Speech production before and after orthognathic surgery: A review

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A review of investigations in which speech production has been studied before and after orthognathic surgery indicates that many subjects demonstrate preoperative articulation errors. The error type most frequently identified was of the distortion variety, which suggests that misarticulating speakers were attempting to produce the sounds but that in most cases the sounds were phonetically incorrect. The /s/ speech sound and the sibilant class in general, of which /s/ is a member, were often found defective in the subjects' speech. Not all speakers had preoperative articulation errors, which suggests the possibility of compensatory articulation patterns. The literature indicates that some persons with certain occlusal and dental conditions do compensate for structural aberrations. Finally, the vast majority of subjects with preoperative misarticulations eliminated or reduced their errors following orthognathic surgery. In the case of speech behavior, it can be stated that surgical alterations in form brought about positive changes in function.

(ORAL SURG. ORAL MED. ORAL PATHOL. 59:10-14, 1985)

Patients with abnormal occlusal patterns often undergo orthognathic surgery for correction of the hard-tissue defects.[1] The desired end result of the surgical procedure is both a cosmetic change and an improvement of functional oropharyngeal behaviors. Functional change may be observed in oral activities, such as swallowing, mastication, and speech.[2,3] A functional behavior that is of interest to oral surgeons, orthodontists, and speech/language pathologists is the articulation of the various speech sounds of the language.

Speech sounds of English can be categorized into two groups, which include vowels and consonants.[4] Physiologically, the difference between the two groups is one of constriction within the vocal tract, particularly in the oropharyngeal area of the vocal tract. The major parameters governing English vowel articulations are the point of tongue position, the amount of constriction created by the tongue position, and, in some cases, the utilization of lip rounding. Consonants, on the other hand, require rather precise points of partial or total constriction in the oropharyngeal area. Contact points of the tongue in conjunction with the teeth, alveolar ridge, and hard and soft palate are employed in the production of many consonant speech sounds. In addition, combinations of the upper central incisors and lower lip and the lips exclusively are also important production points for certain consonant sounds.

It is likely that an abnormal skeletal and/or occlusal pattern could interfere with the production of speech sounds, since there is a malalignment of the oral articulators.[5] This appears particularly critical for consonant speech sounds because of the different constriction points and the manner of constriction required for production. The position stated herein is that functional behaviors of the dentofacial complex, such as speech production, may be adversely affected by deviations of a structural nature. This form-function dichotomy has been termed an abiding issue that is of concern to the disciplines of oral surgery, orthodontics, and speech pathology.[6]

Inherent within this form-function relationship are several related sub-issues or questions. First, what is the relationship between speech-sound production and occlusal problems? While we know that patients with occlusal defects exhibit sound-production errors, we also know that some do not.[3,7] This lack of a consistent pattern suggests that some subjects develop compensatory strategies in adapting to their deformities. Finally, are there changes in speech-

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sound production of either a positive or a negative nature following orthognathic surgery?

The purpose of this article is to review those investigations that have examined the speech-production abilities of persons prior to and following orthognathic surgery. Emphasis in this review will be on the questions posed previously. In this way, a tentative statement may be made regarding the complex relationship between occlusal defects and speech production prior to and following surgical intervention.

REVIEW OF THE LITERATURE

Goodstein, Cooper, and Wallace[8] presented speech data from five patients who underwent surgical procedure for correction of mandibular prognathism. Pre- and postoperative speech evaluations were audio-taped while patients produced silibant sounds in word, sentence, and paragraph contexts. Postoperative evaluations were carried out at the removal of intermaxillary fixation and 8 weeks following surgery. All patients demonstrated some degree of initial misarticulatory involvement; however, the extent of the involvement cannot be determined from their report. The type of articulatory errors noted during sampling periods included distortions, substitutions, and the omission of sounds, but relative frequency of the error types was not given. Following surgery, three patients showed no change in their error patterns when evaluated. The two remaining subjects showed improvement in speech production at successive tapings, but errors continued to be noted. In no instance was there an increase in the number of errors following surgery; subjects either remained static or showed slight improvement.

Turvey, Journot, and Epker[9] investigated the effects of orthognathic surgery on nine patients who presented with an open-bite deformity. Speech evaluations emphasizing production of the /s/ and /z/ sounds were obtained prior to surgery and 3, 6, and 12 months postoperatively.

Surgically, two patients exhibited either some skeletal or occlusal movement without compromise of the occlusion, whereas one patient had a partial occlusal relapse. Eight of the nine patients were identified as having some degree of impairment of the /s/ and /z/ sounds prior to surgery. The type of error was classified as either a substitution or some form of distorted production. One year following surgery, five of the eight patients with errors improved completely while two subjects showed partial improvement. One subject's misarticulations increased in severity following surgery.

In an investigation carried out by Schwarz and Gruner[10] forty patients underwent maxillary advancement surgery. The group was composed of thirty-one cleft palate and nine noncleft patients. The extent of advancement differed among patients, but the range was from 3 to 20 mm. The speech of the patients was evaluated just prior to surgical intervention and approximately 4 months following maxillary advancement. The areas of speech evaluation included assessment of oral articulation, velopharyngeal closure, and nasal resonance. Each of the areas was evaluated, and a numerical ranking of severity was provided. The preoperative status of individual subjects with respect to the specific areas of evaluation indicated some degree of impairment for thirty-six subjects or 90 percent of the total group. Computed gain scores revealed that twenty-eight subjects in the cleft subgroup improved their oral articulation skills. Twenty-four showed a deterioration in velopharyngeal closure, while twenty-eight either changed positively or remained unchanged with respect to nasal resonance. A single subject showed no change, and another demonstrated a deterioration in articulation skills following surgery. Seven noncleft patients with articulation errors demonstrated a positive shift in oral articulation skills, four showed a slight deterioration in velopharyngeal closure status, and two had a negligible change in nasal resonance. The overall data indicate that oral articulation did change positively following maxillary advancement surgery, but velopharyngeal closure for speech was adversely affected in many cases for both cleft and noncleft persons.

Glass, Knapp, and Bloomer[7] studied the articulation, lingual diadochokinesis, and swallowing behavior of five adult subjects who underwent surgical treatment for mandibular prognathism. Evaluations were conducted on the day before surgery and 8 weeks postoperatively. The articulation task dealt exclusively with the /s/ speech sound, and postoperatively all subjects showed a decrease in /s/ distortions from preoperative levels. Despite the positive change in /s/ articulations, maladaptive lingual diadochokinetic behavior increased. The discrepancy between the articulation task and the diadochokinetic task is difficult to explain since the /s/ sound, along with the /t/, /n/, and /l/, was included in the latter task. The authors thought that the increase in maladaptive lingual diadochokinetic behavior might be due to the absence of placement cues that were present in the former oral environments of each patient. As the postoperative evaluation was conducted a short time after the release of maxillomandibular fixation, the discrepancy may have resolved with time.

Goldsmith and associates[11] studied articulation in seven patients who exhibited various forms of verti-

cal, horizontal, and lateral facial disproportions. The subjects ranged in age from 14 to 23 years, and six of the seven also presented an open-bite component. Preoperatively and 9 to 18 months postoperatively, all subjects underwent speech evaluation with videofluoroscopy during speech, blowing, whistling, and swallowing tasks. Results indicated very little change in status following orthognathic surgery. Three subjects displayed preoperative lingual protrusion and lisp, which remained unaltered. An additional subject had a "slight" lingual protrusion, which improved following surgery. No changes were reported in the swallowing behavior of any subjects.

The largest sample of patients (forty-one) undergoing orthognathic surgery and speech study was reported by Witzel and her associates.[3] Twenty-nine patients displayed retrognathia, and seventeen of the twenty-nine also had an open bite. Eleven patients had prognathism, with seven of them displaying open bite. One had open bite only. The articulation of each subject was evaluated "live" just prior to and 6 months after surgical intervention.

The presurgery evaluations indicated that twenty-two patients, or just over 50 percent of the total population, displayed articulation errors. Sibilant problems were found in all misarticulating subjects. In addition, Witzel and colleagues found errors with bilabial sounds in subjects who had retrognathia and labiodental errors in the prognathic group. Following surgery, the articulation status of the group improved significantly. A total of thirty-three patients earned maximal scores on the articulation test, as compared with a preoperative figure of nineteen subjects. Within the group of thirty-three subjects, fourteen had exhibited preoperative errors. The remaining eight subjects also improved, but the improvement was incomplete.

Garber, Speidel, and Marse[12] studied the articulation skills of six patients before and after surgical correction of maxillary prognathism. Their experimental design included postsurgical sampling at intervals of 5 to 7 days, 1 month, 3 months, 6 months, and 1 year following splint removal. Patients had their speech evaluated under conditions of quiet and noise. The latter condition consisted of 90-decibel sound pressure level speech noise presented bilaterally. Group performance graphs indicated articulatory production errors prior to surgery; however, the status of individual subjects was not reported. The mean number of errors in both the quiet and noise conditions during reading increased immediately following surgery but decreased to presurgical levels at the 1-month testing period. At subsequent testing periods, modest decrements in the average number of articulation errors were noted. Despite a similar trend across sampling periods, the magnitude of the errors was greater in the noise condition. Normalcy ratings of the patients' spontaneous speech in quiet and noise showed a pattern similar to that found with the reading tasks. There was an increase in the severity rating just after surgery, followed by a return to presurgical levels, and then further drops at latter sampling points. The authors indicated that most errors were of the distortion type, and the overall speech of each subject was not severely impaired preoperatively.

The final study in this series was undertaken by us[13] and included twenty subjects with various skeletal deformities. We classified subjects' deformities on the basis of horizontal or vertical relationships of the jaws. There were three patients in whom anteroposterior discrepancies of the maxilla were greater than those of the mandible (Class II) and eleven with the mandible greater than the maxilla (Class III). An additional four patients had vertical maxillary excess, and two presented facial asymmetry. All subjects underwent speech evaluations before surgery, immediately following splint removal, and at 3- and 6-month intervals thereafter. A total of twelve subjects exhibited articulation errors before surgery. The initial preoperative error level of the group increased at the time of splint removal and then declined to levels that were below preoperative figures. Five of the twelve subjects demonstrating errors initially were free of any errors at the final testing period. An additional five subjects showed reductions in the number of postoperative errors, and two remained unchanged. Most of the recorded articulation errors were of the distortion type and generally involved the sibilant sound class.

DISCUSSION

The studies reviewed are heterogeneous with respect to a number of dependent and independent variables; however, there are some generalizations which can be made with regard to the questions posed earlier. Table I presents a composite summary that lists each study along with additional identifying information. Perusal of Table I shows that almost all of the investigations contained subjects with preoperative misarticulations. The percentage figures ranged from a low of 54% to a high of 100%. Note that the exact numbers of preoperative subjects showing articulation errors are not available from the study by Garber, Speidel, and Marse.[12] The Schwarz and Gruner[10] study included a large group of cleft palate patients. Nevertheless, if one collapses figures across studies, approximately 72% of those persons studied had preoperative articulation errors. It is evident from the reported data that persons with

Table I. Summary of investigations which have studied misarticulating subjects before and after orthognathic surgery

Investigators	*No. of subjects*	*Deformity*	*No. and % of subjects with preoperative misarticulations*	*Types of error*	*Postoperative status of subjects' articulation*		
					Positive change	*Unchanged*	*Negative change*
1. Goodstein, Copper, and Wallace (1974)	5	Mandibular prognathism	5 (100%)	Distortion, omission, substituion	2 (40%)	3 (60%)	
2. Turvey, Journot, and Epker (1976)	9	Open bite	8 (88%)	Substitution distortion	7 (88%)		1 (12%)
3. Schwarz and Gruner (1976)	40	Maxillary deficiencies	36 (90%)	Unknown	35 (97%)	1 (3%)	1*
4. Glass, Knapp, and Bloomer (1977)	5	Mandibular prognathism	5 (100%)	Distortion	5 (100%)		
5. Goldsmith et al. (1977)	7	Various deformities	4 (57%)	Substitution, distortion	1 (25%)	3 (75%)	
6. Witzel, Ross, and Munro (1980)	41	Mandibular retrognathia, prognathia, open bite	22 (54%)	Unknown	22 (100%)		
7. Garber, Speidel, and Marse (1981)	6	Maxillary prognathism	Unknown	Distortion	Yes†		
8. Ruscello, Tekieli, and Van Sickels (1983)	20	Maxillary and mandibular prognathism, vertical maxillary excess, facial asymmetry	12 (60%)	Distortion	10 (83%)	2 (17%)	

*The subject displaying a negative change showed no preoperative articulation errors.
†The number of subjects exhibiting a positive change is unknown.

occlusal defects do present errors of articulation; however, the relationship is not a simple one. That is, while a majority of the persons included in the cited studies did exhibit articulation errors, others undergoing orthognathic surgery did not.

The type of error most frequently reported was that of the distortion type. Sound-production errors are classified as distortions, substitution, and omission. The fact that distortions were most often reported suggests that subjects were attempting to produce various speech sounds but that the productions were not within acceptable phonetic boundaries. Since all subjects were in the adult age group, this would be expected. That is, in adults the phonemic systems had been established; consequently, errors are usually surface or phonetic in nature.

The most frequent speech-sound error across the investigations reviewed was the /s/ speech sound.[7, 9, 12, 13] The /s/ sound, a sibilant, is produced in the alveolar and front palatal area. Witzel, Ross, and Munro[3] noted errors in the production of sibilant sounds in patients with all types of occlusal defects. They suggested that adequate production of these sounds is very sensitive to a specific position of the tongue and accurate direction of the airstream over the teeth.

It is interesting that although the vast majority of subjects had articulation errors, some did not. This suggests that some kind of compensatory pattern is developed by these subjects. Subtelny and his associates[2, 14] conducted two investigations that examined the production of the /s/ speech sound in speakers with Class II, Division 1 malocclusions. In the later study, the experimental group contained thirty normal speakers with no occlusal problems, thirty-one normal speakers with malocclusion, and twenty defective /s/ speakers with malocclusion. Analysis of the measures indicated that speakers with normal speech and occlusion protruded the mandible slightly while producing /s/, and the incisors approximated an edge-to-edge relationship. On the horizontal plane, the tongue tip was positioned posterior to the lower incisors; vertically, the tip was either elevated above the lower incisors or below the level of the lower incisal edges.

Comparison of a group with normal speech and occlusion with the Class II patients revealed a number of significant differences. The normal speakers with malocclusion retruded rather than protruded their mandibles during /s/ production. They also showed tongue retrusion, which appeared to be in conjunction with the mandibular adjustment. The defective speakers with malocclusion protruded their tongues beyond the lower incisors; the tongue tip was positioned approximate to the lingual surface of the upper incisors.

In contrast to the previous study, Guay, Maxwell,

and Beecher[15] presented data which indicated that there may be anatomic limits to the use of successful compensatory movements. The investigators examined /s/ production in twelve patients with Class III malocclusion. Eleven of the twelve subjects misarticulated the /s/ sound as assessed through words and conversation. Cephalometric radiographs were taken at rest and during prolongation of the /s/ sound. Measurements were made and then compared with data that had been reported by Subtelny, Mestre, and Subtelny.[14] During /s/ production, subjects retruded the tongue, tended to depress the mandible significantly, and showed a larger than normal distance between the tip of the tongue and the anterior mandibular dentition. The authors believed that the tongue retrusion represented an effort to achieve a more normal relation between the tip of the tongue and the anterior maxillary dentition. There was no indication that the normal /s/ speaker behaved differently from the pattern reported by Guay and his colleagues. The investigators thought that the difference between their findings and those of the Subtelny group could be explained on the basis of anatomic differences. In the Class II patients, compensation could be used successfully, whereas the presenting condition of the Class III patients prevented successful compensation.

It appears, then, that some persons with facial deformities do have the ability to develop compensatory patterns of articulation in the production of certain speech sounds. The study reported by Guay, Beecher, and Maxwell[15] revealed compensatory behavior which was not successful for speakers with Class III malocclusion. That is, compensations were noted but the sound was produced incorrectly. They felt that there were anatomic constraints in the Class III patients. There may be a threshold in this deformity type wherein compensation cannot be used in an effective manner.

Finally, if subjects with dentofacial deformities do present with articulation errors, will surgery that normalizes the facial bones improve the abnormal speech? In the studies reviewed, most subjects with preoperative misarticulations either eliminated their errors completely or demonstrated substantial reductions in the number of errors. Collapsing data across studies in which numbers are available, we found that 88% of the patients with preoperative errors showed a positive change in their articulatory performance. The relatively high percentage indicates that orthognathic surgery does result in improved articulation. The overall figures are also impressive, since subjects studied across investigations were extremely heterogeneous with respect to type and severity of occlusal defect.

Approximately 12% of all subjects were found to be unchanged or showed some negative change postoperatively. Within this small subgroup, most were patients who did not show positive postoperative change but remained static. The one subject reported by Turvey, Journot, and Epker[9] displayed a postoperative increase in /s/ errors that was accompanied by partial relapse of a posterior crossbite. Schwarz and Gruner[10] reported that subjects' oral articulation skills declined, but the exact nature of the decline cannot be discerned. Following surgery none of the investigations found deteriorations in the speech of persons who spoke normally prior to the surgical procedures.

REFERENCES

1. Ewan WG: Aspects of speech and orthognathic surgery. *In* Lass NJ (ed): Speech and language, New York, 1980, Academic Press, Inc., pp. 239-298.
2. Subtelny JD, Subtelny JD: Malocclusion, speech, deglutition. Am J Orthod **48:** 685-697, 1962.
3. Witzel MA, Ross RB, Munro IR: Articulation before and after facial osteotomy. J Maxillo Fac Surg **8:** 195-202, 1980.
4. Ladefoged P: A course in phonetics, New York, 1982, Harcourt Brace Jovanovich, Inc.
5. Bloomer HH: Speech defects associated with dental malocclusions and related abnormalities. *In* Travis LE (editor): Handbook of speech pathology and audiology, New York, 1971, Appleton-Century-Crofts.
6. Shelton RL, Trier WC: Issues involved in the evaluation of velopharyngeal closure. Cleft Palate J **13:** 127-137, 1976.
7. Glass L, Knapp J, Bloomer HH: Speech and lingual behavior before and after mandibular osteotomy. J Oral Surg **35:** 104-112, 1977.
8. Goodstein DB, Cooper D, Wallace L: The effect on speech of surgery for correction of mandibular prognathism. ORAL SURG **37:** 846-849, 1974.
9. Turvey TA, Journot V, Epker N: Correction of anterior open bite deformity: a study of tongue function, speech changes, and stability. J Maxillofac Surg **4:** 93-102, 1976.
10. Schwarz C, Gruner F: Logopedic findings following advancement of the maxilla. J Maxillofac Surg **4:** 40-55, 1976.
11. Goldsmith DH, Berkman MD, Soprintzen RJ, Rothschild D, Trieger N: Functional adaptation of the speech and swallowing mechanism following surgical correction of dentofacial deformities, Abstract 145, Third International Cleft Palate Congress, Toronto, Canada, 1977.
12. Garber SR, Speidel TM, Marse G: The effects on speech of surgical premaxillary osteotomy. Am J Orthod 79: 54-62, 1981.
13. Ruscello DM, Tekieli ME, Van Sickels J: The effects of orthognathic surgery on speech production, paper 0457, mini-seminar presentation, American Speech-Language/Hearing Association, 1983.
14. Subtelny JD, Mestre JC, Subtelny JD: Comparative study of normal and defective articulation of /s/ as related to malocclusion and deglutition. J Speech Hear Disord **29:** 264-285, 1964.
15. Guay AG, Maxwell DL, Beecher R: A radiographic study of tongue posture at rest and during the phonation of /s/ in Class III malocclusion. Angle Orthod **48:** 10-11, 1978.

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