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SPEECH AND SWALLOWING CHANGES ASSOCIATED WITH SAGITTAL OSTEOTOMY: A REPORT OF FOUR SUBJECTS

Felicia A. Bruce and Marvin L. Hanson

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Abstract

The purpose of the study was to determine the immediate and possible long-term effects of a mandibular osteotomy upon speech and tongue thrust (where present). To explore this, four subjects who exhibited a Class III malocclusion or skeletal underbite, in addition to a lisp, were evaluated before and after undergoing a sagittal osteotomy. The evaluation consisted of identical speech and tongue thrust assessments completed within two weeks of and nine weeks after the scheduled surgery. Both evaluations were completed by a panel of three speech-language pathologists. The speech evaluation required the subject to read ten /s/ and ten /z/ phoneme sentences taken from the McDonald Deep Test of Articulation. Each subject was judged as either exhibiting or not exhibiting a lisp on each sentence read. The tongue thrust evaluation utilized a quantitative tongue thrust baseline measurement in which the subject's tongue position was ranked during the swallowing of food, liquid, and saliva.

Postsurgical speech results indicated that there was a marked improvement of articulation scores for three of the four subjects. Two of the subjects demonstrated complete correction of lisping behavior. Postoperative tongue thrust measurements suggested that there was no change in tongue thrusting patterns. Three of the four subjects demonstrated a tongue thrust.

The benefits of oral and maxillofacial surgery are varied. Some benefits are emphasized when surgical remediation of a skeletal deformity or malocclusion are considered. Jaw surgery may provide more favorable occlusion which may, in turn, result in an improved profile or cosmetic appearance, improved temporomandibular function, and improved chewing and eating habits.

An important consideration of jaw surgery should also be the immediate and possible long-term effects upon speech and/or oral habits, particularly swallowing and resting tongue posture. One can clearly see that by surgically altering the size and configuration of the oral cavity, there may be significant changes not only in an individual's ability to produce specific speech sounds, but also in their habitual swallowing patterns. Little research has been done to investigate these changes. These issues are important to consider for two reasons: Effects on speech intelligibility may be a factor to consider when contemplating jaw surgery, and surgical results may facilitate speech and/or orofacial myofunctional therapy.

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The purpose of the study was to determine the immediate and possible long-term effects of a mandibular osteotomy upon speech and tongue thrust (where present). To demonstrate this, four subjects with a Class III malocclusion or skeletal underbite, in addition to a lisp, were evaluated before and after undergoing a sagittal osteotomy (a surgical procedure to reposition the mandible in a normal relationship). This examination consisted of both a speech and tongue thrust assessment.

Review of the Literature

Limited research has been conducted on mandibular surgery, especially in conjunction with its effects upon speech and/or swallowing habits. First, of all the five components of speech (respiration, phonation, resonance, articulation, and cerebration) articulation is the major area that is most likely to be affected by the presence of dental abnormalities (Kent & Schaaf, 1982). Speech is formulated by the articulation of the lips, alveolus, hard palate, velum, and most importantly, the tongue. Because the tongue has the ability to alter the size and configuration of the oral cavity, it is considered the most important articulator. If structural deviations exist, such as a malocclusion, then tongue placement may be affected resulting in defective speech production.

Mandibular prognathism may lead to problems in production of the /s/ and /z/ phonemes since the maxillary anterior teeth may alter the pathway of the narrow stream of air being driven against the incisal edges of the mandibular anterior teeth. This entire process is an essential maneuver for the creation of sibilant phonemes (Kent & Schaaf, 1982).

A study by Glass et al. (1977) attempted to answer the following questions: Does the modification of oral structures influence oral behaviors? Do observable changes in oral behavior occur in response to the change in the dimensions and configurations of the oral environment? If such changes do occur, are the changes beneficial to speech?

Five patients who exhibited a skeletal Class III malocclusion in addition to some speech distortion were evaluated one day prior to jaw surgery and also after arch bar removal (approximately eight weeks postsurgery). Findings indicated that all patients showed similar changes in three oral behaviors: (a) An increase in maladaptive lingual diadochokinetic behavior, (b) A decrease in

sibilant distortions, and (c) A change in swallowing patterns. There appeared to be no clear explanation for the postsurgical increase in maladaptive tongue behaviors. The conclusion of the study was that alteration of the dimensions and configuration of the oral environment achieved through mandibular osteotomy will indeed produce a change in oral behavior. A positive change in sibilant production and a negative change in lingual diadochokinetic behavior resulted (Glass et al., 1977).

To examine /s/ production in both a prognathic subject and four micrognathic subjects, a perception test was undertaken using many of the recorded /s/ sibilants in the word "say". The prognathic subject's speech was used to confirm the findings of Glass et al. (1977). The speech of the micrognathic subjects was used to see if any systematic changes in noise amplitude during /s/ production occurred after surgical correction (Ewan, 1980). The basic premise was if occlusion is improved, the amplitude of the higher noise frequencies produced by air turbulence should increase for both prognathic and micrognathic subjects. The subjects pronounced a number of words in the sentence frame "say _____ again" before surgery and four weeks after removal of fixation wires.

Eighty-three percent of the judgments indicated a rise in /s/ noise frequency due to a more approximate interdental closure. Sixteen percent were judged as unchanged. Thus, there is a difference between presurgical and postsurgical /s/ productions. The change involved an increase in the amplitude of the higher end of the noise frequency spectrum.

Results also indicated that some micrognathic surgery patients will also have an increase in amplitude of the higher noise frequencies during the production of /s/. An /s/ sound will sound "higher or sharper" postsurgically (Ewan, 1980).

In another study, 41 patients who were undergoing a facial osteotomy were evaluated before and after surgery to determine the relationship between articulation and dental occlusion (Witzel, Ross, & Munro, 1980). The subjects included one patient with apertognathia (skeletal open bite) only, 29 with retrognathia (17 with apertognathia). Of the entire group studied, 22 displayed articulation errors prior to surgery with errors in sibilant production in all groups, except the patient with apertognathia. There was no significant correlation between the severity of the occlusal defect and the total articulation score or scores for the sibilants, labiodentals, and bilabials.

Postoperative results indicated that aesthetic appearance, reduction of occlusal defect, and improvement in the mean total articulation score had occurred. There was significant improvement in the sibilant sounds for all groups and in the mean bilabial score in patients with retrognathia.

The overall results supported the theory that occlusal defects can influence articulation (Witzel et al., 1980). Since sibilant errors were predominant in patients with all types of occlusal defects, one can conclude that adequate production of sibilants is very dependent upon the

specific position of the tongue as well as the accurate direction of the air stream over the incisal edges of both maxillary and mandibular teeth. Articulation is affected not only by the change brought about in the teeth and jaw relationship but also in the alteration in the oral cavity, soft tissue, and lips.

A review of speech production before and after orthognathic surgery was also taken into consideration by Ruscello, Tekieli, and Van Sickels (1985). Twenty subjects, with maxillary and mandibular prognathism underwent speech evaluations before surgery. Immediately following splint removal and at three- and six-month intervals the same speech evaluation was given. Twelve patients exhibited articulation errors preoperatively. The initial preoperative error level of the group increased at the time of splint removal and decreased thereafter. Five of the 12 subjects were error free at the time of final testing, five subjects showed a reduction in the number of postoperative errors, and two remained unchanged. The majority of the errors were distortions and generally involved the sibilant sound class (Ruscello et al., 1985). No description of the speech evaluation was given.

A study by Weimar and Astrand (1977) utilized tape recordings of 30 patients prior to and six months after mandibular prognathism surgery. The results indicate that 25 of the patients demonstrated normal speech and five possessed mild speech defects. Three of these were detectable postoperatively and in the remaining two patients speech was still defective but less so. Speech soon adjusts to the altered organs of speech after surgical correction of mandibular prognathism (Weimar & Astrand, 1977).

Finally, in conjunction with tongue behavior, Barrett and Hanson (1978) asserted that patients with normal occlusion show a typical pattern of muscle activity and patients with malocclusions demonstrate muscle patterns differing from those of normal subjects. They stated: "Patients with Class II--Division 1, Class II--Division 2, Class III, and postural Class III malocclusion can be differentiated on the basis of their patterns of muscle activity" (p. 211).

Reports of other types of surgery involving the jaws are: (a) sagittal osteotomy of the mandibular horizontal ramus for correction of apertognathia--report of a case (Kempf, 1977); (b) speech considerations with maxillary advancement procedures (Mason, Turvey, & Warren, 1980); (c) tongue pressures and tooth stability after anterior maxillary osteotomy (Proffit & Knight, 1977); (d) effects on speech of surgical premaxillary osteotomy (Garber, Speidel, & Marse, 1981); and (e) correction of anterior open bite deformity--a study of tongue function, speech changes, and stability (Turvey, Journot, & Epker, 1976).

Summary

A thorough review of the literature during the past decade indicated that there is little research dealing with the accompanying speech and swallowing effects of

mandibular surgery. All of the studies reported improved articulation performance (for subjects with misarticulations) in addition to the occlusal and cosmetic changes. Only one of the studies took into consideration tongue behavior, other than for speech. There was no research dealing specifically with the effects of this surgical procedure on tongue thrust, or chewing and swallowing patterns.

Subjects

Participants in this study included one female aged 16, and three males aged 19, 26, and 43 years. All four subjects were patients of the same oral surgeon. Subjects were identified and selected as prospective candidates for this study based upon the following criteria: (a) each was identified by the oral surgeon as exhibiting a malocclusion to be surgically remediated by a sagittal osteotomy of the mandible; and (b) the subjects exhibited some speech distortion, as evidenced by a lisp. None of the subjects had received therapy for tongue thrust. Following is an individual representation of each subject.

SUBJECT 1 — This 26-year-old male exhibited a Class III malocclusion with supraeruption of the lower incisors. He had both a sagittal osteotomy of the mandible and a horizontal symphyseal osteotomy (a surgical procedure to augment or reduce the chin). He demonstrated a slight frontal lisp prior to surgery. Speech was not a concern for this patient as he was not aware of any speech distortions. He had not received previous speech and/or orofacial myofunctional therapy. His jaw surgery was performed primarily to improve occlusion and cosmetic appearance.

SUBJECT 2 — This 16-year-old female possessed a Class III malocclusion and vertical open bite with some maxillary deficiency and extreme hyperplasia (excessive growth). She underwent both a sagittal osteotomy of the mandible and a horizontal symphyseal osteotomy to improve chewing, occlusion, and facial profile. This patient demonstrated a very noticeable strident lisp before

surgery. Speech was a major concern as she was very conscious of her sound distortions. She had received speech/language therapy during the fifth grade to improve correct production of the /s/ and /z/ phonemes.

SUBJECT 3 — This 19-year-old male exhibited a Class III malocclusion, vertical open bite, horizontal hyperplasia, and asymmetry with deviation to the left of the mandible. A sagittal osteotomy of the mandible was performed. He had a frontal lisp but was unaware of any distortion in sibilant production. Surgery was performed to improve temporomandibular joint functioning since he had experienced some pain and popping in that area. Occlusion and facial symmetry also improved.

SUBJECT 4 — This 43-year-old man broke a condyle at age 21 which caused his jaw to grow unevenly, resulting in facial asymmetry. He was diagnosed as possessing mandibular asymmetry, a vertical open bite, and prognathism with left condylar hyperplasia. A Lefort 1 osteotomy (an osteotomy which permits repositioning of the maxilla) with segmentalization and sagittal osteotomy of the mandible with alloplastic graft (graft of a man made material) to the mandible was performed. He underwent surgery to improve jaw functioning since he suffered from temporomandibular joint pain, and to improve cosmetic appearance. He demonstrated a frontal lisp and was aware of his speech distortions. He was concerned about his speech since he dealt with the public in his profession.

Surgery

The purpose of the surgery was to correct the basic defect of mandibular prognathism related to excessive horizontal growth of the mandibular body and/or ramus. This structure is positioned in an anterior relationship to the remainder of the facial skeleton. Thus, it represents both a functional and developmental disorder: *Functional* in the sense that speech, mastication of food, deglutition, and temporomandibular joint functioning may

be adversely affected, and *developmental* since the spatial relationships of the facial bones are altered.

Surgical correction of mandibular horizontal hyperplasia by a sagittal osteotomy requires bodily repositioning of the tooth-bearing portion of the mandible. The surgery is performed at the junction of the horizontal and vertical portions of the mandible. The temporomandibular joint is left unaffected and continues to function in its original manner following surgery. A horizontal osteotomy cut is made through the inner table of the mandible in the ascending ramus. This cut is placed above the mandibular lingula to avoid damage to the neurovascular structures entering this area. The cut is then carried anteriorly down the ascending ramus to the molar region, where it is directed inferiorly to the lower border of the mandible. An identical procedure is then performed on the opposite ramus. Small chisels, or osteotomes, are then used to separate the proximal and distal segments of the jaw. The lower jaw is now separated into three pieces: Two proximal segments--each attached to the temporomandibular joint and a distal horseshoe-shaped segment carrying the teeth. The distal segment is then repositioned posteriorly to correct the skeletal deformity and provide a normal dental relationship. Bone is then removed in the area of the lateral osteotomy cut to permit the segments to lay together accurately. The jaw is then stabilized in this position by passing stainless-steel wires through drill holes in the proximal and distal segments and by tightening these wires. In addition, an acrylic template is placed between the teeth, which are then wired in a closed position. The jaw is thus protected from any movement during the healing phase which is approximately six to eight weeks.

Evaluation Procedures

Identical speech/language and tongue thrust evaluations were completed within two weeks prior to the scheduled surgery, and also two to four weeks after the stabilizing splint had been removed which is approximately nine weeks after surgery.

SPEECH/LANGUAGE EVALUATION

Previous to testing, the subject was not informed by the examiner of the specific phonemes to be evaluated. The speech evaluation required the subject to read ten /s/ and ten /z/ phoneme sentences adapted from the sentence portion of the McDonald (1964) Deep Test of Articulation. Both the /s/ and /z/ markers found at the top of the test pages were covered by tape to prevent the subject from identifying the test sounds. Each sentence read by the subject was recorded by a panel of three judges (speech pathologists experienced in both the evaluation and treatment of tongue thrust), as either exhibiting or not exhibiting some distortion or a lisp. After the entire speech and tongue thrust testing and brief conversation with each patient, a qualitative opinion about the lisp type and severity was formulated by each judge. During the last evaluation, subjects were asked a series of questions pertaining to their feelings about their speech and the jaw surgery that was performed.

Judges' ratings for both the /s/ and /z/ phonemes were averaged to obtain an average number of distortions (lisps) per ten sentences both before and after jaw surgery. Interjudge agreement was calculated for each measurement and was never less than 90%.

TONGUE THRUST EVALUATION

(see table 1 on page 5)

The tongue thrust evaluation was also conducted by the three judges. The subjects were ranked using a 0-2 scale (Barrett & Hanson, 1978) which provided for quantitative tongue thrust baseline measurements, representing the following tongue positions (described in relation to both maxillary and mandibular teeth): (0) No dental contact, (1) tongue touches with some degree of force at least one-half of the lingual surface of one or more anterior teeth, and (2) protrusion of the tongue beyond the cutting edge of the upper and lower teeth.

Subjects were judged while performing the following actions: (a) swallowing solids, (b) swallowing liquid and (c) swallowing saliva. Each judge independently evaluated the subject by assigning a numerical score for each of the above activities. In addition, each subject was asked to describe where his/her tongue rested.

Results

SPEECH

Overall there was a marked improvement of articulation scores for both the /s/ and /z/ phonemes during the postsurgical evaluation for three of the four subjects. Subject 2 showed no improvement. Two of the four subjects demonstrated complete correction of lisp behavior, and the remaining individual improved from an average of ten to two lisps per ten sentences, presurgical to postsurgical, respectively.

TONGUE THRUST BASELINE MEASUREMENTS

Before and after tongue thrust assessments included results of all tongue thrust measurements during swallowing food, saliva, and water, as well as the individual's descriptions of their tongue-resting position. For all four subjects there was no change in tongue thrusting behavior postoperatively (a tongue thrust was present in three of the four subjects).

INDIVIDUAL SUBJECTS

Subject 1: Subject 1 had 100% correction of distortions for both the /s/ and /z/ phonemes. He felt that there was no significant change in his speech since surgery. Tongue thrust measurements remained unchanged.

Subject 2: Subject 2 scored the same number of errors on /s/ postsurgically and errors on /z/ decreased by one. She was extremely concerned about her speech. Tongue thrust remained the same and, for these reasons, she was advised to seek both speech/language and orofacial myofunctional therapy.

Subject 3: Subject 3 also showed improvement by the decrease in error for both /s/ and /z/ sentences. Tongue thrust baseline measurements were the same. He felt that

TABLE 1

Tongue Thrust Baseline Measurements

Subject	Preobservation/ postobservation	Swallow water	Swallow saliva	Swallow solids	Patient report of tongue resting position
1	Pre	1	1	1	Tip against bottom part of upper teeth.
1	Post	1	1	1	Same as above.
2	Pre	2	2	2	Tongue low and forward with mouth open
2	Post	2	2	2	Same as above.
3	Pre	2	2	2	High and forward with tongue on anterior teeth.
3	Post	2	2	2	Tongue against upper teeth.
4	Pre	0	0	0	Notices both tongue up and down.
4	Post	0	0	0	Same as above.

Note: Interjudge agreement for all was 100% with the exception of the postsurgical assessment for Subject 3 where 90% interjudge agreement existed.

there was no significant change in his speech postsurgically.

Subject 4: Subject 4 demonstrated error-free production for all sentences postoperatively, although he admitted that he was working hard at producing the sentences correctly. No tongue thrust was present before or after surgery, probably due to the fact that his jaw deformity was not developmental but accidental in origin.

Summary

Postsurgical speech results indicated an improvement of articulation scores for three of the four subjects. Complete correction of the lisping behavior was seen in two of the subjects. Postoperative tongue thrust measurements remained unchanged.

Discussion

A comparison of all the speech and tongue-thrust results can be made in relation to the form/function dichotomy. It appeared that articulation function improved with the alteration of the mandible since three of the four subjects showed a 70% or greater improvement in both /s/ and /z/ production postoperatively. Subject 2 was the only patient who did not improve. She exhibited a more severe and noticeable lisp postoperatively.

The increase in correct production of sibilants may be

due to the smaller interdental space created by jaw repositioning. The smaller space allows for approximate placement of the articulators. This, in turn, creates more air turbulence which makes the sibilants more distinct and precise. These findings coincide with those of studies identified in the literature review to this study.

With respect to tongue behaviors, three of the four subjects exhibited both a developmental Class III malocclusion and a tongue thrust. This may be due to the tendency of a prognathic individual to position his/her tongue low and forward toward the mandibular anterior teeth at rest and during chewing, swallowing, and sound production. These habitual postures and behaviors may be difficult to change just by altering the configuration of the oral cavity and may require systematic retraining. Since the tongue thrust behaviors were constant and unchanged, function did not adhere to form. To promote permanence of the ideal jaw and dental relationship, orofacial myofunctional therapy should be recommended.

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