal inadequacy. However, the majority of studies fail to document the nature and timing of observed resonance and articulatory change. Such knowledge would improve efficacy of speech therapy following velopharyngeal management by minimizing lost time, revenue, and client "burnout" effects from therapy provided at inappropriate times.

## Statement of Purpose

The purpose of this study was to examine the pattern and consistency of sound production following surgery in individuals exhibiting velopharyngeal inadequacy due to anatomical deficits. Few previous studies have documented the exact nature of articulatory change that occurs after surgery to improve velopharyngeal functioning (Broen, Letcher-Glembo, & Moller, 1988).

This study examined speech production patterns of individuals who demonstrated velopharyngeal incompetence severe enough to warrant surgical management. Speech samples were collected prior to surgical physical management, 1 month postsurgical management, and 4 months postsurgical management. It was hypothesized that patterns of speech observed before surgery would be indicative of those typically reported in the literature as being associated with velopharyngeal incompetence, namely hypernasality, weak pressure consonant productions, accompanying nasal air emission, and potential compensatory backing of sounds. It was further hypothesized that the subjects' speech patterns would change after surgery, and that by 4 months postsurgery, speech production patterns would have settled into a stabilized pattern.

The specific research questions asked in this study were:

1. What type of speech patterns do subjects referred for surgical management of velopharyngeal incompetence demonstrate presurgically?

2. What changes in the speech patterns of the subjects are observed in the immediate month following surgery for velopharyngeal incompetence?

3. Do these changes settle into a stabilized pattern of speech production by 4 months postsurgery?

## Definition of Terms

*assimilation*: a process by which a sound is changed to become more similar to another sound in the word (Weiss, Gordon, & Lillywhite, 1987).

*bilateral cleft:* a term referring to clefting that affects both the right and left sides of the oral and/or facial structures (Gorlin, 1993).

*bipedicle flap*: a surgical term referring to a piece of tissue with two attached bases (Dreyer & Trier, 1984).

*Broen CVC Probe*: an imitative, single-word test consisting of 78 items that allows for the examination of the articulation patterns of initial and final consonants of target words (Broen, Moller, Kittelson, & Houge, 1983).

*craniostenosis*: a term referring to a contracted skull due to premature closure of the cranial sutures (Thomas, 1985).

*diacritic errors:* a term used for the purposes of this study to indicate errors in phoneme production that were identified in transcription by the use of diacritic markers. These represent errors beyond those occurring in place, manner, and/or voicing.

*diacritic markers:* transcription symbols that are used to distinguish the characteristic with which a distorted phoneme is produced.

*diacritics:* a system whereby the actual pronunciation of a phoneme can be indicated.

*hypernasality*: a resonance problem stemming from the lack of separation of the oral and nasal cavities for sounds that require velopharyngeal closure (Moller & Starr, 1993).

*hyponasality*: a loss of nasal resonance on normally nasalized sounds (i.e., /n/, /m/, /ŋ/) due to structural deviations in the nasal or pharyngeal cavities that occlude or partially occlude openings between the nasal and oral cavities (Moller & Starr, 1993).

*hypoplasia*: incomplete or arrested development of an organ or part (Thomas, 1995).

*intelligibility*: understandability; often expressed as a percentage of contextual speech understood by the listener.

*mandibular hypoplasia*: incomplete or arrested development of the mandible (jaw bone) (De Vinne, 1990).

*nasal emission*: inappropriate nasal air flow during production of pressure consonants (i.e., stops, fricatives, and affricates) that can distort sound production; can be audible or inaudible.

*nasal turbulence*: a sound produced when the soft palate approximates the posterior pharyngeal wall of the nasopharynx. Also referred to as a nasal snort (Trost-Cardamone & Bernthal, 1993).

*obturator*: a type of prosthetic appliance that serves to occlude residual fistulae in the hard or soft palate; at times this term is used by some professionals interchangeably with the term "speech bulb."

*palatal lift*: a type of prosthetic speech appliance used when the soft palate is of sufficient length but lacks sufficient mobility to achieve velopharyngeal closure (Letcher-Glembo, 1997).

*paresis*: partial or incomplete paralysis.

*pharyngeal flap*: a surgical procedure whereby a flap of donor tissue is elevated from the midline posterior pharyngeal wall and its free end is brought forward and sutured into the soft palate; allows the lateral pharyngeal walls to contact the flap tissue resulting in improved velopharyngeal closure for speech (Shons, 1993).

*pharyngoplasty*: a type of reparative surgery of the pharynx that ideally serves to improve velopharyngeal closure by reducing the distance between the lateral pharyngeal walls; serves as an alternative procedure to pharyngeal flap surgery; it is often recommended for individuals whose velopharyngeal inadequacy (VPI) is related to impaired movement of the lateral pharyngeal walls (Goode & Ross, 1972).

*primary palatal surgery*: initial surgery used to close a cleft of the hard and/or soft palate (Shons, 1993).

*residual oronasal fistula*: a "hole" between the oral and nasal cavities resulting from incomplete healing or breakdown of a primary palatal repair.

*secondary palatal surgery*: secondary surgery used to correct deficiencies still present after initial palatal surgery (Shons, 1993).

*speech bulb*: an appliance that is used when the soft palate is too short to make adequate contact with the posterior pharyngeal wall (Letcher-Glembo, 1997).

*speech prosthesis*: a dental appliance that is worn against the palate and is attached to the maxillary teeth with a posterior extension that assists in the achievement of velopharyngeal closure (Letcher-Glembo, 1997).

*sphincter pharyngoplasty*: a surgical procedure in which two superiorly based lateral wall flaps are incised and are connected by a transverse incision. The flaps are then turned transversely and sutured with a midline closure. This technique is employed primarily in patients whose lateral pharyngeal wall movement is restricted, impairing velopharyngeal closure (Shons, 1993).

*submucous cleft*: refers to an imperfect muscle union across the soft palate underlying the mucous membrane.

*surgical intervention*: intervening with the client via surgical procedures designed to improve speech.

*unilateral cleft:* a term referring to clefting that occurs only on the right or left the side of oral and/or facial structures (Gorlin, 1993).

*unipedicle flap*: a surgical term referring to a piece of tissue with one attached base (Shons, 1993).

*velopharyngeal dysfunction*: a general term for inadequate velopharyngeal closure.

*velopharyngeal inadequacy (VPI):* a general term for inadequate velopharyngeal closure (Letcher-Glembo, 1997).

*velopharyngeal incompetency*: a term suggesting adequate soft palate length in the presence of impaired palatal mobility (Letcher-Glembo, 1997)

*velopharyngeal insufficiency*: a term that suggests a short palate in relation to the depth of the oronasal pharynx (Letcher-Glembo, 1997).

*velopharyngeal mechanism*: a term referring to the structures involved in achieving velopharyngeal closure, e.g., the soft palate and the pharyngeal walls.

# CHAPTER II

# REVIEW OF THE LITERATURE

This study examined the sequence and timing of articulatory change following surgical improvement of velopharyngeal functioning. A study of this type required an understanding of the nature, causes, and populations associated with VPI. Furthermore, review of the speech characteristics associated with VPI and treatment techniques utilized in its management was undertaken. A limited number of speech outcome studies were available for review.

## Definition of Velopharyngeal Inadequacy

Velopharyngeal competence is important for the production of normal speech. The soft palate or *velum*, and the lateral and posterior pharyngeal walls at times approximate to form a sphincter that acts to separate the nasal and oral cavities from each other. Velopharyngeal closure is achieved primarily by the elevation and backward movement of the soft palate coupled with the mesial movement of the lateral pharyngeal walls in order to form the sphincter (Hirschberg, 1986). This separation of the oral and nasal cavities allows for the production of sounds which require the closure of this sphincter for their formation (Chaco & Yules, 1969).

In English, all sounds except /m, n, and ŋ/ require closure of the velopharyngeal mechanism for their proper production. When the soft palate and pharyngeal walls fail to approximate sufficiently enough to separate the oral and nasal cavities, VPI is said to exist.

A study conducted by Isshiki, Honjow, and Morimoto (1968) found that the critical size of velopharyngeal closure necessary for the production of acceptable speech was approximately 5 mm in diameter. Increased velopharyngeal gap size was associated with increased nasality and articulatory defects during speech.

## Causes of Velopharyngeal Inadequacy

VPI can occur as a result of a variety of anatomical and neuromuscular conditions. In the case of anatomically based VPI, an insufficient amount of tissue is present to close the velopharyngeal sphincter. This tissue inadequacy can present itself in the form of a short soft palate. For example, an individual with cleft palate may demonstrate sufficient motor movement, but the soft palate may be too short to make contact with the pharyngeal walls (Hirschberg, 1986). The more specific term for this condition is *velopharyngeal insufficiency* (Letcher-Glembo, 1997). Another cause of anatomically based velopharyngeal insufficiency occurs when a pharynx is too deep. In this case, the soft palate is of adequate length and mobility, but is still unable to achieve sufficient velopharyngeal closure with the walls of the pharynx due to the greater distance required (Neiman & Simpson, 1975).

Neuromuscular conditions resulting in paresis can also contribute to VPI. In paresis, the anatomy appears to be intact, but the muscles involved in velopharyngeal closure lack sufficient strength or mobility to function properly (Hirschberg, 1986). This condition is referred to as *velopharyngeal incompetency*. Therefore, VPI can result from both anatomical and physiological deficiencies that prevent sufficient sphincter closure from occurring.

## Relationship Between Orofacial Clefts and Velopharyngeal Inadequacy

As previously mentioned, VPI can be caused by anatomical or physiological deficiencies. Populations whose deviant anatomical structure results in an increased incidence of VPI include: overt cleft palate, residual oronasal fistula, submucous cleft, and anatomical deficiencies arising from tonsillectomy and adnoidectomy. Anatomical causes of VPI can be seen in syndromes such as Klippel-Feil, Pierre-Robin, craniostenosis, and mandibular hypoplasia (Minami, Kaplan, Wu, & Jobe, 1975).

A study conducted by Jensen, Kreiborg, Dahl, and Fogh-Andersen (1988) found that the incidence of cleft palate was 1.89 per 1,000 births. Clefting has been shown to be caused by the failure of embryonic structures to fuse in the critical period prior to 12 weeks of fetal life (Kraus, Kitamura, & Latham, 1966). The presence of clefting can have severe implications for the architecture of the lip and nose.

Cleft lip and palate disorders can assume many configurations. These disorders can include unilateral or bilateral clefting of the lip tissue. The cleft lip occurs on a continuum ranging from a notch on the lip to extending into the floor of the nostril. A cleft palate can involve the hard palate, which is the anterior part of the roof of the mouth consisting of bone covered by mucosa, and/or the soft palate which is the posterior portion of the roof of the mouth composed of muscle tissue and mucosa (Letcher-Glembo, 1997). Clefting may extend through both the hard and soft palates creating an open communication between the oral and nasal cavities.

A less severe and more rare type of clefting, the *submucous cleft*, is the exception. In the case of a submucous cleft, the palatal structure appears to be intact, but primarily muscular deficits exist . This defect can often be detected by the presence of a bluish line at the midline of the soft palate, a bifid uvula, and a notch along the midline of the posterior border of the hard palate (Hirschberg, 1986). These clefts can often be detected during palpation. In summary, clefting that can result in VPI may either be overt in nature or covert as in the case of the submucous cleft.

Surgery to close a palatal cleft is usually performed between 12 and 18 months of age (Shons, 1993). According to McWilliams, Morris, and Shelton (1990), the goals of cleft palate surgery are to create a velopharyngeal mechanism that is capable of creating a separation between the oral and nasal cavities during speech, improve the intake of food, reduce the occurrence of upper respiratory infections, and improve middle ear status. Initial closure of clefts of the hard and soft palate is referred to as *primary palatal surgery* (Shons, 1993).

Two primary palatal surgical designs are used today: the V-Y procedure and the Von Langenbeck procedure (Bzoch, 1989; Dreyer & Trier, 1984). The V-Y procedure involves the elevation of two unipedicle flaps of palatal mucoperiosteum, one on either side of the cleft. The flaps are then repositioned so that the cleft is covered and the soft palate is elongated (Shons, 1993). In the Von Langenbeck procedure, two bipedicle flaps are elevated, approximated, and sutured. A limitation of this procedure is that minimal palatal lengthening can be obtained.

Several studies have attempted to determine the success rate for speech following primary palatal surgery with success defined as adequate velopharyngeal closure for speech purposes. Dreyer and Trier (1984) reported that 62% of their subjects achieved acceptable or excellent speech results following the completion of the V-Y procedure. The Von

Langenbeck procedure was found to produce acceptable to excellent speech results in 62% of the subjects studied by Dreyer and Trier (1984). While these palatal surgery techniques have been shown to improve speech, primary palatal surgery fails to result in adequate velopharyngeal closure for speech purposes in approximately 25% of patients (McWilliams et al., 1990).

## Speech Characteristics Associated with Velopharyngeal Inadequacy

Differences in the adequacy of the velopharyngeal mechanism can account in part for differences observed in the articulation patterns of individuals with VPI. Isshiki et al. (1968) found that as the velopharyngeal gap size increased, the nasal effects on speech increased. Individuals with only marginal velopharyngeal insufficiency may nasalize only those consonants that are adjacent to nasals through the process of assimilation. Individuals with more severe VPI, however, are subject to misarticulation of all non-nasal sounds.

The primary speech deficits associated with insufficient velopharyngeal closure are hypernasality and nasal emission (Hirschberg, 1986). The inappropriate coupling of the oral and nasal cavities is primarily responsible for these phenomena. Hypernasality is associated with alterations in the resonance characteristics of non-nasalized sounds such as vowels (Kummer, Curtis, Wiggs, Lee, & Strife, 1992). Factors involved in the hypernasality of vowels includes the placement of the tongue, size restriction of the oral cavity, and the constriction of the lips.

A study conducted by Carney and Sherman (1971) found that high vowels were most likely to become nasalized in individuals with VPI secondary to cleft palate. Their study revealed that individuals whose VPI was unrelated to clefting were more likely to nasalize low vowels. The difference between the cleft and non-cleft groups was explained by the fact that high vowels required more velopharyngeal closure to produce. Therefore, the more impaired the velopharyngeal mechanism, the more likely that high vowels will become nasalized (Carney & Sherman, 1971; Spriestersbach & Powers, 1959). In a severely impaired velopharyngeal mechanism, both high and low vowels may be nasalized (Spriestersbach & Powers, 1959). In summary, hypernasality is related to nasal distortion of vowel sounds, and the degree of VPI will determine which vowel sounds are affected.

Nasal emission has been defined as inappropriate air loss through the nose. This occurs when the production of high-pressure consonants are accompanied by visible and/or audible nasal escape due to the lack of velopharyngeal closure (Kummer et al., 1992). The study by Kummer et al. (1992) suggests that nasal rustle or turbulence is a form of nasal emission, and may occur in relatively mild cases of VPI. It is caused by the friction of air as it is forced through a small velopharyngeal gap. This study also indicated that true hypernasality, either with or without nasal emission, usually resulted from larger velopharyngeal openings than those found in cases where solely nasal rustle was observed.

Studies have shown that impaired production of pressure consonants such as plosives and fricatives, the presence of omissions, and occurrence of sound substitutions are common in VPI. These articulatory errors reduce the speech intelligibility of this population (Hirschberg, 1986; Van Demark & Hardin, 1985). In summary, hypernasality, nasal air emission, and consonant sound production especially for plosives and fricatives are indicative of VPI.

Speakers with more seriously impaired velopharyngeal mechanisms tend to make use of compensatory strategies. When adequate build-up of air pressure for production of plosives and fricatives cannot be achieved, individuals may attempt to produce these sounds at the level of the larynx or pharynx (Hirschberg, 1986). The substitution of *backed* sounds such as glottal stops for plosives such as /p, t, k, b, d, g/ is a common strategy used to compensate for the impaired intra-oral air pressure.

In a study conducted by Henningsson and Isberg (1986), findings conclude that glottal stops were indeed a compensatory mechanism related to lack of movement of the lateral pharyngeal walls and marked by increased levels of hypernasality in speech. Trost-Cardamone and Bernthal's (1993) findings support that a compensatory backing pattern of articulation to replace the production of fricatives is used by some individuals due to the lack of sufficient intra-oral air pressure for proper production of these sounds. A more recent study found that speakers with velopharyngeal insufficiency often hold the tongue posteriorly in order to produce more perceptually correct speech. Although this compensatory tongue posture changed somewhat after flap surgery, it was not eliminated (Tanimoto, Henningsson, Isberg, & Ren, 1994).

In summary, several compensatory strategies may be used by the population with VPI. Such strategies may continue even after velopharyngeal closure has been achieved by successful surgical or prosthetic management. Due to the persistent use of compensatory strategies after velopharyngeal management in the VPI population, speech therapy may be necessary to encourage the correct production of speech sounds.

## Management of Velopharyngeal Inadequacy

Four treatment options have traditionally been used to treat VPI: speech therapy, pharyngoplasty, pharyngeal flap surgery, and prosthetic management (Letcher-Glembo, 1997). Effective management of VPI frequently requires prosthetic or surgical techniques. Speech therapy may be used in conjunction with physical management to improve the speech outcome for these individuals.

## Speech Therapy Management of Velopharyngeal Inadequacy

Research directed at determining the effectiveness of speech therapy indicates that intervention will improve the speech of clients with adequate or marginal velopharyngeal mechanisms. However, this approach appears inappropriate for most individuals with hypernasality (Starr, 1993). Intervention that is to be effective in treating the client with inadequate velopharyngeal closure must usually involve some treatment of the physical valve mechanism, either through the use of a prosthesis or through flap surgery (Bradley, 1989). Only when the soft palate can approximate the pharyngeal walls appropriately can articulation therapy be of benefit.

Research conducted by Van Demark (1974) to determine the efficacy of speech therapy in subjects with cleft palate and varying degrees of VPI found that although articulation treatment did improve the speech of speakers with mild or marginal velopharyngeal competence, articulation treatment did not benefit individuals with incompetent velopharyngeal mechanisms. Van Demark did not specify the nature of the speech therapy involved.

## Prosthetic Management of Velopharyngeal Inadequacy

Prosthetic techniques have been utilized to improve VPI. There are three main types of speech prostheses: obturators, speech bulbs, and palatal lifts (Letcher-Glembo, 1997).

The basic design of all three types of prosthesis includes an anterior palatal portion that is retained in place by use of the maxillary teeth.

The first type of prosthesis is an obturator which is constructed to occlude a *fistula*, or residual opening, in the hard and/or soft palate that directly communicates with the nasal cavity. An obturator may be equipped with a posterior extension or bulb designed to assist with velopharyngeal closure.

The second type of prosthesis, a speech bulb, is utilized when the soft palate is inadequate in length. The speech bulb fills the velopharyngeal space and velopharyngeal competence is obtained by the mesial movement of the pharyngeal walls as they come into contact with the bulb (Zarb & Witzel, 1993). Reduction programs, in which the size of the obturator's posterior bulb is gradually reduced, have proven successful in some individuals in developing greater pharyngeal wall movement (Leeper, Sills, & Charles, 1993).

The third type of prosthesis, the palatal lift, is not intended to substitute for deficient tissue. Rather, its purpose is to elevate a soft palate that is of sufficient length but lacks the motor ability to contact the pharyngeal walls as is seen in the dysarthrias. With this type of prosthesis, the soft palate is lifted into contact with the posterior pharyngeal wall ideally eliminating hypernasality and improving articulation and intelligibility (Letcher-Glembo, 1997).

In a study by Kipfmueller and Lang (1972), the palatal lift prosthesis was shown to have a marked effect on speech intelligibility primarily through a decrease in consonant errors. A study conducted by Gonzalez and Aronson (1970) reported that prosthetic placement resulted in moderate to marked reduction of hypernasality and nasal emission, and an increase in speech intelligibility in subjects with neurological deficits. This study did note the continuing presence of compensatory errors in their subjects, but did not report on the nature of the articulatory change present in the improved speech of their subjects.

Hardy, Netsell, Schweiger, and Morris (1969) also showed general improvement in the articulation scores of their subjects. Their study reported an improvement in the production of fricative and plosive sounds as a result of the prosthetic placement.

In agreement with other studies, Lawshe, Hardy, Schweiger, and Van Allen (1971) found that prosthetic management of velopharyngeal incompetency resulted in decreasing nasality and improvement in articulation. Their study did not, however, describe which aspects of articulation had improved.

A more recent study found that the percentage correct of nasals, glides, and pressure consonants improved with the placement of palatal lifts (Yorkston, Honsinger, Beukelman, & Taylor, 1989). These improvements resulted in speech that more nearly resembled the speech of velopharyngeally competent speakers. Successful use of the palatal lift prosthesis as determined by the presence of reduced hypernasality, improved articulation, and increased intelligibility has been documented in individuals with spastic, flaccid, and mixed spastic-flaccid dysarthrias (Aten, McDonald, Simpson, & Gutierrez, 1984; Duffy, 1995).

Surgical Management of Velopharyngeal Inadequacy

One procedure used to treat VPI in individuals with compromised velopharyngeal mechanisms is the surgical procedure referred to as *pharyngoplasty*. This procedure is used to recreate a bulge along the posterior pharyngeal wall that the soft palate will be capable of making contact with to achieve velopharyngeal closure. In this procedure a superiorly based tissue flap is elevated from the posterior pharyngeal wall. The base of the flap is located at the level of the Eustachian tube openings with the free end extending to the level of the epiglottis. The flap of tissue is made as wide as possible. The flap is then folded in half and sewn to itself with the free end being rolled under and sutured to the base of the flap. Next, the sides of the flap are sewn together and sutured to the lateral pharyngeal walls (Goode & Ross, 1972). This procedure produces a bulge of tissue which reduces the anterior-posterior dimensions of the pharynx thereby allowing the soft palate to make contact with the posterior pharyngeal wall and achieve velopharyngeal closure.

Other surgical techniques have been employed to assist with velopharyngeal closure. Injections of Teflon and collagen into the pharyngeal walls for the purpose of creating pseudo-adenoidal pads to assist velopharyngeal closure by reducing the dimensions of the pharynx and increasing the likelihood of closure have been studied (Sturim & Jacob, 1972).

*Pharyngeal flap surgery* is the most common surgical method of improving velopharyngeal closure in compromised individuals. Superiorly-based pharyngeal flap surgery appears to be the treatment of choice in the cleft population (Minami et al., 1975). Flap surgery is usually performed between the ages of 6 and 12 years. In this procedure, a flap is created by lifting a unipedicle of soft tissue from the posterior wall of the pharynx. While one end of the flap remains attached to the pharyngeal wall, the other end is sutured to the palate. The flap then acts as a bridge to partially occlude the velopharyngeal space. Spaces on either side of the flap permit the passage of air, nasalization of sounds when appropriate, and the passage of nasal drainage. The hope is that the two openings on either side of the flap will be able to close via the mesial movement of the lateral pharyngeal walls during speech sounds that require velopharyngeal closure.

A palatal pushback, the V-Y procedure, is sometimes used in conjunction with the pharyngeal flap. This procedure acts to correct a short palate by moving the palate posteriorly. This procedure reduces the space that the soft palate must travel to contact the posterior pharyngeal wall (Minami et al., 1975). A pharyngeal flap can then be inserted into the posterior edge of the pushback, thereby helping to achieve velopharyngeal closure.

## Speech Outcomes Following Surgical Management of VPI

A study be Engstrom, Fritzell, and Johanson (1969) found that pharyngeal flap surgery resulted in improved intelligibility in 80% of their subjects who had not previously used a prosthesis. This study also showed that 66% of subjects who had previously used a prosthesis maintained or improved their intelligibility levels after flap surgery. This study did not report on the articulatory nature of the speech improvement, and appeared to evidence some difficulty in the training of the listener judges used to determine if speech improvement had indeed occurred.

According to a study conducted by Goode and Ross (1972), the pharyngoplasty procedure has yielded good speech results in their subjects. These researchers, however, did not elaborate on the methods used for the speech evaluations, nor did they report the speech results. A recent study revealed that although pharyngoplasty resulted in improved speech in terms of decreased hypernasality and nasal air emission for all their subjects, pharyngoplasties performed before the age of 7 years gained the best speech results (Eufinger, Bremerich, Eggeling, & Gellrich, 1995). This study did not elaborate on the nature of the spontaneous speech improvement.

In a study conducted by Sturim and Jacob (1972), the injection techniques appear to work well in improving the speech of carefully selected patients. Subjects' speech characteristics were re-assessed at 6 week, 6 month, and 1 year intervals postoperatively. The study results commented in general terms about general speech improvement, but made no mention of the nature of articulatory change encountered after the injection procedure. Appropriate patients for Teflon injection have smaller gaps in the functioning of the velopharyngeal mechanisms than do patients who undergo pharyngeal flap surgery. Successful use of implant techniques can only be expected in individuals with mild VPI and a mobile velum (Hirschberg, 1986).

Studies have shown pharyngeal flap surgery to effectively eliminate hypernasality in children (Argamaso et al., 1980; Shprintzen et al., 1979). However, a potential side effect of pharyngeal flap surgery is hyponasality. Hyponasality is usually overcome in children as a result of pharyngeal growth. In a study to determine the results of pharyngeal flap surgery on hypernasal speech in adults, it was found the hypernasality was completely eliminated in 90% of the subjects. It was also found that 15% of these subjects became hyponasal, and that the resulting hyponasality in adults was permanent (Hall, Golding-Kushner, Argamaso, & Strauch, 1991).

In a retrospective study conducted by Van Demark and Hardin (1985), it was found that articulation test scores improved after pharyngeal flap surgery. This study made note of typical speech errors prior to surgery, and also indicated that articulation errors due to nasal distortion decreased while an increase in oral distortion was noted after pharyngeal flap surgery (Van Demark & Hardin, 1985). This study did not report on any other aspects of articulatory change resulting from pharyngeal flap surgery. Research concerning the speech results associated with pharyngeal flap surgery indicates that significant improvement can be expected, especially in the reduction of hypernasality (Argamaso, Levandowski, Golding-Kushner, & Shprintzen, 1994).

A study conducted by Broen, Letcher-Glembo, and Moller (1988) focused on determining the error types made and the time until age-appropriate speech was produced in a small sample size of children with cleft palate who had undergone pharyngeal flap surgery. This study found that glides and nasals were substituted for oral stops, fricatives, and affricates prior to surgical management. These errors were found to have disappeared by 4 months postoperatively. This study suggested that compensatory strategies had to be "unlearned," and that age-appropriate speech was achieved by most subjects by 1 year postoperatively.

## Summary Statement

VPI refers to the inability to achieve adequate separation between oral and nasal cavities when needed for speech or swallowing purposes. Individuals with clefts, despite initial lip and palate repairs, are at risk for VPI. Speech deficits primarily associated with VPI are hypernasality and nasal air emission (Hirschberg, 1986). Hypernasality can affect both consonant and vowel sounds. Nasal air emission usually occurs in the presence of high pressure consonants (Kummer et al., 1992).

Individuals with seriously impaired velopharyngeal mechanisms tend to make use of compensatory strategies such as the substitution of backed sounds such as glottal stops for plosives (Henningsson & Isberg, 1986; Hirschberg, 1986). A backing pattern of articulation in which the tongue is held posteriorly is also a strategy used in the production of fricatives (Tanimoto et al., 1994; Trost-Cardamone & Bernthal, 1993).

Studies focusing on the physical management of VPI have revealed that speech does improve as a result of prosthetic and surgical techniques. Studies following the performance of pharyngoplasty and pharyngeal flap surgery have found that these interventions improve the speech of individuals with VPI particularly in the reduction of hypernasality (Argamaso et al., 1980; Eufinger et al., 1995). The majority of studies, however, have failed to document the sequence and timing of the articulatory change associated with improved speech.

Few studies have documented when articulatory changes settle in to a stable articulatory pattern following surgical management of VPI. As many individuals who undergo treatment for velopharyngeal incompetence also require further speech therapy, it would be of benefit for speech-language pathologists to be aware of expected speech patterns following physical management. Such knowledge could enhance timing or (re)initiation of speech therapy, goals of treatment, and expected outcomes.

# CHAPTER III

# METHODS

The purpose of this descriptive pilot study was to document speech production patterns following surgical management of velopharyngeal incompetence as measured in the month before surgery, 1 month postoperatively, and 4 months postoperatively. The design of the present study was based on research conducted by Broen, Letcher-Glembo, and Moller (1988). The two studies differed in the length of time postsurgically that the subjects were followed. The present study followed the subjects for 4 months postsurgically, whereas the Broen et al. study followed their subjects for 12 months postsurgically.

This research study sought to answer the following questions:

1. What type of speech patterns do subjects referred for surgical management of velopharyngeal incompetence demonstrate presurgically?

2. What changes in the speech patterns of the subjects are observed in the immediate month following surgery for velopharyngeal incompetence?

3. Do these changes settle into a stabilized pattern of speech production by 4 months postsurgery?

## Subjects

### Subject Recruitment and Informed Consent

Subjects who met the study criteria were identified through key personnel at Oregon Health Sciences University's (OHSU) Child Development and Rehabilitation Center, an agency providing cleft and/or speech habilitation within the state of Oregon. Portland State University's (PSU) (Appendix A) and OHSU's (Appendix B) Committees on the Use of Human Subjects in Research gave prior approval for potential subjects to be sent a cover letter (Appendix C) that notified families of the study and requested they call the researcher(s) if interested in participating.

Subjects and/or their families contacted the Primary Investigator if they wished to serve in the study. Subsequently, those who agreed to participate received two copies of a written consent form jointly approved by PSU's and OHSU's Committees on the Use of Human Subjects in Research (Appendix D). Child subjects, persons 17 years or younger, required parent/guardian consent to participate. The child subjects provided verbal and/or written consent to participate. Individuals who consented to participate and met criteria for inclusion were contacted and scheduled between the time period of September, 1996, and April, 1998. Subjects were not paid for their participation in this study.

Subject Description and Selection

The following criteria were used in the selection of all subjects who participated:

1. Subjects were at least 5 years of age or older as this helped to ensure their ability to participate in imitative tasks.

2. Subjects were diagnosed by a certified speech-language pathologist not directly involved in this project as demonstrating velopharyngeal incompetence that required physical management. This diagnosis was made via perceptual and/or instrumental assessment prior to enrollment in this study.

3. Subjects included in this study were to be scheduled for surgical management of VPI, but had not had surgery before the initial articulatory testing session of this study.

4. Subjects demonstrated VPI due to clefting. Subjects did not have any known neurological, physical, cognitive, or severe medical problems with the exception of his or her cleft.

5. Subjects passed a pure tone hearing screening at 25 dB.

Subject Demographics

Two subjects participated in the present study. Both subjects were speakers of Standard American dialect. Subject #1 was an 8 year, 0 month old male at the start of this study with an unrepaired submucous cleft and VPI. Limited information regarding the history of this subject's medical management or past speech therapy was available due to a foster parent living situation that varied prior to and throughout the duration of this study. Participation in the present study was consistent and timely in terms of meeting the time period requirements for study completion.

Subject #2 was a 12 year, 1 month old male at the start of the study with a past diagnosis of bilateral cleft lip and palate. Subject #2 had undergone surgical lip adhesion at 5 days and full lip repair at 6 months of age. Primary palate repair was performed at 10 months of age. Subject #2's history included the use of a speech prosthetic appliance, in conjunction with continued active speech therapy, to achieve adequate velopharyngeal closure and improved speech production. Table 1 shows additional pertinent data regarding the subjects of the present study.

Table 1

Age, in Years and Months, of the Subjects and
Type of VPI Surgery Performed

| Subject # | Age at Time of Surgery | Type of Surgery |
|---|---|---|
| 1 | 8 years, 0 months | Sphincter Pharyngoplasty |
| 2 | 12 years, 1 month | Pharyngeal Flap |

## Procedures

### Test Instrument

The Broen CVC Probe (Broen et al., 1983), a 78-item single word imitative task that allows for the analysis of initial and final consonants was utilized as the tool to collect a structured speech sample from the subjects (Appendix E).

During the administration of the Broen CVC Probe, an individual is asked to repeat stimulus words. Responses are transcribed by the examiner. Subsequently, the individual's productions for initial consonants are scored as correct or incorrect on the Initial Consonant Matrix scoring form (Appendix F) according to the manner in which it was produced.

Completion of the task results in 78 potential initial word position (IWP) phonemes that can be scored. Similarly, the individual's productions for final consonants are scored on the Final Consonant Matrix (Appendix G). As 7 of the 78 items actually consist of CV combinations rather than CVC combinations, 71 final word position (FWP) productions can be scored following administration of the test. This instrument allows for the types of production errors made by the subject to be categorized according to manner, place, and voicing of production. The Broen CVC Probe elicits all initial and final sounds more than once, and allows the percentage correct for each sound to be computed.

Additionally, diacritic markers (Appendix H) were applied, as needed, to document the nature of actual verbal responses. For the purposes of this study, the term *diacritic errors* was used to indicate those error types that were documented in transcription by the use of diacritic markers. Examples of categories demonstrating errors documented by the use of diacritic markers include the following: (a) nasality errors such as hypernasality; (b) secondary articulations such as interdentalized productions; (c) modifications in the primary articulation such as partial de-voicing of voiced phonemes; (d) stop release errors such as excessive aspiration; (e) timing and juncture errors such as pausing; and (f) force of production errors such as weak consonant production. Intelligibility measures were not completed in this study.

Nature and Timing of Data Collection

Subjects, who met study criteria for inclusion and consented to participate, were seen individually for a single data gathering session during the month that preceded their velopharyngeal surgery. The subjects were also seen individually for a single data gathering session 1 month after surgery and again for a data gathering session 4 months after surgery.

At each of these data gathering sessions, the subject participated in the administration of the Broen CVC Probe (Broen et al., 1983). Subject responses were transcribed on-line and were also tape recorded for later analysis by the Principal Investigator. A Marantz professional portable cassette recorder model PMD201 and an Audio-Technica condenser microphone model AT831b placed 6 inches from the subject's mouth were utilized for the audio tape recording. Responses were recorded on the Initial Consonant and Final Consonant Matrices for each subject for their three data collection samples namely, prior to surgery, 1 month postsurgery, and 4 months postsurgical management.

## Transcription

All speech samples from the Broen CVC Probe, gathered presurgically and 1 and 4 months postsurgically per each subject, were transcribed using the International Phonetic Alphabet. Furthermore, diacritics markers were used during the transcription as needed to accurately reflect error patterns observed. Appendix H contains a list of the diacritic markers utilized in this study (Bush et al., 1973; Shriberg & Kent, 1982). The use of diacritic markers to score secondary articulation patterns helps to account for speech differences observed, such as accompanying audible nasal air emission and/or wet-sounding speech, when the speech parameters of place, manner, and voicing are intact.

## Reliability

Twenty-five percent of all productions were re-transcribed by the Principal Investigator as well as independently transcribed by a certified doctoral level speech-language pathologist to enable computation of intra- and inter-rater reliability. Percentage of agreement calculations were computed for both intra- and inter-rater reliability for each of the following: (a) phonetic transcription of initial word position consonants, (b) phonetic transcription of vowels, (c) phonetic transcription of final word position consonants, (d) diacritic marker use during transcription of initial word position consonants, (e) diacritic marker use during transcription of vowels, and (f) diacritic marker use during the transcription of final word position consonants.

Intra-Rater Reliability

To determine the degree of intra-rater reliability, 25% of all productions were re-transcribed by the Principal Investigator. Intra-rater reliability was calculated for phonetic transcription (Table 2) and use of diacritic markers (Table 3). Intra-rater reliability for actual phoneme production was at 100%. Agreement for the use of diacritic markers during transcription of vowels and initial and final consonants ranged from 91 to 93%.

Table 2

Intra-Rater Phonetic Transcription Reliability of Both Subjects' Speech Samples Across Pre and Postsurgical Data Gathering Sessions

| Word Position or Vowel | Percent Agreement |
|---|---|
| Initial Word Position | 100 |
| Vowels | 100 |
| Final Word Position | 100 |

Table 3

Intra-Rater Use of Diacritic Markers Reliability of Both Subjects' Speech Samples Across Pre and Postsurgical Data Gathering Sessions

| Word Position or Vowel | Percent Agreement |
|---|---|
| Initial Word Position | 93 |
| Vowels | 93 |
| Final Word Position | 91 |

Inter-Rater Reliability

Twenty-five percent of all productions were independently transcribed by a certified speech-language pathologist who randomly transcribed 40 items from the initial test session and 10 items each from the second and third test sessions for each subject. Inter-rater reliability for all scoring was quite high ranging from 78% to 100%. Table 4 presents inter-rater phonetic transcription scoring reliability while Table 5 presents inter-rater reliability data for use of diacritic markers. Phonetic transcription inter-rater reliability ranged from 98 to 100% while inter-rater reliability for diacritic marker use was 78 to 86%.

Table 4

Inter-Rater Phonetic Transcription Scoring Reliability of Both Subjects' Speech Samples Across Pre and Postsurgical Data Gathering Sessions

| Word Position or Vowel | Percent Agreement |
|---|---|
| Initial Word Position | 98 |
| Vowels | 100 |
| Final Word Position | 98 |

Table 5

Inter-Rater Use of Diacritic Markers Reliability of Both Subjects' Speech Samples Across Pre and Postsurgical Data Gathering Sessions

| Word Position or Vowel | Percent Agreement |
|---|---|
| Initial Word Position | 81 |
| Vowels | 86 |
| Final Word Position | 78 |

Additional Inter-Rater Reliability Testing

Because of the observed dip in inter-rater reliability for final consonant diacritic marker use, further analysis of the final word position agreement of diacritic markers was undertaken to determine in which contexts the transcribers differed most. Specifically, the level of inter-rater reliability for final word diacritic marker transcription was studied: (a) per study subject, and then subsequently (b) per timing of visit, namely presurgery, 1 month postsurgery, and 4 months postsurgery for Subject #2 as greatest variability in inter-rater reliability was observed in the scoring of this individual's speech samples. Results are presented in Tables 6 and 7. It is noted that for transcription of Subject #2's speech, inter-rater reliability increased over time with 85% inter-rater diacritic marker use reliability achieved by 1 month postsurgery.

Table 6

Inter-Rater Use of Diacritic Markers in Final Word Position Transcription Reliability According to Subject Across Pre and Postsurgical Data Gathering Sessions

| Subject # | Percent Agreement |
|---|---|
| 1 | 80 |
| 2 | 77 |

Table 7

Inter-Rater Use of Diacritic Markers in Final Word Position Transcription for Subject #2 According to Data Collection Period Reliability

| Test Session | Percent Agreement |
|---|---|
| Presurgical Test | 74 |
| 1 Month Postsurgery | 85 |
| 4 Months postsurgery | 90 |

Use of the Data to Respond to the Study's Research Questions

Research Question #1 asked, "What type of speech patterns do subjects referred for surgical management of velopharyngeal incompetence demonstrate presurgically? Each subjects' presurgical Broen CVC Probe results were used to respond to this research question. Descriptive analysis techniques were applied.

Research Question #2 asked, "What changes in the speech patterns of the subjects are observed in the immediate month following surgery for velopharyngeal incompetence?" Each subjects' 1-month postsurgical Broen CVC Probe results were used to respond to this research question. Descriptive analysis techniques were applied.

Research Question #3 asked, "Do these changes settle into a stabilized pattern of production by 4 months postsurgery?" Each subjects' 4-month postsurgical Broen CVC Probe results were used to respond to this research question. Descriptive analysis techniques were applied.

Data Analysis

When data collection was fully completed, each subjects' Broen CVC transcription results were scored using the scoring matrix forms for each of the following data collection periods: presurgery, 1 month postsurgery and 4 months postsurgery.

Descriptive analysis techniques were utilized to respond to the study questions. Specifically, the following calculations were computed for each of the 2 subject's data at the three data collection periods: (a) percentage of errors in place of production of initial and of final consonants, (b) percentage of errors in manner of production of initial and of final consonants, (c) percentage of errors in voicing of initial and of final consonants, and (d) percentage of errors due to the following combined factors as indicated by diacritic marker: (a) resonance/nasality distortion, (b) secondary articulation, (c) modification in primary articulation, (d) stop release error, (e) timing and/or juncture error, (f) force of production error.

To assist in the presentation of the study results, graphic charts were created for each of the 2 subject's data to demonstrate results of each of the three data collection periods for the following: (a) percentage of errors in *place* of production of initial and of final consonants, (b) percentage of errors in *manner* of production of initial and of final consonants, (c) percentage of errors in *voicing* of initial and of final consonants, and (d) percentage of productions that were in error due to any of the combined diacritics. Descriptive analytical techniques were utilized to describe the nature of place, manner, and voicing errors observed. Further analysis was completed and graphic illustrations were completed to further explore the nature and frequency of diacritic error patterns. Diacritic error patterns were presented graphically for each subject's presurgical, 1 month postsurgery, and 4 months postsurgery data according to the frequency of occurrence in the following categories: nasality errors, secondary articulation errors, modifications in the primary articulation errors, stop release errors, timing and/or juncture errors, force of production errors, and other errors not corresponding to the above mentioned categories. Descriptive analytical techniques were utilized to describe the particular nature of each subject's diacritic error patterns.

# CHAPTER IV

# RESULTS AND DISCUSSION

The purpose of this study was to help document the pattern and consistency of sound production following surgery in individuals exhibiting VPI due to anatomical deficits. Two subjects participated in three data gathering sessions each in which the Broen CVC Probe, a 78-item single word imitative task, was administered and audio recorded. These administrations occurred in the month preceding the subjects' surgery, and at 1 and 4 months after surgery. Scoring and analysis of the subjects' repeat performances on the Broen CVC Probe allowed for description of pre and postsurgical speech patterns in this sample population of individuals demonstrating VPI. Subject demographics and reliability procedures were described. The study's findings are reviewed. Study limitations and overall impressions of the study results are discussed.

## Results

### Results: Speech Patterns of the Subjects Prior to Surgical Management for VPI

Research Question #1 asked, "What type of speech patterns do subjects referred for surgical management of velopharyngeal incompetence demonstrate presurgically?" To address this question, each subjects' 1-month prior-to-surgery performance results on the Broen CVC Probe were utilized.

*Place of Articulation*

Figures 1 and 2 graphically demonstrate for Subjects #1 and #2 respectively the percentage of errors in place of articulation during production of initial word position (IWP) and final word position (FWP) consonants during the presurgical period. Subject #1 demonstrated place error rates of 3% and 6% respectively during the production of initial and final consonants. In IWP, Subject #1 demonstrated interdental production of alveolar sibilants, namely /ð/ for /z/ and /θ/ for /z/. In FWP, Subject #1 similarly demonstrated interdental production of alveolar sibilants (θ/s, θ/z) and alveolar production of an interdental phoneme namely /t/ for /θ/.

Subject #2 demonstrated place error rates of 3% and 4% respectively during production of initial and final consonants. In IWP, Subject #2 demonstrated the alveolar production /d/ for the interdental /ð/ and a labiodental production /f/ for the interdental /θ/. In FWP, Subject #2 demonstrated alveolar /n/ production of the velar nasal /ŋ/ and the labiodental production /v/ for the interdental /ð/.

*Manner of Production*

Subject #1 did not demonstrate any errors in manner in IWP during the presurgical period. He demonstrated a 1% error rate in manner of production in FWP. Specifically, he substituted a stop plosive /t/ for the fricative /θ/.

Subject #2 demonstrated a 1% error rate in manner of production for IWP during the presurgical period. Specifically, Subject #2 substituted the alveolar stop /d/ for the fricative /ð/. He did not demonstrate any FWP manner errors presurgically.

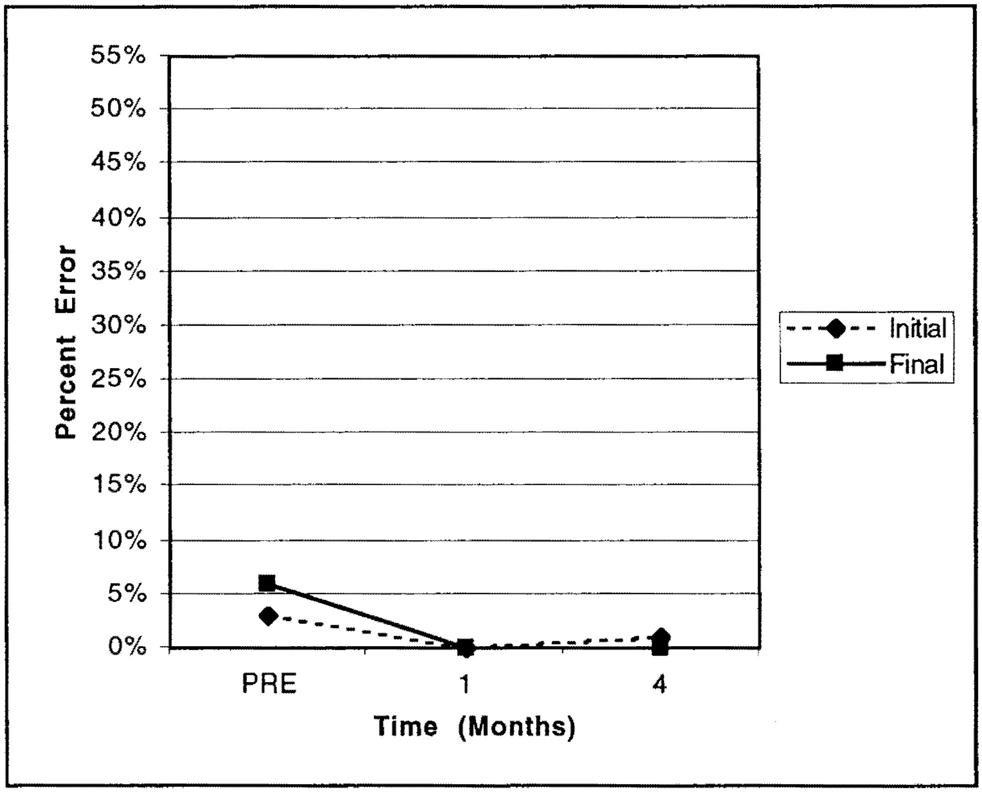


Figure 1

Presentation of Results: Percentage of Subject #1's IWP and FWP Place Errors Presurgically, 1 Month Postsurgically, and 4 Months Postsurgically

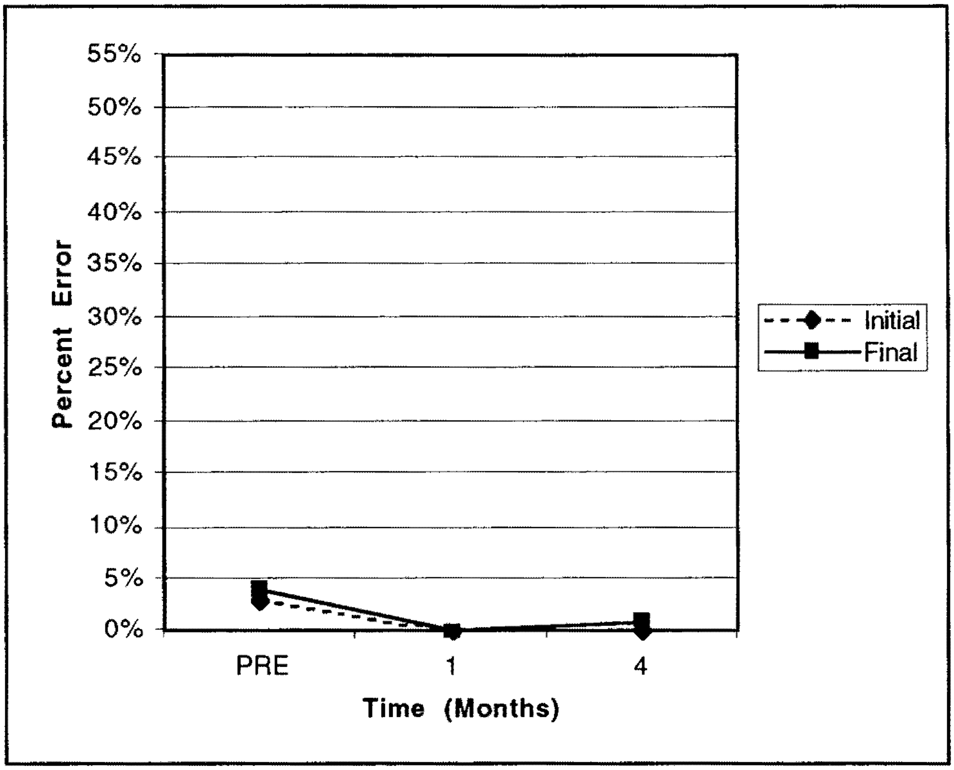


Figure 2

Presentation of Results: Percentage of Subject #2's IWP and FWP Place Errors Presurgically, 1 Month Postsurgically, and 4 Months Postsurgically

*Voicing*

Subject #1 demonstrated a 3% error rate in the voicing of IWP consonants during the presurgical period. Specifically, he substituted the voiceless fricative /f/ for the voiced fricative /v/. He also substituted the voiceless fricative /θ/ for the voiced fricative /z/. Subject #1 demonstrated voicing errors in FWP consonants 3% of the time presurgically. His errors were the substitution type in that he produced the voiceless fricative /f/ for the voiced fricative /v/ and the voiceless fricative /θ/ for the voiced fricative /z/.

Subject #2 did not demonstrate any errors in the voicing of initial or final consonants during the presurgical period.

*Diacritics*

In addition to the calculation of percentage of errors in place, manner, and voicing, percentage of accompanying diacritical errors were scored. Diacritic errors fell into the major categories of nasality, secondary articulations, modifications of primary articulations, stop release errors, timing and juncture errors, and force or production errors. Errors that did not fall into the listed categories was classified as *other*. Appendix H lists specific error types within each of these major diacritic categories.

Figure 3 graphically demonstrates for Subject #1 the percentage of productions accompanied by diacritic errors. Subject #1 demonstrated diacritic errors on 28% of his IWP productions or namely on 22 out of 78 words produced. He demonstrated errors on 49% of FWP consonant productions.

To better understand the frequency and specific nature of these diacritic errors, graphs were completed for Subject #1's presurgical data. Figure 3 presents Subject #1's overall percentage of diacritical errors for IWP and FWP. As seen in Figure 4, Subject #1,

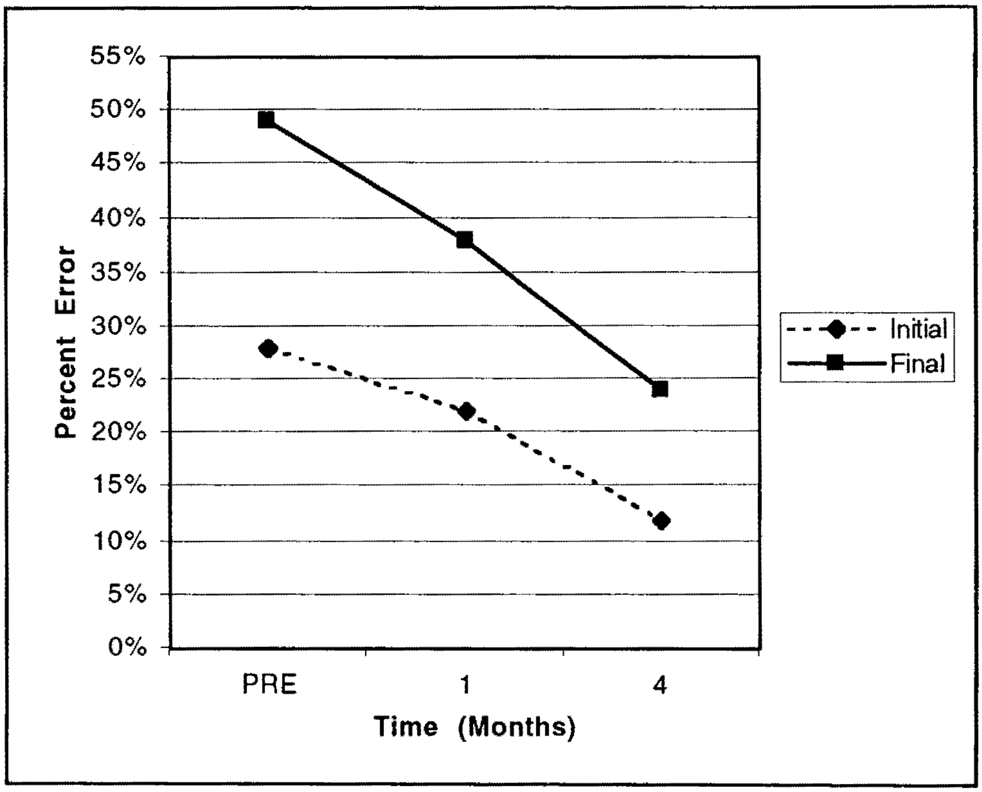


Figure 3

Presentation of Results: Percentage of Subject #1's IWP and FWP That Contained Diacritic Errors Presurgically, 1 Month Postsurgically, and 4 Months Postsurgically

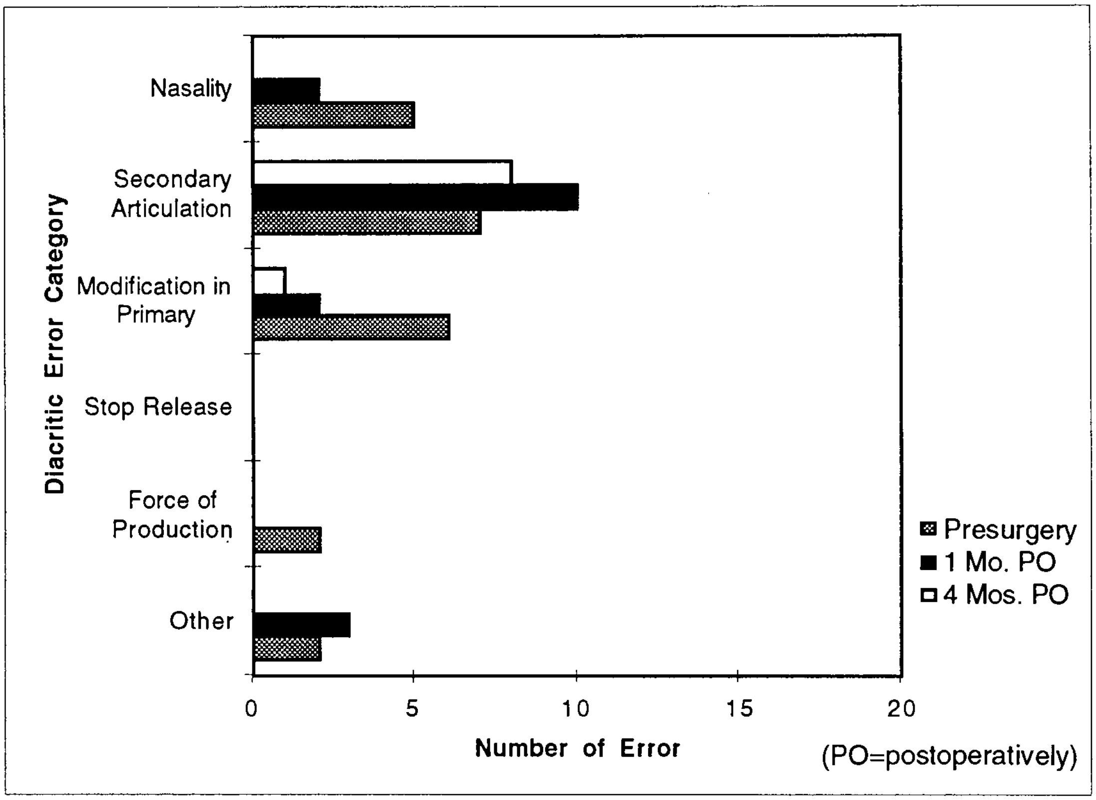


Figure 4

Presentation of Results: Subject #1's Frequency and Pattern of Diacritic Errors in IWP Consonants Presurgically, 1 Month Postsurgically, and 4 Months Postsurgically in IWP, demonstrated predominantly secondary articulation characterized by interdental productions on three occasions, derhoticization (3x), and frication (1x). His second most common diacritic error pattern involved modifications in primary articulation that were characterized by accompanying breathiness (5x) and partially voiced voiceless phonemes (1x). His third most common diacritic error pattern involved nasality in that four IWP consonant productions were accompanied by audible nasal air emission. Hypernasality was observed in one CVC word production that did not contain a nasal consonant. His fourth error pattern involved force of production characterized by weak pressure consonants. His final diacritic error pattern presurgically was classified as *other* in that he produced an epenthesis by adding a vowel to an IWP consonant on two occasions.

Subject #1 demonstrated diacritic errors on 34 out of 69 FWP productions which equated to an error rate of 49%. It is reiterated that he only had 69 out of a possible 71 final word productions because of two omissions. As Figure 5 reveals, his most predominant FWP diacritic error pattern involved modifications in primary articulations in that on 14 occasions, voiced phonemes were partially de-voiced. His second most predominant FWP error pattern involved force of production in that pressure consonants were produced weakly in six instances. The third most common error pattern fell in the category of secondary articulations because of three interdentalized productions; one fronted production; and one production produced with wet quality. The fourth most commonly produced errors were in the category of *other* due to four instances of epenthesis (vowel additions). The next most commonly produced errors fell in the category of stop release errors due to three instances of unreleased stop plosives. The final component of Subject #1's FWP diacritic

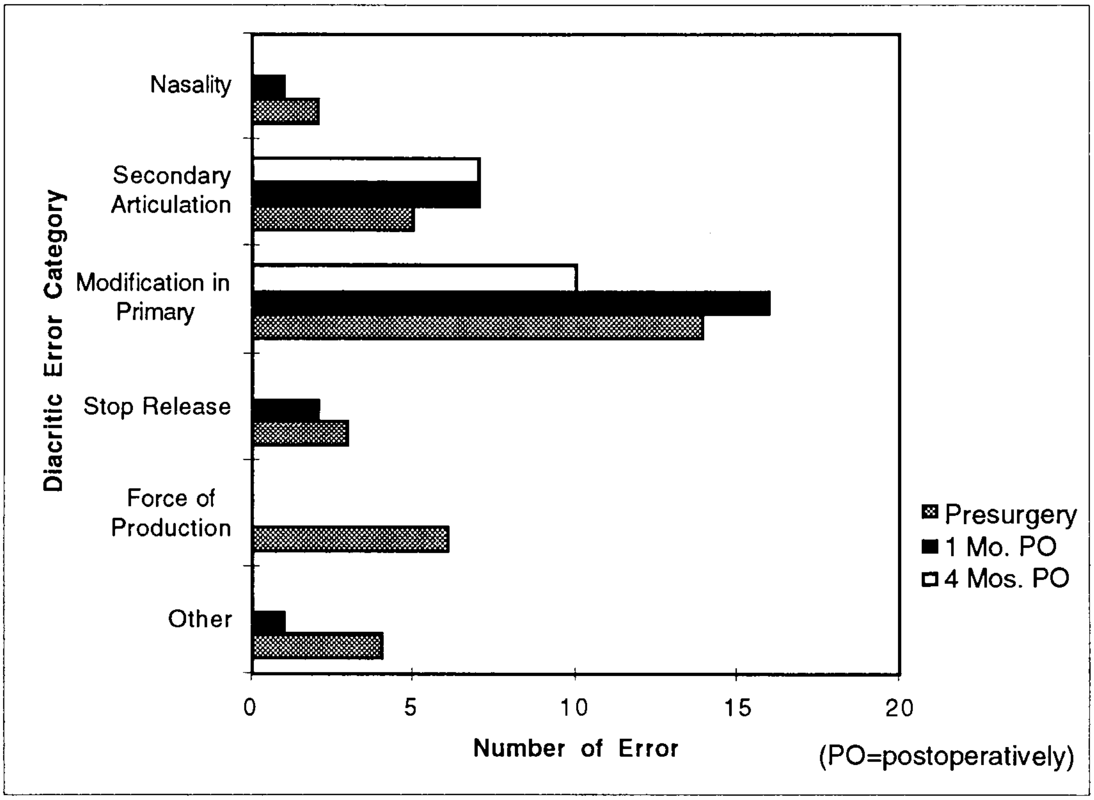


Figure 5

Presentation of Results: Subject #1's Frequency and Pattern of Diacritic Errors in FWP Consonants Presurgically, 1 Month Postsurgically, and 4 Months Postsurgically errors involved nasality in that two productions were accompanied by audible nasal air emission.

Turning now to Subject #2, as can be seen in Figure 6, he demonstrated diacritic errors on 17 out of 78 or 22% of IWP consonant productions and on 52% of FWP consonant productions. Figure 7 reveals that presurgically Subject #2 in IWP demonstrated predominantly errors in nasality (audible nasal air emission 7x; hypernasal resonance 2x). His second most predominant diacritic error pattern involved modifications in primary articulation in that he partially de-voiced voiced phonemes on six occasions. His final error involved secondary articulations involving wet sounding quality (2x).

Subject #2 demonstrated diacritic errors on 37 out of 71 FWP consonant productions which equaled an error rate of 52%. As Figure 8 reveals, Subject #2's most predominant presurgical error pattern in FWP consonant production involved modifications in primary articulation as a result of partial de-voicing (13x) and backing of consonants (3x). His second most common FWP error pattern involved nasality characterized by accompanying audible nasal air emission (7x) and hypernasality (2x). His third most common FWP error pattern involved force of production due to pressure consonant weakness (8x). His least occurring FWP presurgical error pattern involved the category of stop release in that on two occasions FWP stop plosives were unreleased.

1-Month Postsurgical Speech Patterns

Research Question #2 asked, "What changes in the speech patterns of the subjects are observed in the immediate month following surgery for velopharyngeal incompetence?" To address this question, each subjects' results from their participation in the Broen CVC Probe in the 1 month following surgery to improve velopharyngeal closure were utilized.

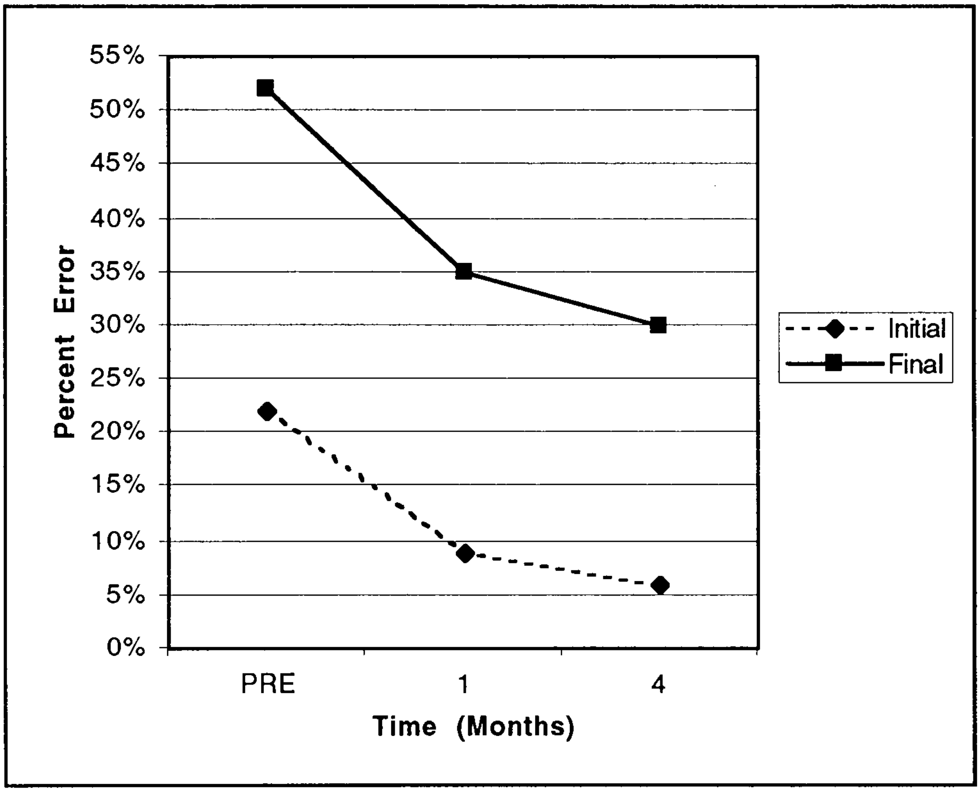


Figure 6

Presentation of Results: Percentage of Subject #2's IWP and FWP That Contained Diacritic Errors Presurgically, 1 Month Postsurgically, and 4 Months Postsurgically

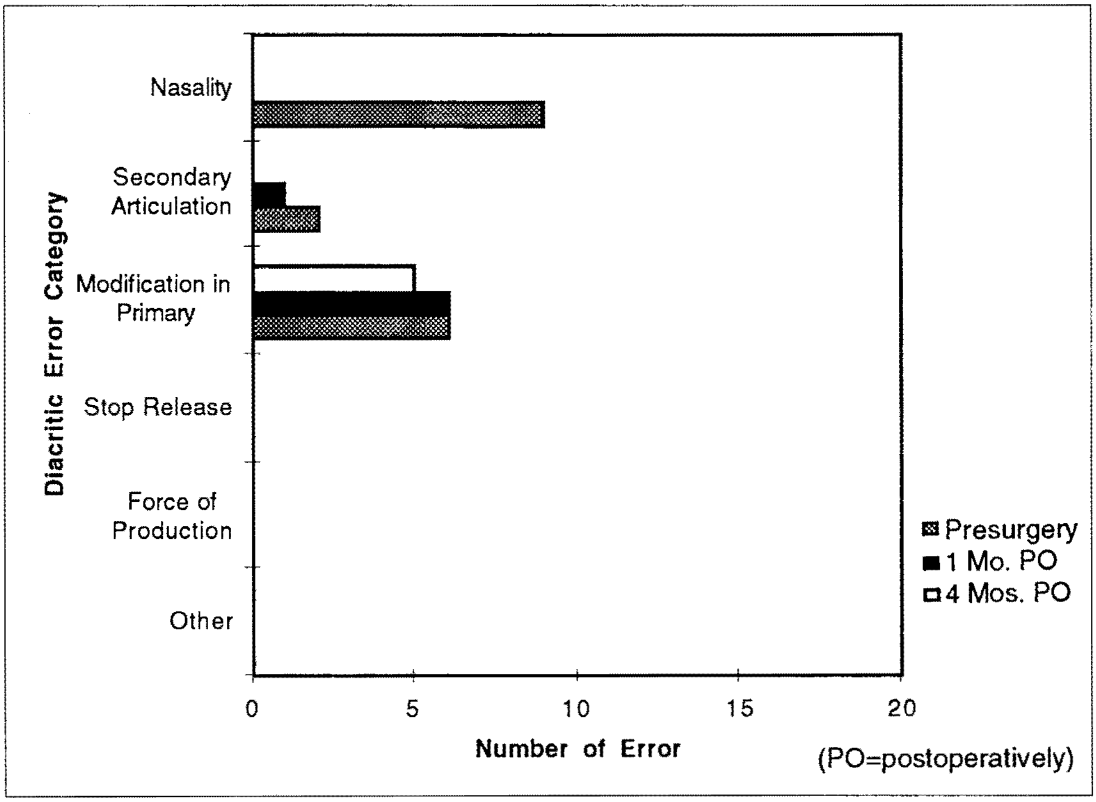


Figure 7

Presentation of Results: Subject #2's Frequency and Pattern of Diacritic Errors in IWP Consonants Presurgically, 1 Month Postsurgically, and 4 Months Postsurgically

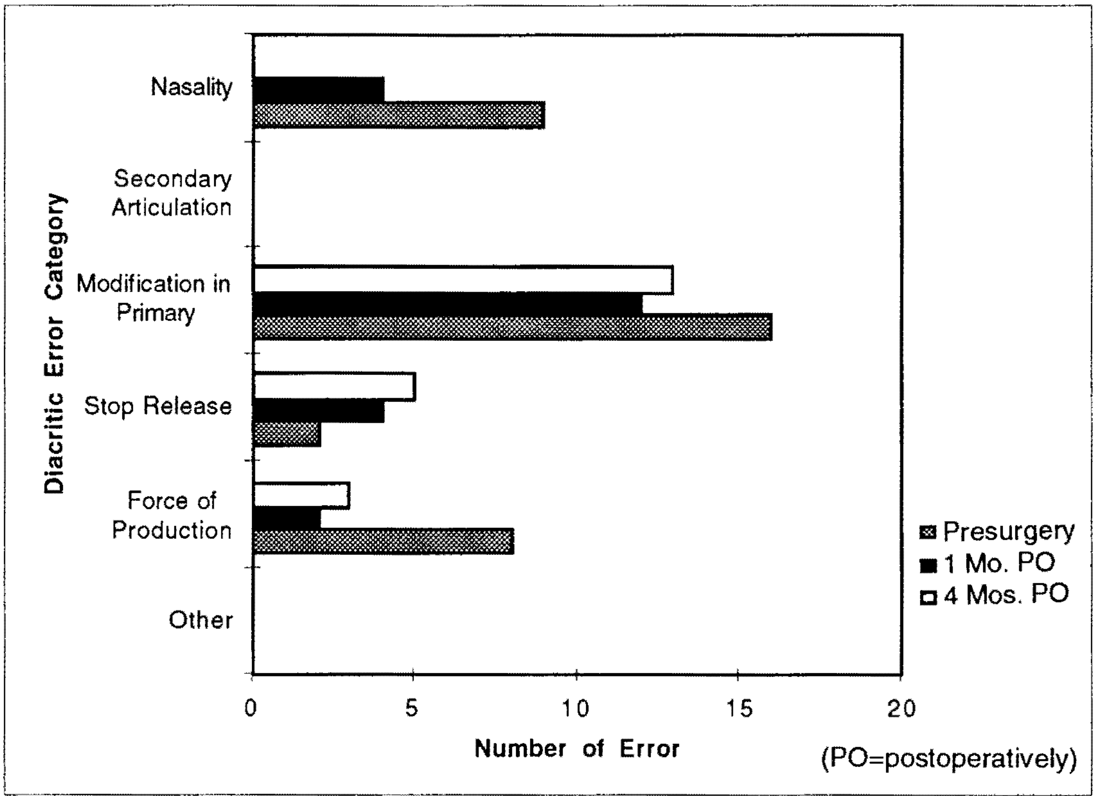


Figure 8

Presentation of Results: Subject #2's Frequency and Pattern of Diacritic Errors in FWP Consonants Presurgically, 1 Month Postsurgically, and 4 Months Postsurgically

*Place of Articulation*

Previously presented Figures 1 and 2 graphically demonstrated percentage of errors in place of IWP and FWP consonant articulation 1 month postsurgically. Subject #1 demonstrated no errors in place of articulation during the 1 month postsurgical period in IWP or FWP consonant productions. Subject #2 similarly demonstrated no errors in place of articulation in IWP or FWP 1 month postsurgery.

*Manner of Production*

Neither subject demonstrated any manner errors in IWP or FWP 1 month postsurgically.

*Voicing*

Voicing production errors for initial consonants equaled 1% for Subject #1's 1-month postsurgical period. These errors were characterized by the substitution of the unvoiced fricative /f/ for the voiced fricative /v/. Subject #1 demonstrated a 1% voicing error rate for final consonants at the 1-month postsurgical period. This error was characterized by the substitution of the unvoiced fricative /s/ for the voiced fricative /z/.

At the 1-month postsurgical period, Subject #2 did not demonstrate any errors in the voicing of IWP or FWP consonant productions.

*Diacritics*

Figure 3, previously presented, demonstrated that Subject #1 exhibited a 22% diacritic error rate as 17 out of 78 IWP consonants were produced in error. His FWP diacritic error rate was higher at 38% because 44 out of 71 FWP consonants were produced in error. Figure 6 demonstrates that Subject #2 exhibited a 9% IWP diacritic error rate (7/78), whereas he demonstrated a 35% FWP error rate (25/71).

To better understand the frequency and specific nature of these diacritic errors, graphical representation of Subject #1's 1-month postsurgical data and can be found in previously presented Figures 4 and 5. Figure 4 demonstrates that 1 month postsurgically, Subject #1 in IWP predominantly demonstrated secondary articulations just as he had presurgically. The secondary articulations were characterized by interdental productions (6x), derhoticization (3x), and palatalized productions (1x). His second most commonly occurring diacritic pattern fell in the category of *other.* These errors were vowel additions (3x). During this 1-month postsurgical period, he demonstrated a tie in the third most commonly occurring error pattern in the categories of nasality and modifications of primary articulation. In contrast to his presurgical productions, nasality errors were fewer but more greatly varied. He demonstrated hyponasality (1x) and accompanying audible nasal air emission (1x). Primary articulation modifications were due to breathiness (2x).

Subject #1, as demonstrated in Figure 5, demonstrated diacritic errors on 27 out of 71 FWP productions 1 month postsurgically. His most predominant FWP error pattern involved modifications in primary articulation. This was due to partial de-voicing of voiced phonemes on 16 occasions. His second most commonly occurring FWP error pattern involved secondary articulations as seven FWP productions were interdentalized. The third most commonly occurring error pattern was the addition of a stop plosive release as in /kɪŋg/ for "king" during two productions. Final error patterns involved observed hyponasality (1x) and the addition of a vowel (1x).

Subject #2's diacritic error rate 1 month postsurgery was noticeably lower than that of Subject #1 in that only 9% of his IWP productions were accompanied by diacritic errors. Previously presented Figure 7 reveals that Subject #2's errors were divided disproportionately over the two categories of modifications in primary articulation (partial de-voicing 6x) and accompanying secondary articulations (wetness 1x).

Subject #2 demonstrated diacritic errors on 25 FWP consonant productions. Previously presented Figure 8 illustrates that his most predominant error pattern, like during IWP production, was in modifications in primary articulation. Specifically, partial de-voicing was present on 12 occasions. The second most commonly occurring error pattern involved the addition of a stop plosive release to nasal phonemes in FWP. Nasal distortion was the third most commonly observed error. But unlike during his presurgical productions, hyponasality was now observed (4x). Persisting force of production errors were observed due to weak FWP consonant production (2x).

## 4-Month Postsurgical Articulatory Patterns

Research Question #3 asked, "Do these changes settle into a stabilized pattern of speech production by 4 months postsurgery?" To address this question, each subjects' results from their participation in the Broen CVC Probe 4 months following surgery to improve closure were utilized.

### *Place of Articulation*

Previously presented Figures 1 and 2 graphically demonstrate percentage of errors in IWP and FWP consonant production in terms of place of articulation 4 months postsurgically. Subject #1 demonstrated a 1% error rate in place of articulation in IWP consonant productions. Specifically, this error was the substitution of the fricative /θ/ for the fricative /s/. Subject #1 did not evidence any errors in place of articulation for FWP consonants.

Subject #2 did not demonstrate any errors in place of articulation for IWP consonants at the 4-month postsurgical period. However, Subject #2 did evidence a 1% error pattern in place of articulation during production of final consonants. This error was the substitution of the fricative /v/ for the fricative /ð/.

*Manner of Production*

Neither subject demonstrated any errors in manner of production during the 4-month postsurgical period.

*Voicing*

Neither Subject demonstrated any voicing errors in IWP or FWP consonant production during this 4-month postsurgical period.

*Diacritics*

In addition to scoring of place, manner, and voicing, accompanying diacritics were scored for the subjects' 4-month postsurgical data. Figures 3 and 6, presented earlier, graphically demonstrated these subjects' percentage of productions accompanied by diacritic errors. Subject #1 demonstrated a 12% IWP diacritic error rate compared to a 24% FWP error rate. Following this same trend of IWP productions being performed with more accuracy, Subject #2 demonstrated a 6% IWP diacritic error rate and a 30% FWP diacritic error rate.

To better understand the frequency and specific nature of these diacritic errors, previously presented Figures 4 and 5 included a graphic display of Subject #1's 4-month postsurgical data. IWP diacritic errors during this period, as illustrated in Figure 4, consisted predominantly of secondary articulations (interdentalizing 6x; accompanying wetness 1x; derhoticization 1x). His second and only other category of IWP diacritic errors involved modifications of primary articulation (partial de-voicing 1x).

Previously presented Figure 5 reveals that for Subject #1, 4 months postsurgically, diacritic errors in FWP consisted of secondary articulations and modifications in primary articulation with the latter being the more predominantly observed. Specifically, partial de-voicing occurred 10 times, interdentalizing of alveolar consonants on six occasions, and wet sounding quality was observed one time.

Subject #2's diacritic error rate 4 months postsurgery, while improved from previous sessions, persisted. As seen in previously presented Figure 6, he demonstrated a 6% error rate and a 30% rate respectively for IWP and FWP consonant productions. His sole IWP 4-month postsurgical diacritic error category was modification in primary articulation due to partial de-voicing. This is illustrated in previously presented Figure 7. His FWP diacritic errors from greatest to least in frequency were in modifications in primary articulation, stop release, and force of production. Pattern of these errors can be seen in previously presented Figure 8. Modifications in primary articulation were due to partial de-voicing (13x). Stop release errors were variable as they were characterized by inconsistent excessive aspiration (3x), Addition of a stop plosive release to a FWP nasal consonant (1x), and unrelease of a FWP stop plosive (1x). Despite the completion of surgical management to improve velopharyngeal closure, weak pressure consonants, a form of force of production errors, continued to be observed (3x).

## Discussion

### Study Limitations

There were several limitations inherent in this study. First, the study sample size was small. The incidence of clefting occurs in approximately 1 in 1000 live births; the rate of submucous clefts is even lower. The subpopulation of this group that requires secondary surgical management to improve velopharyngeal closure is even smaller. These small sample sizes lend them selves to single subject and small group size subject design.

A second limitation is that the subjects were only followed for a 4-month time period following their surgical procedures. Speech patterns had not yet stabilized. The fact that this project was a Master's thesis did not lend itself to further longitudinal collection of data.

A third limitation is that the Principal Investigator did not have access to the subjects' medical records. It would have beneficial to have precise detail regarding timing and nature of procedures completed.

A fourth limitation was the lack of available input regarding the timing and nature of speech therapy intervention in the case of Subject #2 and the lack of clarity of what, if any, active services were received by Subject #1. Review of such records would have shed additional light on their speech progress.

Presurgical Speech Patterns

The presurgical speech patterns demonstrated by this study's subjects included minor articulatory placement errors. Such errors included interdental production of alveolar consonants. This may have been an aftermath of therapy as individuals who have been previously observed to *back* sounds are, at times, exposed to exaggerated tongue blade-to-edge of the central incisor productions of alveolar consonants as a means of eliminating the observed backing pattern. Minor errors in manner of production were evidenced in the substitution of stops for fricatives. Compensatory strategies of glottal stopping and the production of pharyngeal fricatives are frequently documented as occurring in the speech of individuals with VPI. It was expected that these strategies would be evident in the speech of this study's subjects as well. However, this was not the case. Hypernasality and nasal air emission, also associated with VPI, were present in this study's subjects which was expected in light of the fact that they were prescheduled to have surgical management of their velopharyngeal closure mechanisms. Both subjects evidenced in addition to hypernasality and nasal air emission, signs of breathiness, weak pressure consonant production, and partial de-voicing. Errors in the voicing of phonemes requiring increased intra-oral pressure (stops, fricatives, and affricates) is consistent with the findings of other studies investigating the speech patterns associated with VPI (Broen and Moller, 1993).

Speech Production Patterns 1 Month Postsurgery

Changes noted in the speech patterns of the subjects' at 1 month postsurgery include a resolution in errors in place of articulation for both subjects. Likewise, manner improved as well. These findings were consistent with those observed in earlier studies. Errors in voicing were diminished, although not eliminated for Subject #1. Diacritic errors showed a pattern of general improvement, but were not eliminated for either subject. As was expected, the diacritic patterns that evidenced a decline in occurrence included errors in hypernasality and audible nasal air emission. Elimination of hypernasality and nasal air emission is consistent with the findings of previous studies (Argamaso et al., 1980; Shprintzen et al., 1979). Hyponasality, however, was demonstrated in place of hypernasality to at least some extent in both subjects. This likely was due to persisting tissue edema at the surgical site.

Patterns of weak pressure consonant production and breathiness decreased. Breathiness is related to the inability to sustain adequate intra-oral air pressure in individuals with VPI. As the functioning of the velopharyngeal mechanism improves, errors in breathiness would be expected to decrease, and indeed they did for these subjects. These findings are consistent with those of earlier studies.

Select speech patterns, however, unique to each subject became more prevalent during the 1-month postsurgical period. These errors included an increase in interdental productions and epenthesis (vowel additions) for Subject #1. Subject #2 demonstrated errors of excessive aspiration of stop plosive phonemes in FWP and addition of a stop plosive release to nasal consonants in FWP. These findings could be related to the narrowing of the velopharyngeal ports brought about by surgical management.

### Stabilization of Speech Patterns by 4 Months Postsurgery

Stable patterns of speech production were achieved in manner of production and voicing by both subjects during the 4-month postsurgical period. Errors in place of articulation had declined from presurgical levels, but were not eliminated from the speech of either subject. Diacritic speech patterns that appear to have stabilized by 4 months postsurgery include hypernasality, audible nasal emission, and breathiness in the production of initial and final consonants. Other patterns such as weak consonant production, were reduced but not eliminated in the speech of Subject #2. This finding was unexpected and suggests the continuing presence of VPI. Subject #1 continued to demonstrate reduced rates of interdentalization and derhoticization.

## Additional Insights

As flap surgery is usually conducted at about 6 years of age, the subjects for studies investigating speech patterns associated with VPI typically are quite young. The present study differs from these studies in that the subjects were older than is usual. One could expect that if they had had "untreated VPI" for their life span, they would have developed a greater number of compensatory speech patterns. Subject #1, who had a submucous cleft, may not have had negative functional impact on speech until he became older and his adenoidal pad began to atrophy. This may have been why surgical repair of the submucous cleft had not been pursued at an earlier date. In terms of Subject #2, the child with bilateral cleft lip and palate who had worn a speech prosthesis, one could gather that the device was successfully developed to assist in VP closure so that he did not have the opportunity to develop a greater amount of compensatory speech patterns.

A pattern of not releasing final stop consonants was present in the presurgical speech of Subject #1. According to Tanimoto et al. (1994), speakers with VPI often hold the tongue posteriorly in order to produce more perceptually correct speech. It seems most likely that this was a compensatory pattern used by this subject to help maintain intra-oral air pressure. The fact that this pattern of not releasing stopped consonants was not present after surgery appears to lend support to the notion of this error being a compensatory strategy.

Partial de-voicing errors of initial and final consonants remained consistent over the span of the study. A study carried out over a longer time period would help determine if this pattern would eventually correct itself. Findings suggest that partial de-voicing is a pattern of accommodation to an inadequate velopharyngeal mechanism that will have to be unlearned.

The presence of weakly produced sounds is a pattern associated with an inadequate velopharyngeal mechanism due to the velopharyngeal valve's inability to sustain intra-oral air pressure (Trost-Cardamone & Bernthal, 1993). Although weak productions decreased after surgery, they were not eliminated. This appears to indicate that some VPI may still be present for one of the subjects in this study.

# CHAPTER V

# SUMMARY AND IMPLICATIONS

## Summary

The purpose of this thesis was to help determine the pattern and consistency of sound production following surgery in individuals exhibiting VPI due to anatomical deficits. This study was accomplished by duplicating a portion of a study originally conducted by Broen et al. in 1988 that focused on the speech productions of children with VPI prior to and after surgery to improve the velopharyngeal mechanism. The Broen CVC Probe, an instrument developed to identify the speech patterns present in individuals exhibiting VPI, was administered to each of this study's 2 subjects on three separate occasions. The first administration occurred in the month prior to surgery. The second administration occurred 1 month postsurgically, and the third administration occurred 4 months postsurgically. At each data gathering test session, the subject would imitate words spoken by the primary investigator. These productions were scored on-line as well as recorded and transcribed later. The scored data were then placed onto matrices for initial and final consonants to identify patterns present in each subject's speech. Additionally, diacritic errors were analyzed. Intra-rater reliability was found to be 100% for the identification of phonemes, and 91 to 93% for the use or absence of diacritical markers used in transcription. Inter-rater reliability was found to be between 98 and 100% for the identification of phonemes, and 78 to 86% for the use or absence of diacritical markers used in transcription. Given the limitations of the study, the following is a summary of the results which support the study's original hypotheses unless otherwise indicated:

1. The type of articulatory patterns that subjects referred for surgical management of velopharyngeal incompetence demonstrate presurgically were documented. The presence of hypernasality and/or nasal air emission was present in the speech of both subjects presurgically. Other speech patterns exhibited that are associated with an inadequate velopharyngeal mechanism include weakness and breathiness of consonant productions. Both of the subjects exhibited partial de-voicing errors that, according to Broen et al. (1993), are typical of individuals with deficits in velopharyngeal valving. Errors indicating a slight backing pattern of articulation, a pattern of excessive aspiration on plosives, and a pattern of not releasing final plosives were also noted.

2. As hypothesized, changes in the articulatory patterns of the subjects were observed in the immediate month following surgery for velopharyngeal incompetence. Speech patterns directly related to the adequacy of the velopharyngeal mechanism, such as hypernasality and weak or breathy productions in the production of initial and final consonants, were reduced or eliminated after surgery. However, speech patterns that represent compensatory strategies, such as partial de-voicing of consonants, did not always decline significantly.

3. Some changes settled into a stabilized pattern of articulation by 4 months postsurgery. The hypothesis that speech changes would have settled into a stabilized pattern by 4 months postsurgery was partially supported by the findings of this study. Hypernasality and/or nasal air emission for initial and final consonants was eliminated in the speech of both subjects by 4 months postsurgery. Likewise, hyponasality, present only at the 1-month

postsurgical session, was also eliminated by 4 months postsurgery. These were the only two patterns in which errors were eliminated in the speech of both subjects by 4 months postsurgery. Other speech errors showed decline, but were not eliminated, in both subjects.

## Implications

### Clinical Implications

The results of the present study indicate from a clinical standpoint that surgical management of VPI in these cases was successful. Hypernasality and nasal air emission present in the production of initial and final consonants were no longer evidenced by 4 months postsurgery. Surgically induced hyponasality had disappeared by 4 months postsurgery as well. Other errors associated with VPI, such as weak and breathy productions, were either eliminated or significantly reduced by 4 months postsurgery.

Although compensatory errors, such as glottal stops and pharyngeal fricatives, were not seen in this study's subjects, these subjects did evidence other compensatory strategies. The presence of increased aspiration after surgery was maintained by 1 subject by the 4-month postsurgical session. The partial de-voicing errors exhibited by both subjects remained stable or slightly decreased over the span of this study. The implication suggested by these data is that compensatory strategies produced in response to an inadequate velopharyngeal mechanism do not always resolve by 4 months postsurgery, and may require articulation intervention to learn the correct production for affected classes of phonemes if errors persist.

The age of the individual who undergoes surgery for VPI may also be a factor in determining how long compensatory errors persist after surgery. Broen et al. (1988)

reported that compensatory errors had disappeared 4 months postsurgically. The subjects involved in the Broen study were younger than those of the present study. The present study's subjects evidence certain compensatory strategies that have persisted longer than the 4-month postsurgical test session and had shown little indication of decreasing. Therefore, another implication that might be drawn from this study is that older individuals may persist in the use of compensatory strategies longer than younger individuals.

One final clinical implication resulting from this study involves the use of standard articulation tests with individuals evidencing speech characteristics typically associated with VPI. As was documented in this study, these subjects made relatively few presurgical errors in place, manner, and/or voicing. The majority of articulation tests available today typically only document error types in place, manner, and/or voicing, although a few allow for the notation of a *distortion*. If individuals such as the subjects in the present study were tested only using these traditional articulation measures, their articulation scores would appear artificially normal. Only when diacritic markers are employed in the transcription of these individuals' speech samples will the true nature of their speech patterns be observed.

## Future Research Implications

In order to offer information and speech services that are more scientifically and less anecdotally based to individuals with VPI and their families as well as to other professionals, more research into the actual speech productions associated with VPI and effects following surgery are needed. Studies identifying the actual speech patterns typical of VPI and the changes that occur in these patterns following surgery are necessary to increase Speech-Language Pathology's professional data pool. Ideally, longitudinal studies that follow subjects for several months after surgery would be helpful in identifying when the majority of individuals settle into stable articulatory patterns. Longitudinal studies would also be helpful in identifying which patterns typically persist in the speech of individuals after surgery, and whether these patterns eventually correct themselves over time. This information would be valuable in the planning and implementation of speech intervention services for individuals after surgery.

The effect that age has on the presurgical speech patterns as well as the postsurgical outcomes would also be of value. It is possible that the age of the individual, as well as the speech intervention that the person has received, will affect the types of presurgical errors that an individual will exhibit. Also, it is possible that older individuals who have had more time to practice incorrect productions may exhibit more persistent error patterns after surgery that will require speech intervention to correct. At the present, it is unknown if there is a difference in presurgical error patterns for children of varying age, or if those errors will resolve in a similar time frame.

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# APPENDIX A

# PORTLAND STATE UNIVERSITY'S USE OF HUMAN SUBJECTS IN RESEARCH APPROVAL LETTER

**OFFICE OF GRADUATE STUDIES AND RESEARCH**
**Research and Sponsored Projects**

DATE: August 14, 1996

TO: Debra Childs SSN#: 544-86-6888

FROM: for Laurie Skokan, Chair, HSRRC 1995-1996

RE: HSRRC Approval of Your Application titled "Speech Production Patterns Following Management of Velopharyngeal Incompetence"

In accordance with your request, the Human Subjects Research Review Committee has reviewed your proposal referenced above for compliance with DHHS policies and regulations covering the protection of human subjects. The committee is satisfied that your provisions for protecting the rights and welfare of all subjects participating in the research are adequate, and your project is approved.

Any changes in the proposed study, or any unanticipated problems involving risk to subjects, should be reported to the Human Subjects Research Review Committee. An annual report of the status of the project is required. This approval is only valid for one year from date of issue.

c: Maureen Orr Eldred
Lisa Letcher-Glembo, Project Advisor

approval.mem

# APPENDIX B

# OREGON HEALTH SCIENCES UNIVERSITY'S USE OF

# HUMAN SUBJECTS IN RESEARCH

# APPROVAL LETTER

OHSU

OREGON
HEALTH SCIENCES UNIVERSITY
3181 S.W. Sam Jackson Park Road, Portland, OR 97201-3098
Mail Code L106, (503) 494-7887 Fax (503) 494-7787

*Institutional Review Board/Committee on Human Research*

DATE: September 23, 1996

TO: Janet Brockman, MS
c/o Lisa Letcher-Glembo

FROM: The Committee on Human Research
MacHall Rm. 2160, Ext. 7887

SUBJECT: IRB#: 4210
TITLE: Speech Production Patterns Following Management of Velopharyngeal Incompetence

This confirms receipt of the ~~revised consent form(s)~~ cover letter, and/or answers to questions, assurances, etc., for the above-referenced study.

It satisfies the requirements of the Committee on Human Research. The protocol and proposal to use human subjects are herewith approved. The IRB# and the date of this memo must be placed in the top right corner of the first page of the ~~consent form~~ cover ltr. This is the approval date of this revised ~~consent form~~ cover letter

Investigators must provide subjects with a copy of the consent form, keep a copy of the signed consent form with the research records, and place a signed copy in the patient's hospital/clinic medical record (if applicable).

Approval by the Committee on Human Research does not, in and of itself, constitute approval for implementation of this project. Other levels of review and approval may be required, and the project should not be started until all required approvals have been obtained. Also, studies funded by external sources must be covered by an agreement signed by the sponsor and an authorized official of the University. The Principal Investigator is not authorized to sign.

If this project involves the use of an Investigational New Drug, a copy of the protocol must be forwarded to the Pharmacy and Therapeutics Committee (Pharmacy Services - Investigational Drugs, OP-16A).

Thank you for your cooperation.

# APPENDIX C

# COVER LETTER FOR POTENTIAL SUBJECTS

October 1, 1996

John and Jane Smith
999 N.W. Nowhere Street
Portland, OR 00000

Dear Mr. and Mrs. Smith:

As you know, your child is to be scheduled for physical management of the velopharyngeal closure mechanism to help improve speech. I would like to inform you of a study that is underway regarding the pattern of speech change following such management. I am not personally conducting this study, but have reviewed the test instrument to be used and feel that it may help contribute new information to the care of children with speech needs such as those we see at OHSU. I will not be receiving any reimbursement for my referral of your child to this study. A colleague by the name of Lisa Letcher-Glembo, Ph.D., at Portland State University, is in charge of the project. She or her graduate student would need to see your child on three occasions for sessions that would last approximately 15 minutes each. The sessions would occur one month prior to physical management, one month following physical management, and three months following physical management. At those sessions, the same thing will occur each time: your child will be asked to repeat 78 single words. At the first session, a brief hearing screening will also be provided. Analysis of results will help contribute to our knowledge base regarding the optimal time for (re)enrollment in speech services following a procedure to improve velopharyngeal closure. I will not be personally reviewing the information collected from your child, but at your signed request, Dr. Letcher-Glembo has assured me findings could be shared with me and/or your attending child's speech/language pathologist.

If you are interested in participating in the study, you may contact Dr. Letcher-Glembo, collect if necessary, at (503) 725-8378. If you decide to participate, or decide to participate and then withdraw from the study, it will in no way effect your current or future relationship with our Clinic. Furthermore, if you have any questions regarding your child's rights as a research subject, you may contact the Oregon Health Sciences University Institutional Review Board at (503) 494-7887.

Sincerely,

Janet Brockman, M.S., CCC-SLP
Director, Craniofacial Disorders Program
CDRC

# APPENDIX D

# WRITTEN CONSENT FORM

TITLE: Speech Production Patterns Following Management of Velopharyngeal Incompetence

PRINCIPAL INVESTIGATORS: Lisa Letcher-Glembo, Ph.D., Assistant Professor and Speech-Language Pathologist

Debra Childs, Masters Degree Candidate

PURPOSE: You have been invited to participate in this research study because you demonstrate velopharyngeal incompetence that is in need of structural management. That is, you demonstrate nasality and cannot successfully improve it without intervention. We are interested in knowing the sequence and pattern of speech change following structural management, for example pharyngeal flap surgery or construction of a prosthetic appliance, so that we can best serve patients with this condition.

PROCEDURES: We will need to see you on three occasions: one month prior to physical management, one month post physical management, and again four months post physical management. During the first session, you will receive a hearing screening and be asked to participate in an imitative articulation task. For example, you will be asked to say "king" and "cheese". Your responses on the articulation task will be audio recorded. The imitative articulation task will be done at all three sessions. Each session will last no longer than approximately 15 minutes.

RISKS AND DISCOMFORTS: There are no foreseeable risks or discomforts anticipated from your participation with the exception of the potential inconvenience of time. If you wish to come to the Portland State University Campus for these sessions, we can have a reserved parking spot free of charge available to you. Or, if you wish, we can travel to your home for collection of the speech sample.

BENEFITS: You may or may not personally benefit from participating in this study. However, by serving as a subject, you may contribute new information which may benefit patients in the future.

CONFIDENTIALITY: Neither your name nor your identity will be used for publication or publicity purposes. You will be given the name and phone number of the principal investigator so that you can schedule with her directly.

COSTS: There are no costs to participating. Parking at Portland State University in a reserved spot could be arranged for you free of charge on the days you are to participate in the study.

LIABILITY: There are procedures that are invasive, however, it must be noted that it is not the policy of the U.S. Department of Health and Human Services, or any federal agency funding the research project in which you are participating to compensate or provide medical treatment for human subjects in the event the research results in physical injury. The Oregon Health Sciences University, as a public corporation, is subject to the Oregon Tort Claims Act, and is self-insured for liability claims. If you suffer any injury from this research project, compensation would be available to you only if you establish that the injury occurred through the fault of the University, its officers, or employees. If you have further questions regarding liability, please call the Medical Services Director at (503) 494-8014.

PARTICIPATION: Lisa Letcher-Glembo, (503) 725-8378 has offered to answer any other questions you may have about this study. If you have any questions regarding your rights as a research subject, you may contact the Oregon Health Sciences University Institutional Review Board at (503) 494-7887. You may refuse to participate, or you may withdraw from this study at any time without affecting your relationship or treatment at the Oregon Health Sciences University. You may be removed from the study prior to study conclusion at the investigator's discretion. You will be informed of new findings that may affect your wish to continue participation. You will receive a copy of this signed consent form at the time of your first scheduled appointment if you choose to participate.

Your signature below indicates that you have read the foregoing and agree to participate in the study.

| | |
|---|---|
| Signature of participant if 18 years of age or older | Signature of parent, if participant is a minor |
| Witness Signature | Principal Investigator |

# APPENDIX E

# BROEN CVC PROBE

NAME ______ NUMBER ______ DATE ______ BIRTHDATE ______ EXAMINER ______

| STIMULUS WORD | INITIAL CONSONANT | | VOWEL CONTEXT Front | | Middle | | Back | | FINAL CONSONANT | |
|---|---|---|---|---|---|---|---|---|---|---|
| | S | R | S | R | S | R | S | R | S | R |
| 1. cheese | tʃ | | i | | | | | | z | |
| 2. chalk | tʃ | | | | | | ɔ | | k | |
| 3. yes | j | | ɛ | | | | | | s | |
| 4. soothe | s | | | | | | u | | ð | |
| 5. puff | p | | | | ə | | | | f | |
| 6. witch | w | | ɪ | | | | | | tʃ | |
| 7. shore | ʃ | | | | | | ɔ | | r | |
| 8. leave | l | | i | | | | | | v | |
| 9. sheep | ʃ | | i | | | | | | p | |
| 10. call | k | | | | | | ɔ | | l | |
| 11. zip | z | | ɪ | | | | | | p | |
| 12. those | ð | | | | | | o | | z | |
| 13. van | v | | æ | | | | | | n | |
| 14. rub | r | | | | ə | | | | b | |
| 15. thumb | θ | | | | ə | | | | m | |
| 16. gate | g | | e | | | | | | t | |
| 17. duck | d | | | | ə | | | | k | |
| 18. hull | h | | | | ə | | | | l | |
| 19. sun | s | | | | ə | | | | n | |
| 20. beam | b | | i | | | | | | m | |

| STIMULUS WORD | INITIAL CONSONANT | | VOWEL CONTEXT Front | | Middle | | Back | | FINAL CONSONANT | |
|---|---|---|---|---|---|---|---|---|---|---|
| | S | R | S | R | S | R | S | R | S | R |
| 21. vow | v | | | | | | a | | o | |
| 22. boy | b | | | | | | ɔ | | ɪ | |
| 23. juice | dʒ | | | | | | u | | s | |
| 24. vote | v | | | | | | o | | t | |
| 25. king | k | | ɪ | | | | | | ŋ | |
| 26. bathe | b | | e | | | | | | ð | |
| 27. mush | m | | | | ə | | | | ʃ | |
| 28. make | m | | e | | | | | | k | |
| 29. bath | b | | æ | | | | | | θ | |
| 30. food | f | | | | | | u | | d | |
| 31. nut | n | | | | ə | | | | t | |
| 32. rib | r | | ɪ | | | | | | b | |
| 33. fudge | f | | | | ə | | | | dʒ | |
| 34. bush | b | | | | | | o | | ʃ | |
| 35. thong | θ | | | | | | ɔ | | ŋ | |
| 36. young | j | | | | ə | | | | ŋ | |
| 37. pig | p | | ɪ | | | | | | g | |
| 38. cow | k | | | | | | a | | o | |
| 39. said | s | | ɛ | | | | | | d | |
| 40. goat | g | | | | | | o | | t | |

NAME_______________ NUMBER_______ DATE_______ BIRTHDATE_______ EXAMINER_______

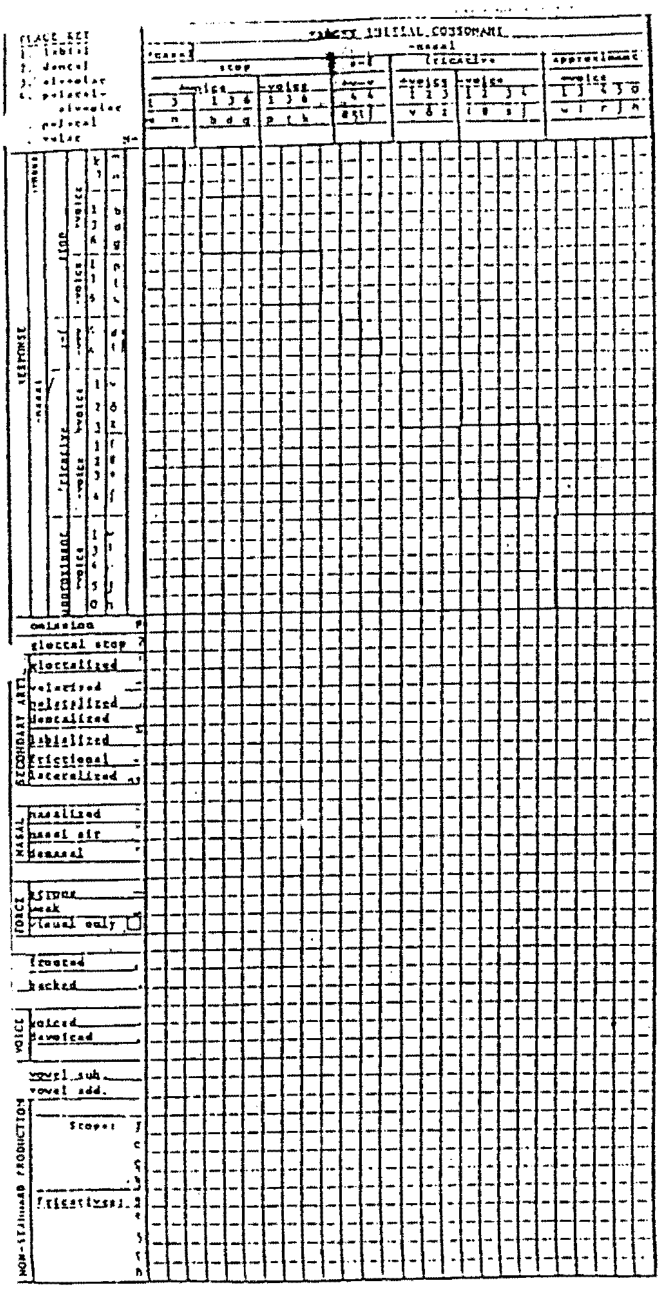
| STIMULUS WORD | INITIAL CONSONANT S | INITIAL CONSONANT R | VOWEL CONTEXT Front S | Front R | Middle S | Middle R | Back S | Back R | FINAL CONSONANT S | FINAL CONSONANT R |
|---|---|---|---|---|---|---|---|---|---|---|
| 41. sigh | s | | | | | | a | | ɪ | |
| 42. mud | m | | | | ə | | | | d | |
| 43. watch | w | | | | | | ɔ | | tʃ | |
| 44. shut | ʃ | | | | ə | | | | t | |
| 45. pope | p | | | | | | o | | p | |
| 46. move | m | | | | | | u | | v | |
| 47. teeth | t | | i | | | | | | θ | |
| 48. huge | h | | | | | | ju | | dʒ | |
| 49. near | n | | ɪ | | | | | | r | |
| 50. ton | t | | | | ə | | | | n | |
| 51. chug | tʃ | | | | ə | | | | g | |
| 52. the | ð | | | | ə | | | | | |
| 53. cup | k | | | | ə | | | | p | |
| 54. thing | θ | | ɪ | | | | | | ŋ | |
| 55. loaf | l | | | | | | o | | f | |
| 56. these | ð | | i | | | | | | z | |
| 57. gum | g | | | | ə | | | | m | |
| 58. was | w | | | | ə | | | | z | |
| 59. jug | dʒ | | | | ə | | | | g | |
| 60. face | f | | e | | | | | | s | |

| STIMULUS WORD | INITIAL CONSONANT S | INITIAL CONSONANT R | VOWEL CONTEXT Front S | Front R | Middle S | Middle R | Back S | Back R | FINAL CONSONANT S | FINAL CONSONANT R |
|---|---|---|---|---|---|---|---|---|---|---|
| 61. now | n | | | | | | a | | o | |
| 62. dish | d | | ɪ | | | | | | ʃ | |
| 63. love | l | | | | ə | | | | v | |
| 64. tooth | t | | | | | | u | | θ | |
| 65. dog | d | | | | | | ɔ | | g | |
| 66. yolk | j | | | | | | o | | k | |
| 67. jeep | dʒ | | i | | | | | | p | |
| 68. thigh | θ | | | | | | a | | ɪ | |
| 69. robe | r | | | | | | o | | b | |
| 70. hedge | h | | ɛ | | | | | | dʒ | |
| 71. zeal | z | | i | | | | | | l | |
| 72. her | h | | | | ə | | | | r | |
| 73. leaf | l | | i | | | | | | f | |
| 74. lathe | l | | e | | | | | | ð | |
| 75. much | m | | | | ə | | | | tʃ | |
| 76. zoom | z | | | | | | u | | m | |
| 77. tone | t | | | | | | o | | n | |
| 78. bus | b | | | | ə | | | | s | |

Broen, P. A. Initial & Final Consonant Word List. 8/86

# APPENDIX F

# INITIAL CONSONANT MATRIX SCORING FORM




INITIAL CONSONANT MATRIX
Cleft Palate Project

Child:____________________

Date:__________ DOB:__________

Examiner:____________________

Task:____________________

Broen, P., Moller, K., Kittelson, C., & Houge, L. Early Phonological Development of Children With Cleft Palate: Preliminary Observations.

1983 ASHA Convention - Cincinnati

This project was supported in part by the Social and Behavioral Sciences Research Grant Number 12-90 from March of Dimes Birth Defects Foundation.

# APPENDIX G

# FINAL CONSONANT MATRIX SCORING FORM

CLEFT PALATE PROJECT

CHILD: ____________________ BIRTHDATE: ________ DATE: ________

EXAMINER: ____________________ TASK: ____________________

PLACE KEY
1. labial
2. dental
3. alveolar
4. palatal-alveolar
5. palatal
6. velar

| TARGET FINAL CONSONANT | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | +nasal | | | -nasal | | | | | | | | | | | | | | | | | | |
| | | | | stop | | | | | | s-ʃ | | fricative | | | | | | | approximant | | | |
| | | | | +voice | | | -voice | | | +v | -v | +voice | | | -voice | | | | +voice | | | |
| | 1 | 3 | 6 | 1 | 3 | 6 | 1 | 3 | 6 | 4 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 1 | 3 | 4 | 5 |
| | m | n | ŋ | b | d | g | p | t | k | dʒ | tʃ | v | ð | z | f | θ | s | ʃ | w | l | r | j |
| N= | | | | | | | | | | | | | | | | | | | | | | |
| RESPONSE +nasal +voice 1 m | | | | | | | | | | | | | | | | | | | | | | |
| 3 n | | | | | | | | | | | | | | | | | | | | | | |
| 6 ŋ | | | | | | | | | | | | | | | | | | | | | | |
| -nasal stop +voice 1 b | | | | | | | | | | | | | | | | | | | | | | |
| 3 d | | | | | | | | | | | | | | | | | | | | | | |
| 6 g | | | | | | | | | | | | | | | | | | | | | | |
| -voice 1 p | | | | | | | | | | | | | | | | | | | | | | |
| 3 t | | | | | | | | | | | | | | | | | | | | | | |
| 6 k | | | | | | | | | | | | | | | | | | | | | | |
| s-ʃ +v 4 dʒ | | | | | | | | | | | | | | | | | | | | | | |
| -v 4 tʃ | | | | | | | | | | | | | | | | | | | | | | |
| fricative +voice 1 v | | | | | | | | | | | | | | | | | | | | | | |
| 2 ð | | | | | | | | | | | | | | | | | | | | | | |
| 3 z | | | | | | | | | | | | | | | | | | | | | | |
| -voice 1 f | | | | | | | | | | | | | | | | | | | | | | |
| 2 θ | | | | | | | | | | | | | | | | | | | | | | |
| 3 s | | | | | | | | | | | | | | | | | | | | | | |
| 4 ʃ | | | | | | | | | | | | | | | | | | | | | | |
| approximant +voice 1 w | | | | | | | | | | | | | | | | | | | | | | |
| 3 l | | | | | | | | | | | | | | | | | | | | | | |
| 4 r | | | | | | | | | | | | | | | | | | | | | | |
| 5 j | | | | | | | | | | | | | | | | | | | | | | |
| omission | | | | | | | | | | | | | | | | | | | | | | |
| glottal stop | | | | | | | | | | | | | | | | | | | | | | |
| glottalized | | | | | | | | | | | | | | | | | | | | | | |
| NAS. nasalized | | | | | | | | | | | | | | | | | | | | | | |
| nasal air | | | | | | | | | | | | | | | | | | | | | | |
| denasal | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |

# APPENDIX H

# DIACRITIC MARKERS

DIACRITICS: CLEFT PALATE PROJECT

Nasality Symbols

[˜] nasalization

[˟] nasal air emission

[˜] weak nasal emission

[˟] denasalization

Secondary Articulations

[ʷ] labialized

[ᵚ] nonlabialized

[_] dentalized

[ʲ] palatalized

[~] velarized

[ˀ] glottalized

[ₓ] frictionalized

[ɬ] lateralized

[˞] rhotacized

[‿] derhotacized

[ ] low frequency energy

[ ] wetness

Modifications in the Primary Articulation

[˂] front

[˃] back

[ˬ] partially voiced

[˳] partially devoiced

[‥] breathy-voiced

Stop Release Symbols

[ʰ] aspirated

[ ] unaspirated

[˺] unreleased

Timing and Juncture Symbols

[ː] lengthened

[ˑ] half lengthened

[˃] shortened

Pause within target item

[/] unfilled pause

[//] long unfilled pause

Force of Production Symbols

[ ] very strong

[_] strong

[ ] base (unmarked)

[ ] weak

[ ] very weak

Other Symbols

Ⓘ ⓐ questionable segment

ø omission

[ ] charateristic which stretches across several segments

☐ inaudible but visually observed


Shriberg, L. D. and Kent, R. D. Clinical Phonetics. New York: John Wiley and Sons, 1982.

Bush, C., Edwards, M. L., Luckau, J. M., Stoel, C. M., Macken, M. A., and Petersen, J. D. On specifying a system for transcribing consonants in child language. Unpublished paper, Child Language Project, Stanford University, 1973.