Mentalis and orbicularis oris activity in children with incompetent lips

An electromyographic and cephalometric study

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In order to study the function and the level of activity of the mentalis and the orbicularis oris superior muscles in subjects with different lip morphology, an electromyographic investigation was carried out on ten children with normal lip position (competent lips) and ten children with lip incompetence. The underlying skeletal and dentoalveolar morphology was studied by cephalometrics. All the children had malocclusions, but had received no orthodontic treatment. It was found that a relaxed lip position with no EMG activity could be taken up by all the children in both groups. Lip closure, mastication, and swallowing were performed with a significantly greater activity in subjects exhibiting lip incompetence than in those with normal lip position. The analysis of cephalometric values in relation to lip posture and perioral muscle activity showed that subjects with incompetent lips and increased perioral muscle activity had great lower anterior face height, high mandibular plane angle, postnormal skeletal jaw relation, and increased lower incisor proclination.

Key-words: Electromyography; cephalometry

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The influence of perioral musculature on the position of the teeth has been widely discussed in the orthodontic literature, but as yet no definite answers are available (*Lear & Moorrees*, 1964; *Proffit*, 1975). We know, for instance, very little of the significance of incompetent lips to malocclusion and retention of orthodontically treated cases. Some important research has been carried out but no conformity of opinion exists. *Marx* (1965) has made an electromyographic comparison of individuals with competent and incompetent lips. The recordings in the resting posture from m mentalis and m orbicularis oris superior revealed a greater activity on a significant level in subjects with lip incompetence. As to incisor inclination Marx's results indicated association between upper proclination — increased activity in the lips and mentalis, and lower proclination — increased activity in the lower lip and mentalis. Reduced muscle activity coincided with incisor retroclination. *Møller* (1966) has drawn the same conclusion in his thesis. A positive correlation between retroclined lower incisors and the activity from upper and lower lips was thus found. *Ahlgren, Ingervall & Thilander* (1973) have investigated lip

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activity in normal and postnormal occlusion during various functions. They found a lower activity of the upper lip during chewing in the postnormal group with proclined maxillary incisors. There was however no such correlation to be found during deglutition. The resting activity of the upper lip was higher in the postnormal group.

In incompetent lip-cases one would, however, like to know more precisely whether the resting and functioning activity of the orbicularis oris and mentalis is abnormal. Intriguing seems also the relation of the lip-mentalis function to morphology.

The purpose of this study was to analyse the activity of the orbicularis oris and mentalis muscles in subjects with incompetent lips and to correlate this activity to dento-facial morphology.

MATERIAL AND METHOD

The selection of patients was made from subjects with malocclusion, who had not yet received any orthodondic treatment. The sample consisted of 10 cases with competent lips (Group I) and 10 cases exhibiting lip incompetence (Group II). The criteria for Group I were that the lips could be brought into contact without discernible muscle contraction in the mentalis area. Lip incompetence was diagnosed in those cases where lip closure was accompanied by a distinct contraction of the mentalis muscle manifested by dimpling in the skin of the chin.

Of the 20 children preliminarily selected for the study 3 were excluded, 2 because of difficulties in accurate diagnosis and 1 because of mandibular deviation due to cusp interference, which would complicate the assessment of the EMG recording during chewing and swallowing. Those 3 patients were replaced by 3 others. Age, sex and malocclusion distributions are described in Table I.

The electromyograms were taken with a Mingograf 800. It was equipped with eight channels, four channels for direct recordings and four channels for integrated recordings. The integrators (EMT 43 B) were constructed to integrate the activity during a fixed time period (for this investigation 0.05 sec) so called epoque integration. The total activity of the EMG pattern was recorded as a summation of the included epoque values. The largest epoque value during a contraction was recorded as the peak maximal activity of the EMG. Surface electrodes in the form of rectangular tin plates (13 × 6.5 mm) were taped on the skin in a bipolar arrangement. The distance between the two electrodes was 10 mm. For the recordings from the mentalis muscle the electrodes were placed over the most prominent part of the chin and symmetrically in relation to the midline of the face. This symmetric arrangement was also used for the superior orbicularis oris muscle. The positions of the electrodes for recordings from the masseter muscles were determined with reference to the gonial angle according to Fig. 1. To reduce the impedance of the skin the sites for the electrodes were cleansed with alcohol and electrode paste was used. Ground leads were attached to each ear lobe. Paper speed was 50 mm/sec. During the following postures and functions recordings were made:

1. Relaxed lip position, calibration 100 μV/cm.
2. Lips closed, calibration 100 μV/cm.
3. Swallowing, calibration 100, 200 or 500 μV/cm.
4. Chewing, calibration 500 μV/cm.

Table I. *Distribution of the cases according to age, sex and malocclusion*

Subject groups	Mean age	Sex		Malocclusion I	II : 1	II : 2	Open bite	Mean overjet	Mean overbite
Competent lips (I)	12.1	5♂	5♀	5	3	1	0	4.0	3.4
Incompetent lips (II)	12.0	5♂	5♀	2	8	0	1	5.5	2.6

The integrated EMG were measured to the nearest 0.5 mm, and the total and maximal (peak) muscle activity was calculated from these measurements. The activity with closed lips was measured during one second from five separate passages and the mean value was used in the analysis. EMG recordings for five swallowings and five chewing cycles were also selected from each patient and the mean values were used accordingly.

A swallowing act was by definition started by the first sign of increase in muscle activity and finished by decrease to normal level of the direct EMG curve. A chewing cycle was defined as the opening and closing phase of the mandible during mastication. Points and reference lines used in the cephalometric analysis are shown in Fig. 2.

Statistical methods. Differences between the two groups were tested with the Wilcoxon Test. Correlations between muscle activity and cephalometric values were measured with the Spearman rank order correlation coefficient (rho).

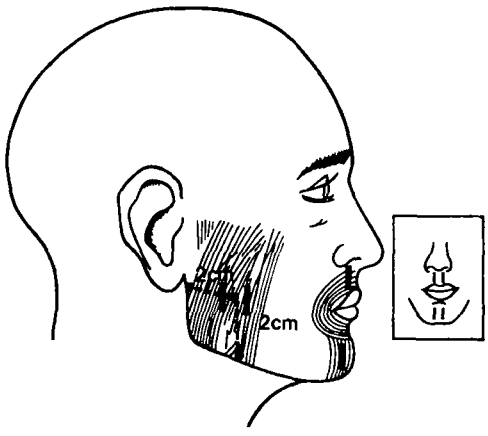

Fig. 1. Diagram of standardized positions of electrodes.

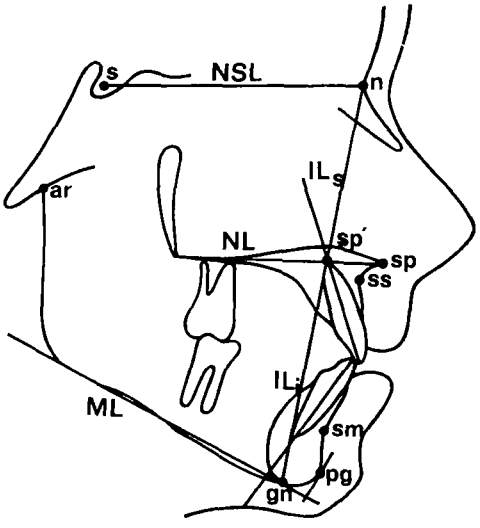

Fig. 2. Reference points and lines in cephalometric analysis.

RESULTS

EMG analysis

Muscle activity, relaxed lips. In both groups it was possible to record a completely relaxed lip position with no EMG activity. In this position the lips were closed (in some just slightly separated) in the competent lip group, but separated in the group with incompetent lips.

Table II. *Integrated EMG activity, maximal and total epoque values (μVs)*) during lip closure Group I: competent lips (n=10). Group II: incompetent lips (n=10)*

	Maximal					Total				
	Group I		Group II			Group I		Group II		
Muscle	$\bar{x}$	S.D.	$\bar{x}$	S.D.	p	$\bar{x}$	S.D.	$\bar{x}$	S.D.	p
Mentalis	0.1	0.9	13.2	12.2	<0.01	9.3	8.4	155.1	149.0	<0.01
Orb oris sup	0.1	0.2	2.0	3.7	<0.05	0.4	0.8	12.0	18.2	<0.05

*) To calculate the amplitude values in μV the epoque values have to be multiplied with 20

Table III. *Integrated EMG activity, maximal and total epoque values (μVs)*) during deglutition Group I: competent lips (n=10). Group II: incompetent lips (n=10)*

	Maximal					Total				
	Group I		Group II			Group I		Group II		
Muscle	$\bar{x}$	S.D.	$\bar{x}$	S.D.	p	$\bar{x}$	S.D.	$\bar{x}$	S.D.	p
Mentalis	2.1	1.2	27.0	14.6	<0.01	10.8	8.6	265.1	159.1	<0.01
Orb oris sup	0.3	0.4	8.2	4.9	<0.01	1.0	2.1	49.9	52.1	<0.01
Masseter	2.3	2.3	3.9	2.5	n.s.	12.2	11.3	17.0	10.0	n.s.

*) To calculate the amplitude values in μV the epoque values have to be multiplied with 20

Table IV. *Integrated EMG activity, maximal and total epoque values (μVs)*) during mastication Group I: competent lips (n=10). Group II: incompetent lips (n=10)*

	Maximal					Total				
	Group I		Group II			Group I		Group II		
Muscle	$\bar{x}$	S.D.	x	S.D.	p	$\bar{x}$	S.D.	$\bar{x}$	S.D.	p
Mentalis	29.8	12.5	47.7	18.1	n.s.	90.9	37.3	252.7	156.2	<0.01
Orb oris sup	2.7	1.5	6.2	2.5	<0.01	6.9	3.9	25.1	16.6	<0.05
Masseter	10.2	9.3	10.4	10.3	n.s.	30.4	29.1	23.8	17.5	n.s.

*) To calculate the amplitude values in μV the epoque values have to be multiplied with 20

Muscle activity, with lips closed. From the recordings during lip closure it was obvious that in patients with incompetent lips the EMG activity was much greater than in patients with competent lips (Table II) (Fig. 3). The integrated EMG activity showed statistically significant differences for both mentalis and orbicularis oris superior.

In the group of patients with incompetent lips there was a great range of variation in perioral activity. Normal lip closure on the other hand appeared as a more stable pattern, i.e. the range of variation as seen by EMG was much smaller. In 8 cases there was no integrated EMG activity recorded from orbicularis oris superior. Conversely, there was a slight increase in mentalis activity in most cases of competent lips.

Muscle activity, deglutition. The swallowing act was performed at a significantly higher level of activity in the upper lip and mentalis in the group with incompetent lips (Table III) (Fig. 4). Six out of the subjects in Group I (competent lips)

showed no discernible integrated EMG activity from orbicularis oris superior and the ranges of variation made it obvious that the subjects with competent lips constituted a more homogeneous group than those with incompetent lips. The variations from the mean values were for the two perioral muscles much greater in Group II. The mean values for the masseter muscles showed a greater activity for Group II. There was, however, no statistically significant difference.

Muscle activity, mastication. The lip-mentalis activity during chewing differed significantly between the groups (Table IV) (Fig. 5). During the opening phase an increased perioral and mentalis activity was recorded in both groups, but the maximal and total activity recorded from incompetent lips was significantly greater, due to the fact that their activity was rather considerable even during the closing phase. The masseter muscle activity during a chewing cycle was greater in Group I, but not on a statistically significant level.

Cephalometric analysis

The linear and angular measurements of interest are given in Table V. Four statistically significant differences between the two groups were found. The distance incision inferius (incisal edge of the lower incisors) to the line nasion — supramentale was greater in cases with incompetent lips. In the same group of subjects the angles for the mandibular plane to the nasion-sellaline (NSL/ML) and to the nasal plane (NL/ML) were increased, indicating a greater anterior height of the face, especially the lower anterior height. The anterio-posterior relation between the jaws was judged by the angle ANB (ss—n—sm). This angle was larger in conjunction with incompetent

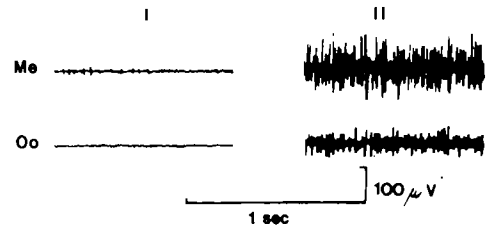

Fig. 3. Electromyograms during lip closure. I: = Competent lips. II: = Incompetent lips Me = Mentalis muscle. O.o = Orbicularis oris muscle.

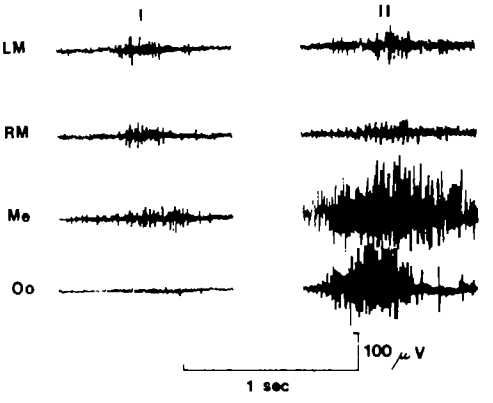

Fig. 4. Electromyograms during deglutition. I: = Competent lips. II: Incompetent lips. LM = Left masseter muscle. RM:= Right masseter muscle. Me = Mentalis muscle O.o = Orbicularis oris muscle.

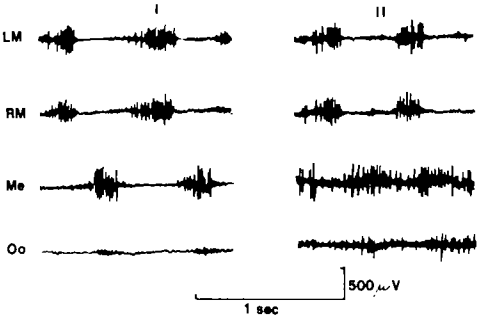

Fig. 5. Electromyograms during mastication. I: = Competent lips. II: = Incompetent lips. LM = Left masseter muscle. RM = Right masseter muscle. Me = Mentalis muscle. O.o = Orbicularis muscle.

Table V. *Cephalometric values (distances in mm, angles in degrees)*
Group I: competent lips (n = 10). Group II: incompetent lips (n = 10)

Variable	Group I $\bar{x}$	S.D.	Group II $\bar{x}$	S.D.	Level of significance
ss—n—sm (ANB)	3.2	1.5	5.6	1.1	$p < 0.01$
NSL/ML	30.2	4.6	36.5	5.4	$p < 0.05$
NL/ML	23.2	3.7	29.9	4.3	$p < 0.01$
ML/pg—sm	63.9	3.4	63.8	4.9	n.s.
$\frac{n—sp' \times 100}{sp'—gn}$	91.4	6.4	86.4	6.5	n.s.
IL_s/NL	108.1	7.4	110,0	5.7	n.s.
IL_i/ML	96.6	6.9	98.3	5.2	n.s.
is nss(mm)	3.6	2.6	4.3	2.1	n.s.
ii—nsm(mm)	3.4	2.3	5.9	1.8	$p < 0.05$

lips (5.6° compared with 3.2°). In our sample there was obviously a tendency for skeletal discrepancy in subjects exhibiting abnormal lip posture.

EMG-cephalometric correlations

Some of the cephalometric values were found to be significantly correlated to perioral muscle activity during lip closure, deglutition and mastication (Table VI). The angle between the nasion-sella-line and the mandibular plane (NSL/ML) showed a positive correlation to mentalis and orbicularis oris activity. The correlation coefficients (rho) for the angle between the nasal and mandibular planes (NL/ML) to muscle activity were higher for all the recorded functions than for the angle NSL/ML: Significance at beyond the five per cent level of confidence occurred in all but one instance, viz the correlation NL/ML to mentalis activity during mastication. The analysis of the ratio between upper and lower anterior height of the face $\frac{(n—sp')}{sp'—gn}$ and its relation to muscle activity produced negative rho-values, all of which were significant for the mentalis muscle.

Various degrees of positive correlations were found between the ANB angle and muscle activity. An increased disharmony in the antero-posterior relation between the jaws is accompanied by an increased muscle activity. As to incisor positions the cephalometric values were mainly correlated to muscle activity with positive coefficients, i.e. there was a tendency that proclination of the incisors required greater muscle activity to accomplish accurate lip functions. However, the only

Table VI. *Correlation coefficients (rho) between integrated muscle activity and cephalometric values*

Variable	Mentalis			Orb oris sup		
	closed lips	deglutition	mastication	closed lips	deglutition	mastication
ss—n—sm (ANB)	0.49*	0.62**	0.61**	0.44	0.65**	0.29
NSL/ML	0.41	0.49	0.41	0.37	0.54	0.38
NL/ML	0.49*	0.56*	0.44	0.46*	0.65**	0.58*
ML/pg—sm	—0.13	—0.10	—0.10	0.17	—0.09	—0.09
$\frac{n—sp' \times 100}{sp'—gn}$	—0.47*	—0.59**	—0.56*	—0.26	—0.35	—0.11
IL_s/NL	0.20	0.25	0.18	0.02	—0.01	0.24
IL_i/ML	0.10	0.09	0.19	0.05	—0.03	0.15
i_s—nss	0.25	0.21	0.13	0.14	0.09	0.31
i_i—nsm	0.38	0.50*	0.47*	0.19	0.31	0.00

significant correlations were between mentalis activity during swallowing and mastication and the distance incision inferius to the line nasionsupramentale (ii—nsm).

DISCUSSION

It is generally agreed that assessment of perioral muscle function and lip posture is of great importance in orthodontic treatment and certainly for avoiding relapse. Concerning etiology of malocclusions, the effect of surrounding soft tissues is a controversial subject. The technique of recording muscle activity with electromyography is nowadays well established and tested, and the possible errors of the method, such as placement of electrodes and intraindividual variation in muscle activity from time to time, have been thoroughly described (*Ahlgren*, 1966; *Møller*, 1966). Thus it is possible to use quantitative methods and to make comparisons between groups of individuals regarding coordination and activity levels in several masticatory and mimic muscles.

Electromyographic investigations have shown that in the majority of children there is perioral muscle activity during lip contact. This implies that a great number of subjects have electromyographically incompetent lips not possible to diagnose in clinic (*Nieberg*, 1960; *Marx*, 1963, 1965). Our recordings from closed lips are in accordance with these findings as far as mentalis activity is concerned. On the other hand there were eight subjects in Group I and three subjects in Group II that were able to achieve lip seal without discernible activity in the upper lip. It is obvious that the principal muscle for lip closure is m mentalis. The significantly greater activity in both muscles for subjects with incompetent lips shows that the clinical diagnosis is confirmed by EMG.

It was possible for all our patients to assume a true relaxed lip position, i.e. with no EMG activity.

Thus, as far as resting activity of the perioral muscles is concerned there was no difference between the two groups. This fact contradicts the results from *Marx*'s (1963, 1965) EMG recordings in the »resting posture», where the mentalis showed very marked activity in some cases with incompetent lips, even while these were held apart. Obviously there may be difficulties in obtaining complete rest in the circumoral muscle group just by encouraging the patient to relax.

As deglutition is usually performed with lip closure it was not unexpected to observe greater activity in incompetent lips. The differences between the two groups were however much greater for the recordings during swallowing than during gentle lip closure. Earlier investigations in this field have not attended to the aspects of lip incompetence, but rather analysed the various patterns of deglutition and their relations to the type of malocclusion. The two basic patterns of deglutition have been referred to as somatic (normal) swallowing characterized by marked masseter activity and small circumoral activity, and the visceral (abnormal) swallowing characterized by the opposite relations in muscle activity (*Tulley*, 1953; *Nieberg*, 1960; *Jacob*, *Haridas* & *Ammal*, 1971). In our material there was just one subject exhibiting tongue thrust deglutition. He was found in Group II and his recordings did not in any apparent way differ from the others with abnormal lip posture. It must be concluded that so called abnormal perioral contraction during swallowing is a common finding for individuals with incompetent lips regardless of tongue function.

The interpretation of our recordings

during mastication agrees with those of previous investigators (*Møller*, 1966; *Ahlgren, Ingervall & Thilander*, 1973). During the opening phase of the chewing cycle the increase in perioral activity was more distinct for the mentalis muscle than for the orbicularis oris muscle. Regarding the peak values for mentalis activity during opening there was no significant difference between the two groups. This finding may be explained by the fact that the lips were in contact during the entire act of chewing, and to maintain this contact during the opening phase a certain increase in mentalis activity was required even for competent lips. The total integrated activity of the chewing cycle on the other hand was much greater for subjects with incompetent lips, because they required contraction in the mentalis also during the closing phase. The same reasoning may be applied for the orbicularis oris muscle, though this muscle in most cases of competent lips appeared on a very low level of activity. Obviously, the lip contact is mainly supported by the mentalis muscle, but in subjects with lip incompetence the lack of adequate lip length is also compensated by an increased activity in the upper lip.

Regarding correlation between muscle activity and incisor positions some contradictory results have been reported (*Marx*, 1965; *Møller*, 1966; *Ahlgren, Ingervall & Thilander*, 1973). In the present investigation it was found that the lower incisors were significantly more protruded in conjunction with incompetent lips. In addition there was a significant positive correlation between mentalis activity and the distance ii—nsm. These findings seem to support *Marx*'s (1965) conclusion that reduced perioral muscle activity is associated with retroclined incisors. The explanation for this seemingly contradictory relationship may be that incompetent lips develop inadequate lip pressure during resting periods, the increased functional activity during short periods being of less significance. This view supports the concept that resting lip pressure is more important for determining tooth position than the functional activity of the lips during swallowing and mastication (*Lear & Moorrees*, 1964). On the other hand our results also seem to indicate that the inclination of incisors may be of secondary importance to perioral activity. The vertical relations of the jaws and the anterior face height seem to have a more decisive influence on the lip posture and consequently on the perioral muscle activity. This statement is based on the following results: (1) The cant of the mandibular plane (NSL/ML and NL/ML) was significantly steeper in Group II (2) NSL/ML and NL/ML were positively correlated to mentalis and orbicularis oris activity, (3) The anterior face height index showed a negative correlation to mentalis activity, i.e. the lower anterior face height was relatively greater in subjects with increased mentalis activity. A summary of previously reported results would certainly lead to the same conclusion expressed by *Rix* (1953): Parted lips at rest (incompetent lips) are not related to any particular incisor position and do not seem to have any direct adverse moulding effect upon the incisors.

Some evidence regarding association between antero-posterior jaw relation and perioral muscle activity have been reported. *Marx* (1965) found significantly greater mentalis activity in a group where the ANB angle exceeded 4° than in a group where this angle was 2—4°. Using occlusal classification according to Angle he demonstrated increased mentalis and

lip activity in Class II : 1 and decreased activity in Class II : 2 as compared with Class I. The only significant difference was however between Class I and Class II : 2 regarding mentalis activity in the habitual posture. *Schlossberg* (1956) found that the mentalis muscle in Class II subjects was more active that in Class I subjects. *Ahlgren, Ingervall & Thilander* (1973) noted that upper lip activity during swallowing was just as small in the normal group as in the postnormal group. In the present study it was found that the antero-posterior skeletal pattern (ANB) was extremely significant in relation to lip incompetence and perioral activity. However, as the incisor positions seemed to be of less importance (overjet was not correlated to muscle activity or lip incompetence) the type of malocclusion is apparently less interesting than the skeletal vertical and antero-posterior relations of the jaws. By multiple regression analysis *Norderval* (*Hasund et al.*, 1973) has developed a formula: ii—nsm = 0.51 (ANB) + 0.1 (NL—ML) + 0.07 N-angle*) —2.80. Consequently, if there are increased values for the angles ANB and NL/ML, one should expect more protruded lower incisors, which may explain our finding of a relationship between lower incisor proclination and perioral activity. Similarly, *Hovell* (1955) stated that the condition of incompetent lips is due essentially to a disproportion between the soft tissues and the bony framework. Our general conclusion agrees in so far that one is most likely to find incompetence and increased perioral muscle activity in subjects characterized by great lower anterior face height (high angle cases, see above) and/or antero-posterior discrepancy between the jaws (postnormal skeletal jaw relation). As a logical consequence of this, our treatment objectives in cases with incompetent lips should be to influence vertical and horizontal growth of the jaws, especially the mandible. At least, every effort should be made to avoid posterior rotation of the lower jaw as a response to treatment.

*) N-angle = ML/pg-sm.

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