THE ANATOMIC AND PHYSIOLOGIC COMPARISON OF THE OBTURATOR ELIMINATORS VS THE SURGICAL CANDIDATES IN AN OBTURATOR REDUCTION PROGRAM

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INTRODUCTION

The obturator or speech appliance and the pharyngeal flap have long been alternative methods of treatment for the correction of hypernasality in patients with velopharyngeal inadequacy. Flap surgery continues to dominate as the proposed treatment method in many institutions, however, select establishments have utilized the combination of both modalities in their reduction of the hypernasal voice quality. The Portland Children's Developmental and Rehabilitation Center (CDRC) is one of the few which employs the use of the temporary speech appliance as the initial treatment phase prior to the consideration of the pharyngeal flap surgery. Their rationale is to utilize the assests of both and thereby decrease the liabilities of each (**Blakeley**, 1964).

Employing this obturation-reduction treatment concept, **Blakeley** (1969) reported that 20% of these patients can eliminate obturator wear without the need for surgery and still maintain normal to near-normal speech. In the same paper, he also noted that approximately 30% of these obturator wearers will undergo successful pharyngoplasties after maximal reduction of their obturators. **Wong and Weiss** (1972) attempted to characterize this "successful" group and determined that they were apt to be younger females with no cleft palate family history. However, to date, no literature provides substantial evidence to identify the make-up of this successful group with regards to the exact anatomy and physiology of the velopharyngeal inadequacy.

It is this investigator's objective to endeavor to establish as well as to compare the anatomic and physiologic characteristics related to

the obturator eliminators versus the surgical candidates. By so doing, this may enable the clinician to more readily determine the prognosis of a particular patient for success in an obturation reduction program. This, in turn, would facilitate the decision of whether or not to render immediate surgical repair to a patient who has otherwise mastered adequate speech skills. In brief, this author hopes this study will aid in the diagnosis and treatment planning of the velopharyngeal inadequate patient.

Specific theories to be evaluated are those which are based on premises found in previous literature as well as observations made by the investigator. Many authors have suggested that the initial age of obturator wear plays a significant role in achieving acceptable speech because there are less habituated errors (i.e., formation of pharyngeal fricatives and glottal stops) in the younger child as opposed to an older individual (**Blakeley**, 1960, 1964; **Bzoch**, 1964, 1965). Further, since muscular stimulation with subsequent pharyngeal wall compensation is the key to the reduction of an obturator (**Harkins**, 1947; **Rosen & Bzoch**, 1958; **Blakeley**, 1960, 1964, 1969; **Weiss**, 1971; **Wong & Weiss**, 1972; **Peterson**, 1974), it has been proposed that pharyngeal inadequacy resulting from structural deficits are more favored for success than those resulting from neuromuscular abnormalities (**Mazaheri & Mazaheri**, 1976). Similarly, patients with normal structural velopharyngeal inadequacies should have less difficulty acquiring normal speech than structurally impaired patients since cleft palate children have been shown to have gross substitution patterns when compared to their normal counterparts (**Bzoch**, 1968).

Moreover, because it has been shown that lateral pharyngeal wall movement is greater than anteroposterior wall movement in palatopharyngeal closure (**Rosen & Bzoch**, 1958), it is speculated that

inadequacies presenting with larger anteroposterior measurements would be less successful than those with smaller anteroposterior measurement. Likewise, it is assumed that inadequacies of smaller proportion are more easily reduced than those with larger dimensions. More specifically, larger obturator bulb patients would be more difficult to reduce out than those with smaller-sized bulbs. Also, it is suspected that velopharyngeal inadequate patients with milder speech abnormalities could attain normal speech with less effort (time) than those with more severe speech defects. It would additionally be presumed that subjects with normal hearing would achieve speech improvement at a more rapid rate than those subjects with abnormal hearing (**Bzoch**, 1964). Lastly, it is believed that patients closely approximating the treatment center would have greater success since convenience can often limit patient compliance in treatment.

Prior to analyzing the previous hypothetical statements, it is important to establish definitions and descriptions to enable the reader to better understand the investigation at hand. Firstly, **velopharyngeal** or **palatopharyngeal inadequacy** comprises both **velopharyngeal incompetency** and **insufficiency** as well as other disorders which disable adequate palatopharyngeal apposition. Incompetency best describes a neuromuscular association, such as a congenitally short palate, cerebral palsy, and palatal paralysis; whereas, insufficiency is most often used to relate to structural defects, such as clefts of the hard and / or soft palate, submucous clefts, and post-adenoidectomy. The two terms are often used interchangeably in reference to velopharyngeal inadequacy.

Secondly, palatopharyngeal closure during speech involves the following palatal and pharyngeal wall muscles: the superior pharyngeal

constrictor, the palatopharyngeus, the salpingopharyngeus, the tensor and levator veli palatini and the velum itself. During speech, contraction of the tensor muscles results in tension of the aponeurosis allowing the palatopharyngeus, constrictor and the salpingopharyngeus muscles to contract and move inwards. Simulataneously, the levator muscles raise the middle third of the soft palate and thereby closes the valve between palate and pharynx, i.e., velopharyngeal closure.

Thirdly, speech characteristic common to the velopharyngeal inadequate individual are hypernasality, nasal emission and articulation disorder. Hypernasality results when ineffective closure transmits air and sound energy into and through the nasal cavity during speech, resulting in unpleasant nasal quality in speech and a reduction of intraoral breath pressure. As a consequence, some speech sounds, particularly the pressure consonants (plosives: p, b, t, d, k, g; fricatives: f, v, th_v, th_l, s, ,sh, zh; and affricates: ch, j) cannot be produced and become distorted as well as weakened. In turn, the likely outcome of this difficulty is exhibited as articulation errors of substitution (egs. pharyngeal fricatives and glottal stops), distortion (mostly due to nasal emission), and omission (usually plosives and fricatives). Therefore, the optimal implementation of a temporary speech appliance in children is recommended at age 3-4 years, when the early pressure consonants are being learned, in order to effect adequate velopharyngeal valving for speech purposes and thereby prevent or alter early error patterns of articulation (**Blakeley,** 1969).

REVIEW OF THE LITERATURE

History of the speech prosthesis

The prosthetic management of patients with palatal insufficiency dates back as early as 2600 B.C. when the Egyptians used prosthetic devices, or obturators, for repairing congenital defects of the palate (**Adisman**, 1971). Prosthetic use as a speech aid came much later, in the early 1500's, when **Amatus Lusitanus** (cited by **Adisman**, 1971) constructed the first known prosthesis designed to improve the speech of a cleft palate patient. From this point on, the objective of prosthetic appliances for patients with palatal insufficiency transformed from a simple obturator to a more complex speech assisting instrument. Subsequently, many different prosthetic attempts were developed, but the actual prototype of today's speech appliance did not arrive until the mid 1800's when **McGrath** (cited by **Harkins**, 1960) introduced a fixed, or immobile, prosthesis with a pharyngeal extension. However, it was actually a few years later that **Suersen** (cited by **Schalit**, 1946) emphasized the importance of the pharyngeal musculature and Passavant's pad (the muscular bulge of the pharyngeal wall located opposite to the anterior tubercle of the atlas bone) in sound formation. Suersen's "rigid obturator" allowed the intact pharyngeal muscles to contact and freely activate against the lateral and posterior surfaces of the appliance's pharyngeal section.

Despite Suersen's significant contribution, his concept was not readily adopted and was abandoned during the nineteenth century. In the late 1800's, mobile type prostheses, attempting to simulate movements of the soft palate, came into vogue. An example was **Kingsley's** "artificial velum" (cited by **Adisman**, 1971), which consisted of two plates of soft rubber connected by a hinge with the

palatinal plate. These also fell into disuse because of difficulty in satisfactorily stimulating the soft palate movements during oral function. Furthermore, movable or hinge type prostheses were notorious for loosening or breaking as well as being harder to keep clean.

Due to intense dissatisfaction of the mobile type prosthesis along with improvements in prosthetic materials and methods, the twentieth century witnessed a revival of the immobile type prosthesis. **Schalit** (1946) and **Sharry** (1958) described the meatus or nasal passage obturator. It consisted of a palatal plate and a rigidly connected perforated lump, which, in turn, occluded the nasal passages in the cleft palate patient, yet permitted nasal respiration. This obturator was based on the assumption that partial occlusion of the nasal cavity resulted in a marked diminution or complete elimination of hypernasality. Both investigators believed that the meatus obturator proved superior over the artificial velum and rigid obturators by eliminating hypernasality without requiring additional training of the pharyngeal muscles.

Although the meatus obturator had its advantages, **Harkins** (1947) renewed Suersen's concept and developed the training prosthesis which was designed to improve palatopharyngeal activity. This appliance consisted of three parts: (1) the palatomaxillary section, which functions for retention and anchorage as well as for mastication and closure of unrepaired cleft; (2) the palatovelar section, which is the interconnecting piece that also contributes to separation of the oral and nasal cavities in unrepaired clefts; and (3) the pharyngeal section, which is a bulb of acrylic resin that provides palatopharyngeal apposition during speech, yet permits nasal breathing and comfortable deglutition. Harkins' obturator was based on the theory that increased

sensory stimulation to the palatopharyngeal region may increase muscle activity and thereby improve palatopharyngeal activity. Consequently, Harkins was the first to propose that the pharyngeal section could be progressively reduced in size due to the increasing compensation of the pharyngeal musculature. **Harkins and Koepp-Baker** (1948) should also be accredited for encouraging use of the prosthetic method in young children. They recommended prosthetic commencement as soon as the deciduous teeth have erupted sufficiently to provide retention and the patient is emotionally capable of cooperation.

A successor to the Harkins obturator was the movable bulb appliance which incorporated the principles of the Kingsley and Suersen appliances. **Fletcher** and his associates (1960) designed a prosthetic device with a movable bulb to provide tactile stimulation to the pharyngeal wall during speech activities. This appliance was constructed to further substantiate **Fletcher's** earlier studies (1957, 1958) which had suggested that forward movement of the upper dorsal pharyngeal wall produced palatopharyngeal closure following tactile stimulation. It was expected that the combined adaptations of the palate and pharyngeal wall would permit gradual reduction in the size of the appliance bulb without detriment to voice quality or speech intelligibility.

The most recent member of the family of pharyngeal extension prostheses is the Lubit Palatal Exerciser (LPE), developed by **Lubit & Larsen** (1971). This appliance consists of a balloon-like pharyngeal bulb, which is inflatable by an attached hand bulb, and a supportive acrylic bite block which embeds the pharyngeal bulb. Inflation of the bulb produces both isotonic and isometric forces on the soft palate as well as the lateral and posterior pharyngeal walls. It is theorized that

these forces on the oropharyngeal tissues will result in improving soft palate neuromuscular control as well as increasing the range of pharyngeal muscular movement in the forward and mesial direction. The LPE was primarily developed to aid in the treatment of velopharyngeal incompetency rather than insufficiency.

Temporary Speech Appliance

By definition, a temporary speech appliance is a speech prosthesis "that is worn during the growth period and which is frequently modified" (**Shelton & Lloyd**, 1963). With the exception of the retentive wires, it is completely constructed of easily alterable, acrylic resin material for the purpose of speech training the young child. **Harkins** (1948) wrote that such a prosthesis could be inserted in a child at two and a half or three years of age. Similarly, **Rosen and Bzoch** (1958) recommended that "a temporary speech appliance makes possible the acquisition of acceptable and even normal speech habits" when surgery is postponed because of speech readiness and development periods.

Furthermore, **Blakeley** (1960,1969) also advocated its specific use for children at the age of 3-4 years, who are still developing speech yet resistant to speech training, in order to equip them with a near-normal system for articulation development. He additionally suggested that the wearer of a temporary speech appliance may be a candidate for later surgery or for permanent prosthesis (**Blakeley**, 1964), or may obtain adequate palatopharyngeal activity to completely abandon the appliance (**Blakeley**, 1969). As a result of these beliefs, the CDRC in Portland, Oregon was one of the first to develop the temporary speech appliance along with a comprehensive program incorporating its use with the purpose of aiding most children with

cleft palate and other palatopharyngeal indequacies to start school with normal or near-normal speech.

Construction and Fitting

The temporary speech appliance is modeled after the Harkins' obturator. **Harkins** (1960) describes in detail the technique used in constructing a prosthetic speech appliance for children; however, there are several modifications which have been adapted at the CDRC, principally by Dr. Harold Louis, their former prosthodontist. Basically, the three-part appliance requires several appointments for manufacturing as well as allowing a period of adjustment for the child patient. The initial appointment of the construction process involves the fitting of bands, preferably onto the maxillary second deciduous molars. Retention lugs (.045-inch wire) are spot-welded onto the bands, bands are cemented, and an alginate impression is taken in order to fabricate the palatal section or plate of the speech appliance.

The plate is then delivered at the second appointment. The patient is given a one week period of adaptation, along with the instructions to wear of the appliance continuously except at bedtime. If for some reason this criteria cannot be met at the end of the first week, more time is allotted for adjustment. However, if the family and child continue to have difficulty at this phase or succeeding stages, construction ceases. A child is considered a poor candidate for a temporary speech prosthesis if he fails at the simple "plate" stage.

The third appointment involves the addition of the palatovelar section of tailpiece. A strip of warmed beeswax is added to the plate and functionally formed to the contour of the soft palate just anterior of the uvula. This is then invested in alginate; wax is removed; and

acrylic resin is added to the original plate. The newly modified appliance is fitted functionally to the curvature of the velum. Pressure indicating paste (PIP) is used to assure a completely passive (not touching the velum) fit . The child is then dismissed for another week to adjust to this new portion.

The fourth appointment is scheduled for the incorporation of the pharyngeal extension or bulb, providing there are no problems associated thus far. The tailpiece is visualized in the oral cavity in order to judge the distance to the end of the soft palate as well as the depth of the pharynx from the velum to the posterior pharyngeal wall. An alginate investment of the existing body and tail is first obtained. Then, the entire tailpiece is removed so that a new tailpiece can be added. An .030-inch wire is formed into a loop and bent to the estimated length and form of the velopharynx. This loop is placed into the investment before processing the acrylic resin. Iowa wax is then added to the pharyngeal section of the wire and functionally molded intraorally to the patient's pharynx. Again, the bulb is invested, processed, and fitted in the mouth using PIP. The child and parent are instructed to leave the appliance in continuously for the first 24 hours, and thenafter to remove it only at bedtime.

The child is rescheduled for successive enlargements within one week intervals, until full obturation is believed to be achieved by the dentist. A formal speech evaluation is done as a team, with the speech pathologist, one month after the last bulb enlargement. Subsequent appointments for reduction and/or additional obturation are done at 4-6 month intervals, again in the presence of a speech pathologist.

Bulb Positioning

The pharyngeal extension of the bulb should ideally be located in the region of palatopharyngeal closure in order to serve best as an adequate speech aid. This subject has been given considerable attention. As previously mentioned, Suersen believed that the pharyngeal portion should be in the area of Passavant's ridge; whereas, proponents of the meatus obturator, such as **Schalit** (1946) and **Sharry** (1958), disagreed and promoted an excessively high placement. **Rosen and Bzoch** (1958) and others (**Shelton & Lloyd**, 1963; **Falter & Shelton**, 1964) also recommended high nasopharyngeal positioning of the pharyngeal extension. **Harkins and Koepp-Baker** (1948) conceived that bulb position should be determined by the location of the greatest constriction in the lumen of the nasopharyngeal port, so that there would be less compensation of the collateral pharyngeal muscles than one introduced at a lower point in the pharynx. **McDonald** (1951) suggested that this point of maximum constriction could be determined by muscle trimming during deglutition. He and **Koepp-Baker** (1951) concluded that this critical point was not fixed, but individualistic depending on the position of the tongue and mandible and the degree of patency of the oropharynx.

Those at the Oregon CDRC side with **Aram and Subtelny** (1959) who suggested that the palatal plane serve as a "guidepost" in approximating the region of muscular function during speech. In their investigation of normal velopharyngeal function in subjects ranging from 4 - 20 years of age, they observed that the soft palate moved in a superior and posterior direction to create a closure, and that the midpoint of palatopharyngeal closure was not only consistently above the level of the palatal plane, but was found to be comparatively stable as well. They found the degree of velar movement from rest to closure

increased with increment in age, and appeared to attain mature levels by approximately 12 years of age.

Speech Testing and Bulb Size

A speech bulb's primary function is to provide adequate palatopharyngeal valving thereby preventing nasal emission and hypernasality during oral speech production as well as permitting sufficient nasal air escape during nasal consonant production. Therefore, speech evaluation is requisite in the bulb fitting process in order to assess adequate appliance function. It is reasoned that "vocal and articulatory effects may be noted immediately upon placement of an adequately fitted bulb" (**Shelton & Lloyd,** 1963). **Rosen and Bzoch** (1958) found that the greatest portion of the pharyngeal muscular valving against the speech bulb is accounted for by the medial movement of the lateral walls of the nasapharynx. They suggested that bulb adjustment was adequate when the user can produce a clear [p], a sustained [f] or [s] without nasal emission, and also an adequate nasal sound, [m]. **McDonald** (1951) noted that bulb reductions were indicated when there was presence of soreness in the throat, difficulty in breathing through the nose, and an absence of nasal resonance on the nasal consonants [m], [n], and [ng], i.e., denasality.

Shelton & Lloyd (1963) noted that the bulb should contact the pharyngeal walls only when the muscles are involved in oral activities, however, at all other times an airway into the nasal passages should be maintained. **Shelton** and associates (1964) also suggested that the relationship between the articulation and patterns of palatopharyngeal closure may be nonlinear, in contrast to **Subtelny** (1961) and **Bjork** (1961) who reported that a gap size of 3-4mm is adequate for acquistion of intelligible speech. However, Shelton's findings were

supported by **Spriestersbach et al** (1961), who observed that once a threshold of inadequate intraoral breath pressure for speech has been crossed, further loss of pressure is not associated with further loss in articulation. Shelton et al also observed that closure was observed more frequently on the [s] and [z] than on any other speech sounds, therefore they reasoned that these sounds might provide a good test to determine closure during phonation.

In addition to the subjective evaluation of speech, additional methods may be helpful in the fitting process. Evaluations for nasal escape of air (such as the nose pinching test, the nasal listening tube, and cold mirror tests) may be performed with the appliance in and out of place. Supplemental tests for assessing effective obturation include manometric, sound pressure, static or dynamic radiographic techniques (i.e., sequential radiography, lateral-view videofluoroscopy), oral and nasal telescopic videoendoscopy, oral and nasal fiberoptic videoendoscopy and lung function tests of ventilation (**Watson & Gray**, 1985).

Nevertheless, the CDRC in Oregon employs **Blakeley's** (1969) methods of assessment. He claims that "no x-ray studies need to be required" to assess adequate voice and articulation development in a child patient. He believes that the speech clinician need only to listen for the early plosives, which may be present and strong, present and weak, substituted for by glottal stops, or produced in association with glottal stops. Additionally, "there is no necessity that plosives be used in the proper positions, only that they be present."

Furthermore, vocal quality and resonance are assessed clinically via the the nasal flutter test, the cold mirror and the nasal listening tube. The nasal flutter test involves alternatingly occluding and unoccluding the nose while the patient continuously phonates "hi" (hee) and then

"hu" (hoo). The presence of sound in the nose would be suggestive of hypernasality. With the use of a cold mirror, the patient is asked to repeat sentences such as: (1) bye baby a bib; (2) tell Teddy to try; (3) I have fifty-five fish. Nasal emission is detected with the presence of air leaks on sounds as well as their weakening. The nasal listening tube also employs repeated sentences such as: (1) puppy, puppy, puppy; (2) bye baby a bib; (3) go get a bigger egg. Any indication of pops, snores, air flow, or weakening of sounds would imply the presence of nasal emission or hypernasality. Obturator reduction does not occur when audible snores or nasal emission can be detected during the production of pressure consonants and nonnasal consonants. If more information is necessary and the patient is compliant, the fiberoptic nasoendoscopy is used to determine the location and size of palatopharyngeal leakage in relation to bulb placement.

Besides evaluating the function of the palatopharyngeal valve with regards to the obturator, fiberoptic nasoendoscopy has been able to show that the greatest activity during speech is in the area of the levator veli palatini muscle and Passavant's ridge, while no gross activity occurs superiorly in the area of the auditory tube (**Beery et al**, 1983). In their study of long-term prosthetically managed cleft palate adults, **Beery** and associates (1983) found that lateral pharyngeal wall mobility is generally equal bilaterally. They also detected Passavant's ridge to extend bilaterally and anteriorly at approximately the level of the hard palate.

Indications and Contraindications

It was once the belief that the prosthetic management of palato-pharyngeal insufficiencies was only indicated in cases where surgical repair was impossible or had resulted in failure. After reviewing

twenty-five years of cleft palate prosthesis, **Harkins and Koepp-Baker** (1948) advocated the conservative alternative to the irreversible surgical approach and wrote that "the full benefit of the prosthetic approach may be realized" in the surgically undisturbed cases. With time, the indications somewhat broadened. **Mazaheri** (1962) indicated that prosthetic speech appliances in the unoperated cleft patients should be considered in: a wide cleft, a paralytic and deficient soft palate, physical conditions contraindicating surgery, and as a means of temporary muscular stimulation when surgical treatment is delayed.

Curtis & Chierici (1964) suggested the additional inclusions: patients whose soft palates are thin, scarred, or extremely short; patients with limited intelligence levels; patients whose palatal and pharyngeal musculature have been affected by bulbar poliomyelitis; patients whose voice quality is acceptable in controlled conditions, but otherwise exhibit rhinolalia; patients who have high expectations of surgery; and as a diagnostic aid in the evaluation of palatopharyngeal closure adequacy in borderline cases requiring surgery. **Dalston's** (1977) criteria for prosthetic management also incorporated the situation when there is no reasonable prognosis for improvement post-operatively.

Mazaheri (1962) also commented on the contraindications for prosthetic speech appliances. They comprise: (1) when surgical treatment is indicated by definitive diagnostic methods; (2) when patients and parents are uncooperative; (3) when the child is mentally retarded, and (4) when the child has rampant caries, partial or complete anondontia, or amelogenesis imperfecta, and (5) when the prosthodontist does not have adequate training in construction of a prosthesis. Whatever the indications or contraindications may be,

teamwork involving the dentist, speech pathologist, and patient is an utmost key to the success or failure of prosthetic management. As **Fitzgibbon** (1923) stated " ...speech training is fully as important as the proper construction of the appliance. It is only through the tolerance, diligence and ability of the teacher, together with the complete confidence and desire to learn and master the appliance on the part of the patient, that success can be obtained."

The Obturator Reduction Program

Harkins and Koepp-Baker (1948) agreed with the teamwork approach as well when they recommended the "extensive interconsultation of the services of the pediatrician, the surgeon, the prosthodontist, the orthodontist, the general dentist, the speech correctionist and the psychologist-educator" in meeting the total needs of the cleft palate child patient. Present cleft palate teams go a step further by additionally incorporating the pediatric dentist, the oral and maxillofacial surgeon, the plastic surgeon, the otolaryngologist, the audiologist, the social worker, the dietician, and the nurse. Together, they provide the philosophic basis in the total rehabilitation of the cleft palate child. Moreover, because speech is considered the most important aspect in the treatment of a child with cleft palate (**Lindgren et al**, 1964), this priority has become the principle of the Oregon Obturator Reduction Program.

As previously mentioned, it is the program's main objective to foster normal or near-normal speech in most children with cleft palate and other palatopharyngeal inadequacies. This is accomplished by: (1) the early interception (at 3-4 years of age) of the child with palatopharyngeal incompetency with a temporary speech appliance, and (2) the promotion of pharyngeal muscular constriction via systematic

reduction of the pharyngeal section of the speech appliance. It is the program's premise that this early intervention will prevent the development of any habituated abnormal compensatory speech mechanisms (**Blakeley**, 1964). This concept has also been supported by **Bzoch** (1965), who compared normal and cleft palate children and found that the latter made four times the omission errors and twice the substitution errors and distorted sounds than their normal counterparts. He also revealed that "the articulation movements of these error patterns involve the habituation of coordinated patterns of neural integration very different from that involved in the normal developmental patterns" (**Bzoch**, 1964). Furthermore, he observed that these errors existed earlier than 3 years of age and were habituated even after adequate palatopharyngeal function had been established.

Early intervention is undoubtedy a major advantage of the temporary speech prosthesis over surgery. Other observed advantages attributed to the temporary speech prosthesis include: (1) greater initial success than surgery in helping achieve adequate palatopharyngeal approximation (**Blakeley**, 1964; **Bzoch**, 1964); (2) minimal risk, no alteration to existing structures, and better results for subsequent pharyngoplasty (**Weiss**, 1971); (3) improved vocal quality is better achieved via pharyngoplasty if the person was a previous obturator wearer (**Blakeley**, 1964; **Lingren et al**, 1964). Specific advantages professed at the CDRC, Oregon Health Sciences University, are: (1) immediate improvement of speech; (2) surgery may be delayed until the ideal time; and (3) it teaches the throat and palate muscles to develop better movement, perhaps to the point of possibly eliminating the need for surgical repair.

Since it began in the mid 1950's, the Oregon program has consisted of approximately 100-125 patients at any given time. **Blakeley**

(personal communication) estimates that each month witnesses two new patients starting as one patient is terminating obturator wear. Of the velopharyngeal inadequacies which have undergone temporary speech appliance therapy, it is predicted that about 199 out of 200 have resulted from one of the cleft palate varieties: unilateral or bilateral incomplete clefts of the palate only (CP); unilateral or bilateral complete clefts of the lip and palate (CL/CP); and submucous clefts. The remainder are composed of velopharyngeal insufficiencies due to other causes such as post- tonsillectomy and adenoidectomy, and of unknown origin as well as velopharyngeal incompetencies such as cerebral injury, Lou Gherig's disease, myotonic dystrophy, post-head injury, post-stroke, and post-poliomyelitis. The goal for this non-cleft group is to create an efficient working valve for speech purposes (**Lindgren et al**, 1964) despite their later intervention.

Although successful obturator reduction and removal involving patients from the velopharyngeal incompetent group have been reported (**Blakeley and Porter**, 1971), it has been noted (**Blakeley**, personal communication) that palatopharyngeal incompetencies related to the neuromuscular abnormalilities are not as successful as those associated with structural disorders. **Arndt** and associates (1965) observed that post-obturation articulation of the acquired defective group is inferior in comparison to the congenitally defective group; however, the acquired group demonstrated more acceptable voice quality. **Subteiny et al** (1966) also added that significantly improved, albeit not generally normal, speech quality and intelligibility can be obtained by the obturation of cleft palate adolescents and adults.

Despite the long history and success stories (**Blakeley**, 1960, 1964, 1969; **Blakeley & Porter**, 1971; **Bzoch**, 1964; **Fletcher et al**, 1960; **Lindgren et al**, 1964; **Lubit & Larsen**, 1971; **Weiss**, 1971; **Wong &**

Weiss, 1972) associated with speech appliance therapy, there still exist opponents to the reduction hypothesis. **Shelton et al** (1968, 1971,1971) could not demonstrate pharyngeal wall activity in their subjects after pharyngeal section reduction, therefore they concluded that the conditions effecting increased movements must be limited. On the other hand, **Dalston** (1975, 1977) advocates primary nasopalatal pharyngoplasty and thereby regards speech appliances as an impedance for self-monitoring of speech. Furthermore, even with the evidence in favor of section reduction, it remains an enigma as to which patient type will achieve systematic reduction of their obturators to the point of elimination. This present study hopes to enlighten that subject matter.

METHODS AND MATERIALS

This study was a retrospective analysis of a nonrandom sample of patients with velopharyngeal inadequacy who had been selected for speech appliance treatment as a decision of the Oregon CDRC cleft palate team, specifically from the periods of 1964 to 1988. The sample originally consisted of 120 patients from all over Oregon and some parts of Washington whose models and appliances had been collected by Dr. Harold Louis, the former prosthodontist at CDRC during most of that time period. 8 of the 120 were discarded because of insufficient data for analysis. The remaining 112 patients, 64 males and 48 females, were divided into 3 groups.

Group 1 consisted of 44 patients, 25 males and 19 females, who had been weaned from their obturators. This group will be referred to as the so-called "successful" group in this paper. Group 2 comprised 47 patients, 29 males and 18 females, who had undergone pharyngeal flap surgery after maximal reduction of their obturators. This group, on the other hand, will be referred to as the "unsuccessful" group, just as a means of differentiation in the comparative analysis. However, it is the author's opinion that any patient able to achieve acceptable speech as a result of the temporary speech appliance should, in essence, be also be deemed successful.

Group 3 included the remaining 21 patients, 10 males and 11 females, who resulted in: a) permanent obturators (N=3, 1M, 2F); b) discontinued treatment or did not undergo flap surgery for some reason (N=7, 3M, 4F); c) moved to another treatment program (N=5, 2M, 3F); or d) are still current in treatment or postponing a surgical decision (N=6, 4M, 2F). Group 3b consisted of 2 patients whose medical condition

resulted in their progressive deterioration, 2 patients who declined recommendation for flap surgery, and 2 patients who never returned for continued treatment (reason unknown). All patients in Groups 1, 2, and 3 with cleft palates had been repaired except for one patient in Group 1 who did not receive repair because of religious reasons.

The following information was retrieved from the medical and dental charts: (1) diagnosis, (2) age at obturator start, (3) period of obturator wear, (4) speech assistance, (5) voice quality at the start and end of treatment, (6) articulation at the end of treatment, (7) family history of cleft lip and/ or cleft palate, (8) associated anomalies, (9) hearing, (10) compliance, (11) treatment recall interval, and (12) distance traveled to the treatment center. Diagnosis was divided into the following categories: (1) bilateral CL/CP; (2) unilateral CL/CP and isolated CP (hard and/or soft); (3) submucous cleft; (4) neuromuscular disorder; (5) unknown origin; and (6) post-tonsillectomy and adenoidectomy (T & A). Unilateral CL/CP and isolated CP were combined for convenience because they were difficult to distinguish in the charts.

Voice quality was rated as normal, subclinical, mild/objectionable, moderate and severe hypernasality as well as hyponasality. Hyponasality was only recorded when no coincident hypernasality was present. Articulation was recorded as abnormal if any error patterns were still demonstrated, therefore it was only recorded after obturator wear because young children normally present with articulation disorders. Treatment recall interval described the period of time between each subsequent reduction or additional obturation appointment once full obturation was considered achieved. Appointments for remake of an appliance were excluded, as were appointments for band recementation. Compliance was initially judged

as good (only 1 missed appointments), fair (2-3 missed appointments, and poor (>3 missed appointments). In retrospect, these categories were too rigid for application with this sample population since many appointments were required. This variable was therefore omitted from analysis.

Additionally, a Miltex millimeter caliper gauge was used to obtain the lateral and anteroposterior dimensions of the obturator bulbs at obturation and at the end of obturator wear from the collected models or discarded appliances. Measurements were obtained at the approximate midpoint of each dimension. The total amount of reduction was then calculated by subtracting the final (end size) measurements from the initial (obturation size) measurements. If multiple appliances were involved, the obturation size of the first appliance was used as the initial measurement.

Statistical analysis was completed between Groups 1 and 2 and only partially for Group 3 because of incomplete data for those who moved or never completed treatment. The following statistics were obtained: means, standard deviations, frequencies, cumulative percentages, t-tests, chi-squares, and Pearson's *r*. Statistical analyses were done on the Harris main frame computer, using the SPSS-X program, with the aid of the Oregon Health Sciences University (OHSU) Research Computing Center. A grant was obtained from the CDRC research fund in order to finance the computer-analyzed statistics. Statistical results were discussed with an OHSU statistician and considered significant at an alpha level of .05. Also, Pearson's correlation coefficients were judged accordingly as: high ($r > .7$), moderate ($.5 \geq r \geq .7$), and low ($r < .5$).

Table 1. Diagnostic Categories Among Groups.

	Diagnosis					
Groups	Bilateral	Unil/Isol	Submuc	Neurom	Unknown	Post-T&A
1	0(0.0)	19(43.2)	6(13.6)	2(4.5)	12(27.3)	5(11.4)
2	11(23.4)	26(55.3)	4(8.5)	5(10.6)	1(2.1)	0(0.0)
3	3(14.3)	10(47.6)	1(4.8)	2(9.5)	3(14.3)	2(9.5)
Total	**14(12.5)**	**55(49.1)**	**11(9.8)**	**9(8.0)**	**16(14.3)**	**7(6.3)**

In Table 1, a comparison of the different diagnostic categories among groups shows that most of the velopharyngeal inadequacies enrolled in the Oregon CDRC Obturation Reduction Program incoporated a greater number of structural defects (87/112 = 77.7%) as opposed to the other abnormalities. In particular, the most common structural diagnosis was the unilateral/ isolated category which represented almost half of the obturator population (55/112 = 49.1%). The least common diagnosis was post-T&A (7/112 = 6.3%), followed closely by neuromuscular disorders (9/112 = 8.0%).

Among groups, Group 1 consisted of no bilateral CL/CP patients, but proportionally more from the unknown (12/16 = 75%) and post-T&A (5/7 = 71.4%) categories. On the other hand, Group 2 had the majority of the bilateral CL/CP (11/14 = 78.6%), unilateral/isolated (26/55 = 47.3%) and neuromuscular (5/9 = 55.5%) individuals, yet less of the unknown (1/16 = 6.3%) and none of the post-T&A patients. From another perspective, Group 2 is noted to have a greater number of cleft patients (41/47 = 87.2%) than non-cleft patients (6/47 = 12.8%), while

Group 1 had a larger segment from the non-cleft varieties (19/44 = 43.2%) and a moderate number from the cleft classes (25/44 = 56.8%). Group 3 included a representative from each diagnostic category in approximately the same proportion as the overall group, with the exception of having fewer submucous cleft patients.

A chi square analysis of Groups 1 and 2 revealed a significant relationship between the groups and their diagnoses, particularly notable in the bilateral, unknown and post-T&A classifications, as previously mentioned. Additionally, when the diagnostic classes were divided into cleft and non-cleft groups, Group 2 was found to have a significantly greater share of the cleft patients (41/66 = 62.1%) than the non-cleft patients (6/25 = 24%) when compared to Group 1, which consisted of a greater proportion of the non-clefts (19/25 = 76%) than cleft patients (25/66 = 37.9%).

Table 2. Frequency, Sex & Age Comparison Among Groups.

Groups		Sex		Age @ start (mos)	
		M	F	range	mean +/- s.d.
1 -	44 (39.3)	25 (56.8)	19 (43.2)	26 - 193	68.5 32.6
2 -	47 (42.0)	29 (61.7)	18 (38.3)	36 - 204	74.6 34.5
3 -	21 (18.7)	10 (47.6)	11 (52.4)	37 - 352	86.7 68.1
Total		**64 (57.1)**	**48 (42.9)**		

Table 2 demonstrates that slightly less than 40% (39.3%) of the obturator patients will be weaned of their obturators and another 40% (42.0%) of these patients will receive pharyngoplasties. Male-to-female ratio of the groups is also exhibited, disclosing a ratio of 1.3:1 in Group 1, a ratio of 1.6:1 in Group 2, and a ratio of 1.1:1 in

Group 3. These were not found to be significantly different when using the t-test. Similarly, the mean age comparison between group 1 (68.5 mos) and group 2 (74.6 mos) in the t-test found no significance, despite the younger age range observed in Group 1 (26-193 mos) as opposed to Group 2 (36-204 mos). The mean age in Group 3 was not statistically analyzed, but it can be noted that their mean age (86.7) as well as their age range (37-352 mos) was higher than in the other groups .

Table 3. Duration of Speech Obturation and Treatment Interval Between Groups 1 and 2.

Group	Obturator Period (mos)			Treatment Interval (mos)		
	range	mean +/- s.d.		median	mean +/- s.d.	
1	6-144	**58.8**	34.8	4.5	4.4	1.6
2	14-147	**89.0**	36.4	4.9	4.8	1.0

The duration of speech obturation and treatment interval of Groups 1 and 2 are shown in Table 3. Although the time range for obturator wear was closely similar between the groups (Group 1 = 6-144 mos; Group 2 = 14-147 mos), testing their means with the t-test found that the obturation period for Group 2 (89.0 mos) was significantly longer than for Group 1 (58.8 mos). On the other hand, there was no difference found in relation to treatment recall intervals between groups.

Table 4. Remedial Speech, Hearing and End Articulation Among Groups.

Groups	Speech Asst		Hearing		Articulation	
	Yes	No	N	AbN	N	AbN
1 - 44	42 (95.5)	2 (4.5)	32 (72.7)	12 (27.3)	39 (88.6)	5 (11.4)
2 - 47	46 (97.9)	1 (2.1)	33 (70.2)	14 (29.8)	35 (74.5)	12(25.5)
3 - 21	21 (100)	0 (0.0)	*8 (38.1)	*11 (52.4)	*6(28.6)	*4(19.0)
Total	109 (97.3)	3 (2.7)	73 (65.2)	37 (33.0)	80 (71.4)	21(18.8)

**Incomplete Data.*

In Table 4, speech assistance, hearing and end articulation was analyzed among groups. In general, remedial speech was almost always present, with only a few exceptions found in two post-T&A individuals in Groups 1 and one isolated CP patient in Group 2, whose mother refused recommended speech therapy. Likewise, hearing differences between Group 1 (N: 32/44 = 72.7%; AbN: 12/44 = 27.3%)) and Group 2 (N: 33/47 = 70.2%; AbN: 14/47 = 29.8%) were not significant, but there seemed to be a greater proportion of abnormal hearing in Group 3 (11/21 = 52.4%) in comparison to the other groups. It should be noted, however, that abnormal hearing described any hearing abnormality ranging from mild to severe and not necessarily whether the hearing loss limited the educability of speech. End articulation was found to be normal in most cases, and determined to be insignificant between Group 1 (39/44 = 88.6%) and Group 2 (35/47 = 74.5%), using chi-square analysis. Despite this insignificance, there was a greater frequency of abnormal end articulation in Group 2 (12/47 = 25.5) than in Group 1 (5/44 = 11.4%). Once more, no accurate comment can be made about end articulation in Group 3 since data was incomplete.

Table 5. Starting and Ending Voice Quality Among Groups.

Groups	Voice Quality					
	Hyponasal	Normal	Subclin	Mild	Moderate	Severe
1 start	0 (0.0)	0 (0.0)	0 (0.0)	12 (27.3)	16 (36.4)	16 (36.4)
end	2 (4.5)	22 (50)	17 (38.6)	3 (6.8)	0 (0.0)	0 (0.0)
2 start	0 (0.0)	0 (0.0)	0 (0.0)	16 (34.0)	17 (36.2)	14 (29.8)
end	10 (21.3)	23 (48.9)	8 (17.0)	5 (10.6)	*	*
3 start	*	*	*	7 (33.3)	8 (38.1)	5 (23.8)
end	2 (9.5)	0 (0.0)	3(14.3)	5 (23.8)	*	*
Total						
start	0 (0.0)	0 (0.0)	0 (0.0)	35 (31.3)	41 (36.6)	35 (31.3)
end	14 (12.5)	45 (40.2)	28 (25.0)	13 (11.6)	0 (0.0)	0 (0.0)

** Incomplete Data.*

A comparison of starting and ending voice quality among groups, in Table 5, reveals that voice quality ranged from mild to severe hypernasality prior to obturator wear and from hyponasal to mild hypernasality at the end of obturator wear (Group 1) or post-flap surgery (Group 2). (Group 3 will again be disregarded because of incomplete data.) No significant differences were found among groups nor between sexes in Groups 1 and 2 in relation to starting voice quality. However, there was a notable difference between Groups 1 and 2 regarding end voice quality when using chi-square analysis. Group 1 was found to have a greater proportion of the subclinically hypernasal individuals (17/25 = 68%) , whereas Group 2 resulted in a greater number of the hyponasal individuals (10/12 = 83.3%). Further, a chi-square between starting and ending voice quality between Groups 1 and 2 suggested that treatment, whether obturator or flap, yielded significant differences in voice change.

Table 6. Family History of CL and/or CP and Associated Anomalies Among Groups.

Groups	Family History		Anomalies	
	Neg	Pos	Neg	Pos
1 - 44	36 (81.8)	8 (18.2)	27 (61.4)	17 (38.6)
2 - 47	39 (83.0)	8 (17.0)	29 (61.7)	18 (38.3)
3 - 21 *	16 (76.2)	3 (14.3)	10 (47.6)	10 (47.6)
Total	91 (81.3)	19 (17.0)	66 (58.9)	45 (40.2)

**Incomplete Data.*

In Table 6, chi square analysis also showed no significant difference between groups 1 and 2 when considering family history of CL and/or CP and associated anomalies. Overall, less than one-fifth (17%) of the population had a positive family history and about two-fifths (41.1%) of the population were positive for associated anomalies. Associated anomalies included Pierre Robin syndrome, dysarthria, dyspraxia, velocardiofacial syndrome and other cardiac anomalies, developmental delay/mental retardation, multiple congenital anomalies, sensorineural hearing loss, epilepsy and seizures, diplegia/hemiplegia, Strickler's syndrome, Sprengel syndrome, metatarsus adductus, idiopathic thrombocytopenia purpura, and osteogenesis imperfecta, in frequency of occurrence. It should also be noted that there was an equal ratio of positive (10/21 = 52.4%) and negative (10/21 = 52.4%) associated anomalies in Group 3 as compared to the other two groups.

Table 7. Distance Traveled Among Groups.

Groups	Distance (miles)		
	<60	60 - 120	>120
1 - 44	29 (65.9)	8 (18.2)	7 (15.9)
2 - 47	34 (72.3)	2 (4.3)	11 (23.4)
3 - 21	15 (71.4)	1 (4.8)	5 (23.8)
Total	78 (69.6)	11 (9.8)	23 (20.5)

Table 7 depicts that the majority (78/112 = 69.6%) of Oregon CDRC obturator patients were located within a 60-mile radius of the Portland treatment center. Approximately one-third (30.4%) of the population was located outside of this 60-mile radius, and one-fifth (20.5%) of the population resided more than 120 miles from the treatment center. Chi square analysis found no significant distance differences between Groups 1 and 2.

Table 8. Obturation and End Bulb Sizes and Total Bulb Reduction Between Groups 1 and 2.

Groups	Obt Bulb		End Bulb		Tot Rdctn	
	Lat	AP	Lat	AP	Lat	AP
1 range	4.7-39.3	2.5-17.0	1.6-24.3	1.1-12.3	-7.4-28.8	-2.0-10.0
mean	**17.7**	**9.1**	**9.3**	**6.8**	8.3	2.4
s.d.	7.5	2.8	5.5	2.9	7.8	2.8
2 range	12.4-40.5	7.3-17.6	4.0-27.8	4.3-16.4	-1.0-27.3	-3.2-12.6
mean	**24.6**	**12.0**	**13.8**	**9.7**	10.8	2.1
s.d.	7.2	2.3	5.8	2.9	7.2	2.9

In addition, an analysis of the lateraland anteroposterior dimensions of the starting (@ full obturation) and ending obturator bulbs as well as their overall reduction can be seen in Table 8. (Only Groups 1 and 2 were compared.) The smallest and largest dimension in both starting and ending bulbs were observed to be smaller in Group 1 than in Group 2. A t-test of the mean bulb sizes also reveals a significant difference between the two groups, particularly related to the smaller mean dimensions found in Group 1. Nevertheless, there was no significance found in the total amount of reduction between Groups 1 and 2.

Furthermore, a chi-square analysis was performed on diagnoses (divided into cleft and non-cleft) versus the starting and ending bulb sizes and total bulb reduction. A significant relationship was discovered in reference to the anteroposterior dimensions of all three variables. It appears that a greater number of the non-cleft classes tend to have smaller anteroposterior bulb sizes than their cleft counterparts.

Specifically, 72% (18/25) of the non-cleft patients and only 40.9% (27/66) of the cleft individuals had starting bulbs with anteroposterior dimensions of less than or equal to 10.6 millimeters (i.e., $\leq$ 50th percentile of the measurements between Groups 1 and 2). Moreover, the starting bulbs in 31.8% (21/66) of the cleft class had anteroposterior dimensions greater than 12.3 millimeters (i.e., > 75th percentile) as compared to only 8% (2/25) in the non-cleft category.

More of the ending bulbs in the non-cleft group (44%) were also smaller ($\leq$ 5.7mm, or $\leq$ 25th percentile) than the cleft group (15.2%). Likewise, 33% of the cleft patients and 8% of the non-cleft patients had anteroposterior dimensions > 10.7mm (i.e., > 75th percentile). In

addition, more individuals in the non-cleft class (64%) had greater total reductions (> 1.8mm, or > 50th percentile) in the anteroposterior dimensions than the cleft patients (47%).

Finally, Pearson's *r* was computed interrelating age, duration of obturation, starting and ending bulb sizes and total reduction. The highest correlations existed between the lateral dimensions of the starting bulbs with their anteroposterior dimensions (r = .71) as well as with the lateral dimensions of bulb reduction (r =. 70). Similarly, the lateral and anteroposterior dimensions of the ending bulbs correlated moderately (r = .62). Moderate correlations were correspondingly found between anteroposterior starting bulb sizes with the anteroposterior dimensions of the ending bulb (r = .56) and the lateral bulb reductions (r = .57).

Low correlations were found in the following: age vs. lateral starting bulb size (r = .24) and lateral ending bulb size (r = .31); duration of obturation vs. lateral starting bulb (r = .30), anteroposterior starting bulb (r = .42), lateral bulb reduction (r = .44) and anteroposterior bulb reduction (r = .26). A negative correlation existed between age and duration of obturation (r = -.34), and between anteroposterior ending bulb and anteroposterior bulb reduction (r = -.48). (Other low correlations were found but excluded in report because it was this investigator's opinion that they aren't worthy of mention.)

DISCUSSION

The most notable finding obtained in this investigation is there are approximately 40% of patients who will eliminate obturator wear without the need for surgery and still maintain normal to near-normal speech. Similarly, another 40% of these obturator patients will receive successful pharyngoplasties after maximal reduction of their obturators. This provides a more current update of **Blakeley's** (1969) data reporting a 20% frequency in obturator eliminators and a corresponding 30% frequency in surgical candidates.

Tne significance noted between groups and diagnostic categories infers that the non-cleft velopharyngeal inadequacies, particularly those of unknown etiology and post-T&A, yield a better prognosis of success in an obturator reduction program. On the contrary, bilateral CL/CP diagnoses will tend to have a poorer prognosis of obturation elimination and are likelier to be flap candidates. The diagnoses of unilateral CL/CP, isolated CP, and submucous cleft seem to neither support nor deny success vs. nonsuccess even though there were more unilateral/isolated individuals in Group 2 and more submucous cleft patients in Group 1. Of interest, one isolated CP patient in Group 1 achieved adequate velopharyngeal closure to discard his obturator despite an unrepaired cleft. This observation defintely refutes **Shelton's** (1968) statement disregarding the advantages of bulb reduction in open cleft palate subjects.

Additionally, the greater proportion of non-cleft patients in the successful group and of cleft individuals in the unsuccessful group implies that non-cleft subjects are apt to be more successful than their cleft counterparts. This statement apparently disagrees with

Wong and Weiss (1972) since their findings were insignificant when interrelating groups and their velopharyngeal defects.

Furthermore, the poorer prognostic tendencies originally postulated about neuromuscular disorders was not substantiated. A differentiation between the types of neuromuscular abnormalities among groups uncovered that the diagnosis of cerebral palsy and post-head injury was linked with the successful group. However, the specific types were not found to dictate success vs. nonsuccess since post-head injury was common to all three groups. Perhaps an association with nonsuccess could be made with the diagnoses of myotonic dystrophy and palatal paresis considering that the former was only shared by Groups 2 and 3 and the latter was isolated in Group 2. Nevertheless, this assumption cannot be validated in this study with such a small sample group of neuromuscular disorders. Moreover, **Blakeley and Porter** (1971) have reported of an unexpected case of obturator elimination in a patient with palatal paralysis. Also, **Fletcher** (1960), **Lubit** (1971), **Lavelle** (1979) and **Duxbury** (1985) have suggested their alternative appliances for the specific treatment of velopharyngeal inadequate patients resulting from neuromuscular disorders.

Again, in contradiction to **Wong and Weiss** (1972), no difference was notable between sexes and groups, nor between groups and mean age. Although, it was observed that the successful group consisted of a younger age range than the nonsuccessful group, statistical analysis showed no significance. Yet, **Blakeley** (1960, 1964), **Bzoch** (1964, 1965) as well as **Wong and Weiss** (1972) cannot be discounted for their stance that younger individuals have fewer formed habits and would therefore be more adaptable.

In addition, **Calnan's** (1958) study, using cinefluorographic comparisons of adults and children with normal velopharyngeal closure,

suggested that pharyngeal wall movements in the adult are considerably less. Further, **Aram and Subtelny** (1959) reported that the degree of soft palatal closure increases with age, thereby necessitating greater compensation from the elder velopharyngeal inadequate patient. Despite this previous data, this investigation implies that perhaps age does not play a role in success vs. nonsuccess in an obturator reduction program.

A better method of analyzing age vs. success in an obturator reduction program would be to compare the end articulation of successful individuals started at a younger age with their elder counterparts. In this study successful individuals who began their obturator before the median age of 59.0 mos (N = 22) was compared to those over 59.0 mos (N=22). In so doing, abnormal end articulation was recognized in two individuals in the former age group and three in the latter age group, thereby noting no real difference. Nonetheless, it should be indicated that when the cut-off age is 48.0 mos, as **Blakeley** has advocated (1960, 1969), end articulation was judged as normal in all those who began obturator wear prior to and up to the age of 4 years old.

Duration of speech obturation was also significant with regard to shorter obturator wear in the successful group. Employing Pearson's product moment correlation coefficient revealed that low positive correlations existed between duration of obturation vs. starting bulb sizes and total bulb reduction. Low negative correlations were also shown with duration of obturation and age. Hence, if an assumption were to be made: the larger the obturator, the longer the obturation period; in turn, the longer the obturation, the greater the reduction; and, as the obturator starting age increases, the period of obturator wear decreases.

Treatment recall period and traveling distance was initially examined to aid in determining patient compliance. It was reasoned by the investigator that patient's who deviated greater than the accustomed four to six month recall may be demonstrating noncompliance. Likewise, it was conceived that the longer the distance, the less the compliance. But, the mean and median treatment intervals between successful and unsuccessful groups were closely similar and thereby meaningless. In addition, the shorter or longer distance traveled had no bearing on an individual's success or nonsuccess. This study, therefore, failed to enlighten whether compliance plays a role in the successful elimination of an obturator.

The presence of remedial speech along with the evaluation in hearing was assessed to determine their effect on end articulation. Since speech assistance was almost always present, and during its rare absence, end articulation was appraised as abnormal in only one case, no significant association between the two variables could be made. Although, it can be stated that speech therapy appears to be the rule rather than the exception in conjunction with speech appliance therapy in the Oregon CDRC Obturator Reduction Program.

Hearing impairment, as previously mentioned, did not represent the lack of hearing which impeded speech education, but rather the particular diagnosis made by an audiologist. For this reason, its analysis may be of no value except for the formation of the following postulations. Since cleft patients are more prone to chronic ear infections than noncleft patients, and Group 2 had a larger number of cleft subjects, the frequency of abnormal hearing in Group 2 would be expected to exceed that in Group 1. This assumption was not proven in this study in view of the nearly equivalent cases of abnormal and normal hearing in both groups.

End articulation was also found to be insignificant between groups. This finding is inclined to support **Karnell's** (1986) view that "once an individual is given an adequate mechanism, comparable articulation can be achieved," despite the method of management. Even though it was not statistically compared to hearing, the frequencies of abnormal and normal cases tend to closely match in both groups. Despite the inadequate data in Group 3, it was noticed that this group had a proportionately greater number of abnormal hearing cases as well as relatively more articulation disorders.

Groups 1 and 2 were seen to have similar frequencies in their starting voice quality, ranging from mild to severe hypernasality. The significant observations were made in the post-treatment voice quality which reflected that the obturator eliminators are likelier to possess subclinical hypernasality, whereas post-surgical patients will have an inclination towards hyponasality. Both groups resulted in normal voice quality in about half of its cases and mild hypernasality was the least frequent ending voice quality. Several of the mildly hypernasal obturator eliminators willfully terminated themselves due to lack of perceptible voice quality change with the obturator in or out. Regardless of treatment type, it can be stated that voice quality did change for the better.

This study, once again, disagreed with **Wong and Weiss** (1972) concerning their association of positive CL/CP family history and nonsuccess in an obturator reduction program. In fact, no significant differences were found with regard to both CL/CP family history and associated anomalies. This latter finding also differs with **Fletcher, et al** (1960) who reported that hypernasal subjects tend to have associated developmental anomalies which extend throughout the oral, pharyngeal, vertebral and other regions. Still, this study found that the

percentage of positive family history and associated anomalies was nearly identical in successful and unsuccessful groups. The most commonly associated anomalies included Pierre Robin syndrome, dysarthria, dyspraxia, velocardiofacial syndrome, and mental retardation/ developmental delay. No specific anomaly was found to significantly predominate one group over the other.

The analysis of bulb measurements revealed that successful individuals were inclined to have smaller starting as well as ending bulbs. This finding concurred in both the lateral and anteroposterior dimensions of the obturator bulb. Interestingly, it was the anteroposterior bulb dimension which proved to be of significance when paralleled with the cleft and non-cleft diagnoses. Specifically, smaller anteroposterior bulb sizes were more characteristically associated with the non-cleft classes; similarly, larger anteroposterior bulb sizes were more typical in cleft individuals. This finding would thereby support this study's original hypothesis interrelating smaller-size bulbs, especially smaller anteroposterior bulbs, with the likelihood of success in an obturator reduction program.

Although mean total bulb reduction between Groups 1 and 2 was not found to be significant with the t-test, the chi-square analysis did indicate that non-cleft individuals had greater anteroposterior bulb reductions than cleft subjects. This finding upholds **Bzoch's** (1968) claim that structurally impaired inadequacies are less capable of palatopharyngeal compensation than their normal structural cohorts.

Lateral bulb reduction was also found to highly correlate with lateral starting bulb size, which in turn, highly correlated with anteroposterior starting bulb size. Lateral ending bulb sizes only moderately correlated with anteroposterior ending bulb sizes. Other moderate correlations related anteroposterior starting bulbs with their

ending bulbs and with lateral bulb reductions. In other words, these correlations can be interpreted to support the concept of symmetrical velopharyngeal closure, with more lateral pharyngeal muscular compensation. Additionally, these findings aid in defending the section reduction hypothesis and thereby refuting Shelton and other disbelievers.

SUMMARY AND CONCLUSIONS

This investigation of 112 velopharyngeal inadequate patients enrolled in the Oregon CDRC Obturation Reduction Program was an endeavor to correlate the anatomical, physiological as well as other characteristics related to the successful elimination of a temporary speech appliance. In turn, it was conceived that this may aid in the diagnostic purposes related to the proper treatment modality of a patient with velopharyngeal inadequacy. In particular, this study hoped to differentiate specific prognostic factors which may aid in distinguishing a successful obturator candidate from a potential surgical patient early on.

Anatomical aspects were primarily related to the difference in obturator bulb sizes and total bulb reduction between groups, whereas the physiological features mainly dealt with the specific diagnostic categories, hearing and resultant voice quality and articulation which closely typified a successful or unsuccessful individual in an obturation program. Other factors considered in the study included initial age of obturator wear, duration of obturation, treatment recall interval, remedial speech, family history of clefts, associated anomalies, and traveling distance. Patient compliance was initially examined, but was omitted due to the investigator's somewhat rigid standards of analysis.

Overall, this study indicates that prognosis is generally good for successful elimination of a temporary speech appliance if an individual had the following characteristics: a non-cleft diagnosis, preferably of unknown etiology or post-T&A; smaller-sized bulbs at full obturation and at termination, especially in the anteroposterior dimension; and,

shorter duration of obturation. This patient will likely have a post-treatment voice quality of normal or subclinical hypernasality. On the other hand, the individual presenting with a cleft diagnosis, particularly bilateral CL/CP, larger-sized bulbs,and longer obturation periods has a predisposition to becoming a surgical candidate. This latter group has a greater probability of attaining either normal or hyponasal speech.

The other variables which were investigated were not found to have significant differences between groups, but should not be disregarded. This author believes that no one specific factor can determine the success in obturator elimination. However, information on compliance may have been useful, since the patient's commitment to prosthetic therapy is essential in treatment progression due to the number of appointments involved, and/or the distance required in traveling to the treatment center. With children, this commitment is more than necessary for both the child, as well as the parent. Both the clinician and parents are burdened with a greater task with the younger child who may be too immature to cooperate for treatment.

In conclusion, this investigation did not truly accomplish the desired objective to specifically identify the successful obturator eliminator from the potential surgical candidate. However, it does provide additional information regarding specific trends in obturator bulb dimensions with regard to a cleft and non-cleft diagnoses. The study may also be beneficial in directing the clinician as to the prognosis of palatopharyngeal inadequate patients resulting from bilateral CL/CP, post-T&A , and unknown origin. More importantly, it has shown that almost 40% of patients enrolled in a systematic obturator reduction program can eliminate obturator wear without the need for surgery and still maintain normal to near-normal speech.

Likewise, another 40% will undergo successful pharyngoplasties after maximal reduction of their obturators.

Future investigation in this subject matter may want to examine the psychological and social aspects of these patients with regard to compliance and success in an obturator reduction program. In addition, it would be advantageous to retrieve information on the final outcome of the Group 3 individuals in order to more accurately determine the subsequent treatment of post-obturator patients. It would also be interesting to compare the results of other obturation reduction programs elsewhere.

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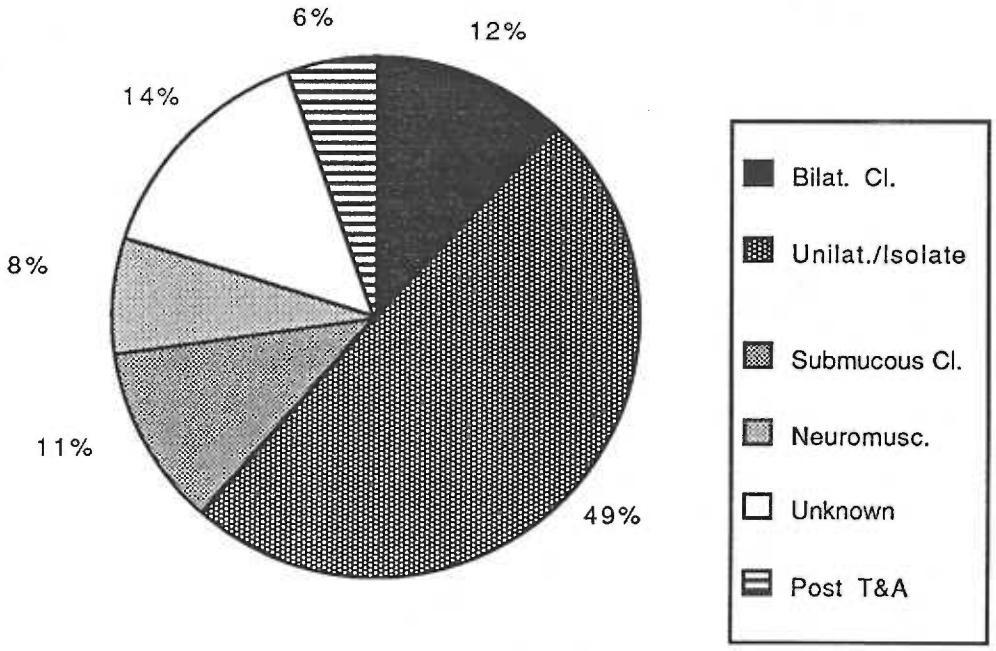
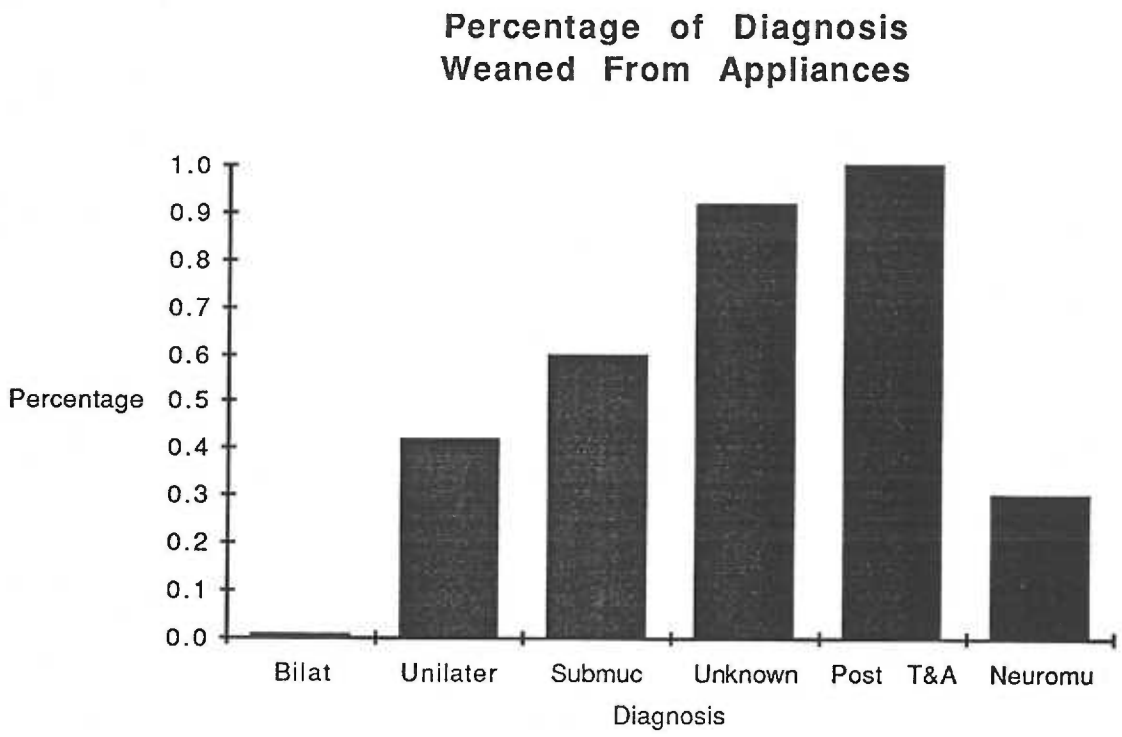
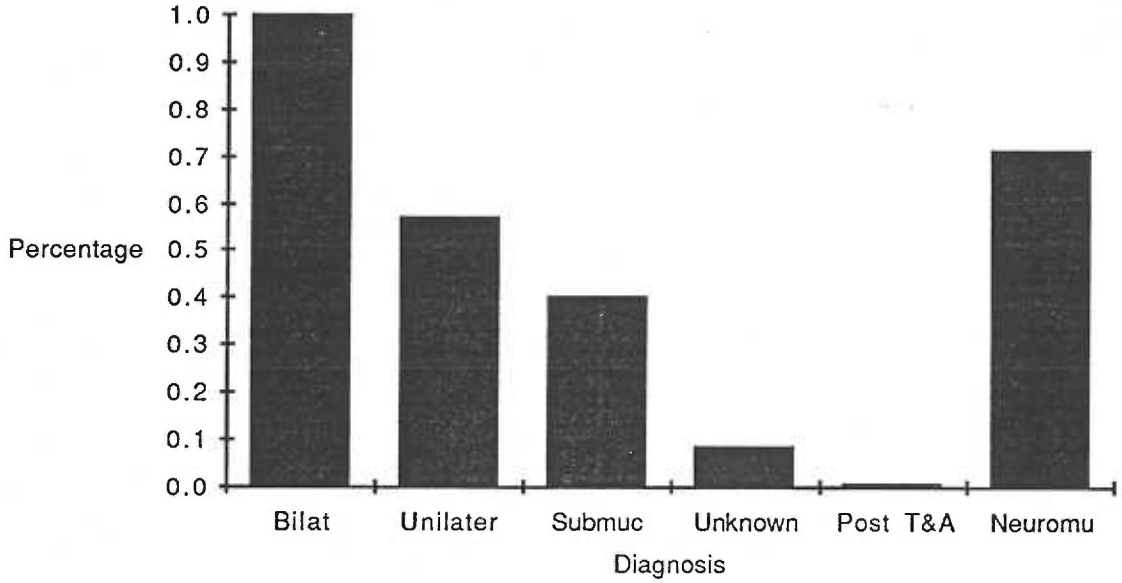
Breakdown of Obturator Patients

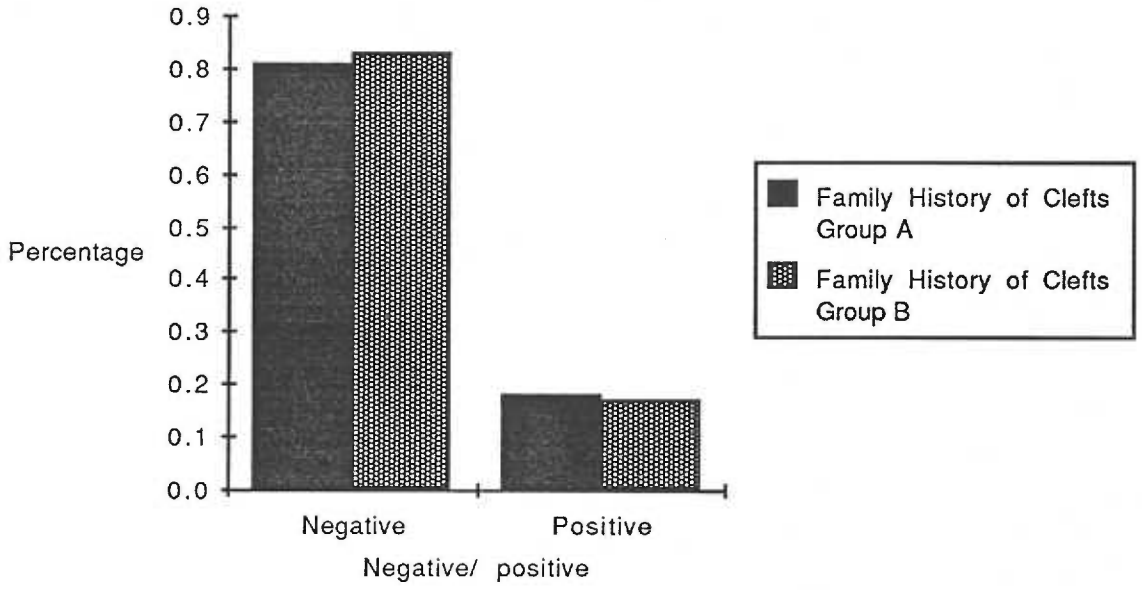


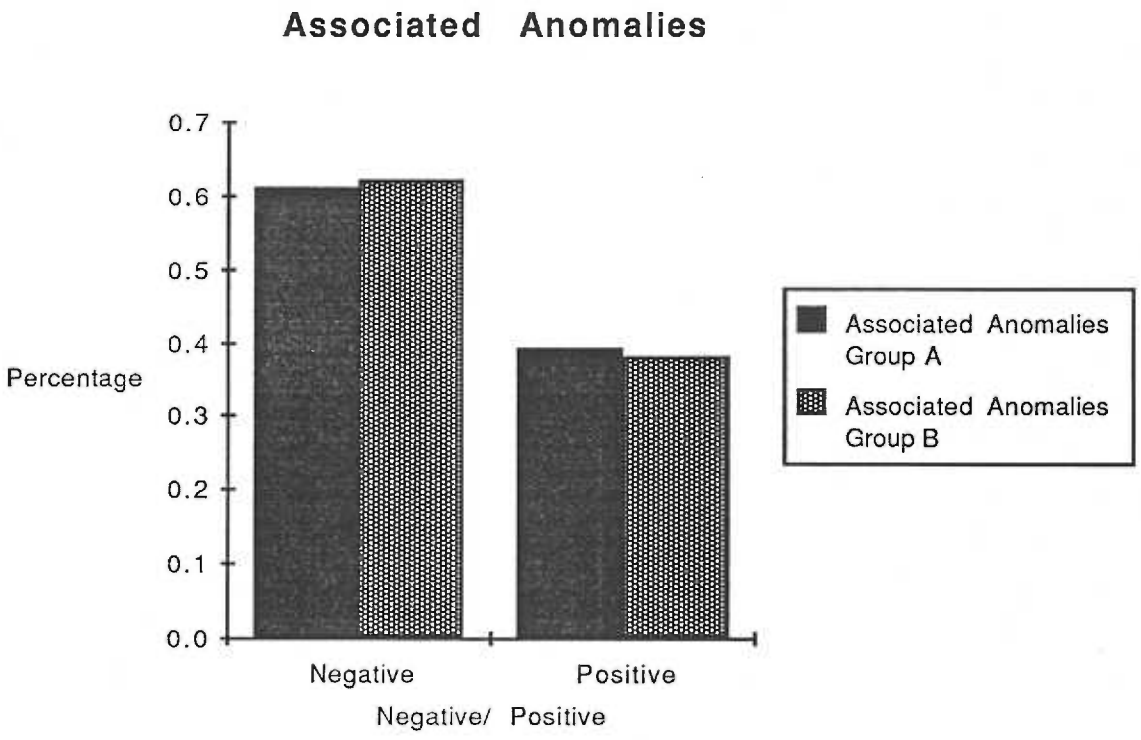

Percentage of Diagnosis
Weaned From Appliances
Percentage
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Bilat
Unilater
Submuc
Unknown
Post T&A
Neuromu
Diagnosis

Percentage of Diagnosis Requiring Surgery

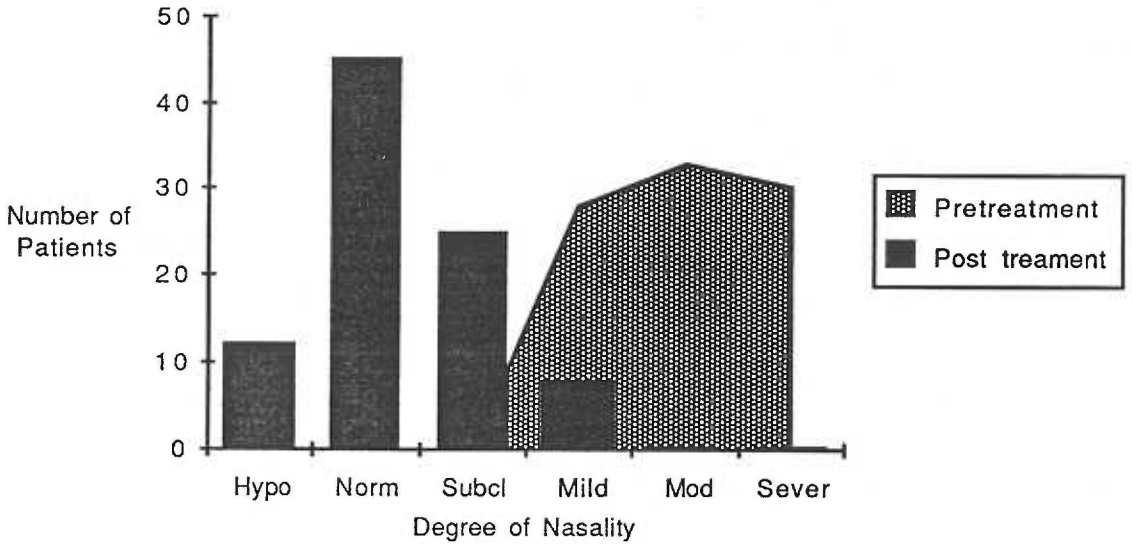


Family History of Clefts




Associated Anomalies
Percentage
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Negative
Positive
Negative/ Positive
Associated Anomalies Group A
Associated Anomalies Group B

Pre and Post Treatment Voice Quality
Total Patients in Groups A & B



Distance Traveled