

THE EFFECTS OF MANDIBULAR OSTEOTOMY ON ARTICULATION AND RESONANCE

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SUMMARY

Pre- and post-operative speech samples were studied in nine adult cases who received mandibular osteotomy. Lateral cephalograms were taken during sustained production of selected sounds and trained listeners judged recordings. In most cases there was an improvement in the general quality of the speech. Considering that the functional relationships between the speech organs had altered, it would appear that some form of adaptation by the speaker had in fact taken place.

OPSOMMING

Pre- en postoperatiewe spraakvoorbeelde is bestudeer van nege volwasse gevalle wat mandibulêre osteotomie ondergaan het. Laterale kefalogramme is geneem tydens die volgehoue produksie van sekere klanke en opgeleide luisteraars het opnames geëvalueer. In die meeste gevalle het die algemene kwaliteit van die spraak verbeter. Gesien dat die funksionele verhoudings tussen die spraakorgane verander het, wil dit voorkom asof adaptasie wel by die spreker plaasgevind het.

Surgical correction of prognathic and retrognathic conditions of the mandible is being undertaken with increasing frequency throughout the world. Mandibular osteotomy, in correcting an abnormal jaw relationship, brings about certain changes affecting the speech organs.

There is a modification in the relative positions of the structures of the oral cavity. These include the palate, tongue, teeth and lips, all of which are involved in articulation. An alteration also takes place in the dimensions of the oral cavity, as well as in the size and shape of the orifice, resulting from the change in position of the teeth and lips.

The aim of this study was to investigate the effects of mandibular osteotomy on those speech parameters which are functions of the supralaryngeal cavities, namely articulation and resonance. Although many maxillo-facial and oral surgeons have commented on the improvement of speech in their patients after correction of an abnormal jaw relationship,^{4 7 9 11} few controlled studies have been published.

Goodstein et al³ studied five persons with mandibular prognathism, all of whom had deviant articulation. They found no significant change in the articulation of their subjects after mandibular osteotomy, but reported that voice quality improved.

METHOD

Nine adults requiring mandibular osteotomy for the correction of a malrelationship between the maxilla and the mandible were studied. Two patients had received speech therapy during childhood for defective production of /s/, but without success.

As research has indicated a direct relationship between the physiological processes of articulation and the acoustic properties of the sound produced,² both of these aspects were investigated.

AUDITORY ACOUSTIC INVESTIGATION

A comparison was made between a pre-operative speech sample and a post-operative speech sample in each case. Two short passages were selected, one in English and the other in Afrikaans, containing all the phonemes of the language concerned. Each subject was required to read the passage in his mother tongue. The post-operative speech evaluations were made between three and eleven months after the operation, the average time lapse being five-and-a-half months, thus ensuring complete recovery of the inferior alveolar nerve, recovery of mandibular movement and allowing the patients sufficient time to adjust to the altered structures so that their speech patterns could be considered stable.

Evaluations of the speech samples were made by five trained listeners. The recordings of each subject were played consecutively to facilitate comparison, but were presented in a random order with regard to pre-operative and post-operative speech in order to prevent possible bias in the judgement. The listeners were asked to make comparative intrasubject judgements with regard to the articulation of the different sounds, paying particular attention to the production of /s/ as the accuracy of this sound is so readily disturbed by any dental irregularity.⁶ The listeners were also asked to consider any additional factors, such as resonance, and projection and quality of the voice.

PHYSIOLOGICAL INVESTIGATION

The place of articulation was studied by means of radiography. As cinefluorography was not available, lateral cephalograms were made during the sustained production of selected speech sounds. A narrow strip of Ray-Tec gauze, approximately 25 mm in length, was placed on the anterior section of the hard palate and another on the anterior part of the tongue, with the radiopaque thread running along the midline of each organ. A thin film of orabase paste was applied to the gauze to ensure adherence to the contours of the palate and tongue during articulation. In the case of English-speaking subjects, the sounds chosen were /θ, s, l, i/; in the case of Afrikaans-speaking subjects /s, l, i/. In analysing the cephalograms, attention was paid to the salient points regarding the relationships of the organs.¹⁰ The following measurements were taken for the consonants /θ, s, l/:-

- A The distance between the upper and lower incisors on a horizontal plane. Where a reversed relationship occurred, with the lower incisors anterior to the upper incisors, the distance is expressed as a minus quantity.
- B The distance between the upper and lower incisors on a vertical plane. Where the incisal edge of the lower teeth was superior to that of the upper teeth, the distance is expressed as a minus quantity.
- C The distance, on a horizontal plane, posterior to the cutting edge of the upper anterior incisors, of the narrowest point of the constriction. Where this point was doubtful or difficult to determine, the mid-point of the constriction was used.⁸

For the vowel /i/ the horizontal and vertical distances between the upper and lower incisors were noted in the same way. The place of articulation was more difficult to evaluate as, in some cases, the highest point of the tongue was too far posterior to be marked on the cephalogram. To obtain an idea of the configuration and position of the tongue, the width of the air channel was measured (i.e. the distance between the palate and the tongue) at the following set points posterior to the upper anterior incisors:

- D 10 mm
- E 15 mm
- F 20 mm

RESULTS

Measurements obtained in the analysis of the cephalograms are given in Table I.

Important points relating to the cephalograms and the listener judgements will be mentioned in individual cases. A comparison of the articulation of /s/ as produced pre-operatively and post-operatively by all subjects, on both the auditory acoustic level and the physiological level, may be found in Table II. The general quality of the speech is also indicated.

Prior to surgery, Case 7 sometimes held the mandible in a forward position when speaking, claiming that she found this more comfortable. An additional cephalogram was taken pre-operatively, viz. of the articulation of /s/ with the mandible in the forward position.

In Cases 1, 8 and 9 the sound /l/ was exaggerated when produced in isolation. As it was felt not to be a true reflection of that person's speech, those tracings were not analysed.

PROGNATHIC MANDIBLE

Case 1

Cephalograms: The sounds were dentalized pre-operatively. Post-operatively, the articulation was modified in accordance with the change in the mandible, and the sounds remained dentalized.

Listener judgement: Both pre-operatively and post-operatively the articulation sounded further forward than normal.

Jaw relationship pre-operatively	Case	Distance mandible moved	Cephalometric tracing																										
			Sound			/s/			/z/			/l/			/i/			/a/											
			A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C									
Prognathic mandible	1	10	1	3	0	-2	0	1	7	1	4	-4	-4	7	-7	-1,5	15	-4	3	11	-3	4	6	6,5	0,5	6	3	2	2
	3	18				5	-2	20	5,5	2	10	6,5	0,5	6	3	11	-3	4	6	5,5	10	3	2						
	4	8				0	1	15	0	6	11	0	1,5	5	3,5	3	5	3	3,5	3	5	3	5						
	5	5				-1	-3	12	0	10	5	-2	13	1	2	3	3	4	12	5	-2	13	1	2	3	3			
	6	10				2	1	11	2	7	4	2,5	6	3	4	2,5	6	3,5	3	4	2,5	6	3,5	3	4	9	9		
	7	5				0	2	8	8	11	7	13	16	8	9	9	9	5	1,5	3	7	*	*						
Retrognathic mandible						11	-7	11	15	0	10	11	-5	4	4,5														
	5					3,5	-2	7,5																					
Prognathic maxilla						2,5	-2	7	5	0	7	3	-1	6	5	6	6												
	8	-				4	-6	9				7	-4	6	5	3	3												
Facial asymmetry						3	-3	4				8	2,5	5	*	*	*												
	9	-				6	2	8	3	1	9,5	*	*	*	*	*	*												

All measurements are given in mm
 * This measurement could not be made as the radiopaque marking is unclear in this area

TABLE I. Analysis of Cephalograms

Case 2

Cephalograms: This case was excluded from the cephalometric investigation as he wore a partial denture which was constructed from radiopaque material, with the result that the outlines of the tongue and palate could not be visualized on X-ray.

Listener judgement: In the pre-operative recording /s/ and /r/ were defective and the consonant clusters were indistinct. In the post-operative recording both the accuracy of articulation and the quality of speech were much improved.

Case 3

Cephalograms: Pre-operatively the constriction for /s/ was pre-palatal. Post-operatively there was a change in tongue position, corresponding to that of the mandibular teeth.

Jaw relationship pre-operatively	Case /s/	Judgement of listeners		Cephalogram of /s/	
		Articulation of /s/	General quality of speech	Place of articulation adjusted in accordance with altered jaw position	Adjustment in tongue posture
Prognathic mandible	1	Remained defective	No change	Yes	No
	2	Improved	Improved	—	—
	3	Remained defective	Improved	Yes	No
	4	Remained acceptable	Improved	No	Slight
	5	Remained acceptable	Deteriorated	No	No
	6	Remained defective	Improved	Slightly	Yes
Retrognathic mandible	7	Remained defective	Deteriorated	Yes	No
Prognathic maxilla	8	Improved	Improved	Yes	Yes
Facial asymmetry	9	Remained defective	No change	No, but no significant anatomical change	No

TABLE II Listener judgement and cephalograms for pre- and post-operative production of /s/.

Listener judgement: In the pre-operative recording the mid-alveolar sounds sounded pre-palatal. Post-operatively the /s/ segment remained deviant, but the speech was generally "pleasing".

Case 4

Cephalograms: The place of articulation remained the same post-operatively as pre-operatively, but slight variations occurred e.g. narrower constriction for /s/.

Listener judgement: Articulation was good on both recordings. Post-operatively the resonance was greatly improved.

Case 5

Cephalograms: The place of articulation was virtually unchanged post-operatively in spite of the alteration in the jaw relationship.

Listener judgement: Articulation was good in both recordings, but resonance was poorer post-operatively.

Case 6

Cephalograms: Both pre- and post-operatively the constriction for /s/ occurred anterior to the usual position.

Listener judgement: With regard to articulation the /s/ was felt to be deviant in both recordings. The speech was generally better post-operatively, however.

Of the six patients who underwent surgery to correct a prognathic mandible, it may be seen that four distorted /s/ pre-operatively. Post-operatively, three of them altered the place of constriction for the sound in accordance with the changed mandibular position. In the case of the subject who produced an acceptable /s/ post-operatively, the position of the constriction in relation to the maxillary incisors was maintained. The place of constriction in relation to the maxilla remained constant in the remaining two cases, who produced /s/ correctly both pre-operatively and post-operatively. In one case, however, a slight adjustment in tongue posture occurred, so that a narrower constriction was formed for /s/.

The general quality of speech was maintained or improved in most cases.

RETROGNATHIC MANDIBLE

Case 7

Cephalograms: In the pre-operative cephalogram with the mandible held in a forward position, and in the post-operative cephalogram there was an extremely small orifice for the escape of air on /s/.

Listener judgement: Resonance was found to be best pre-operatively with the mandible in the natural position. The /s/ was defective in all the recordings.

There was only one subject with a retrognathic mandible. Her articulation remained the same but the general quality of her speech deteriorated post-operatively.

PROGNATHIC MAXILLA

Case 8

Cephalograms: Pre-operatively, for the production of /s/, the lower incisors are in contact with the upper alveolar ridge. The tongue humps considerably at the point of constriction and then drops sharply anterior to this, probably to form a channel of sufficient width to conduct the air stream. Post-operatively the mandibular incisors are in a lower position and there is thus more space behind the upper incisors and adjacent alveolar ridge. Articulation takes place in a more anterior position and the superior surface of the tongue is flatter, with a gentle rise to form the constriction.

Listener judgement: /s/ is deviant pre-operatively, but improved post-operatively. The speech generally and in particular the quality of the voice, is better post-operatively.

Following the operation in this case, the articulation of /s/ was improved by an adjustment in the place of articulation, in addition to modification of the configuration of the tongue.

FACIAL ASYMMETRY

Case 9

Cephalograms: The operation resulted in a comparatively small change in the relation of the lower teeth to the upper teeth. The articulation of /s/ occurred far forward in the mouth in both cases.

Listener judgement: The /s/ was deviant at times both pre-operatively and post-operatively. There was no significant difference in speech between the two recordings.

With no significant anatomical change produced surgically, there was no change in articulation or resonance of this subject's speech.

DISCUSSION AND CONCLUSIONS

Post-operatively, the anatomical structures are such that the person may have the potential for normal speech. The acoustic impression of his speech, however, will be determined by the complexity of muscular movements which he makes in relation to his oral morphology.¹ In the limited number of subjects studied, certain effects on articulation and resonance were observed.

In most cases there was an improvement in the general quality of the speech, which may be attributed to the creation of a more favourable oral environment for optimal resonance. This substantiates the finding that an increase of space between the dorsum of the tongue and the palate brings about a corresponding increase in the carrying power of the voice.⁵ Pre-operatively the relationship between the jaws is such that the orifice of the mouth is basically on a horizontal plane. In the post-operative state, there is a greater space between the maxillary and mandibular teeth in the vertical dimension, through which speech may be emitted.

In the subject with the retrognathic mandible the general quality of speech deteriorated post-operatively. Surgery included a myotomy of the anterior digastricus and the geniohyoid muscles, and the possibility of the deterioration of speech quality being related to a muscular change in the posture or support of the tongue warrants further investigation.

With regard to articulation, when the place of production of the sound was adjusted in accordance with the new position of the teeth and jaw, no change occurred in the acoustic properties. Such a change did occur, however, when the place of production was adjusted and, in addition, the posture of the tongue was modified. When the place of production remained the same, the acoustic properties of the sound changed. In view of the alteration of the jaw relationship, the maintenance of the place of articulation implies a marked change in the functional relationship between the speech organs.

Adjustments made by the speaker in adapting to the alteration in the oral morphology will either facilitate or restrict any changes perceived in his speech. The effects of oral surgery on the speech of the individual can therefore not be predetermined, and any generalizations should be made with caution.

Certain implications arise with regard to speech therapy for articulatory defects in persons with an abnormal jaw relationship. While defective articulation might be related to such an anomaly, surgical correction of the malrelationship will not necessarily result in normal articulation. This may be accounted for by the habitual patterns of muscular movements, maintained by the characteristic functioning of the various feedback systems of the individual. In two cases, where speech therapy was attempted prior to surgery, it was not successful. Although this aspect was not included in the present investigation, it is suggested that the better functional relationship between the structures of the oral cavity post-operatively, may facilitate treatment.

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