Effects of a myofunctional appliance on orofacial muscle activity and structures

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In the orthodontic literature, much attention has been paid to the problem of controlling interferences with dentofacial growth caused by abnormal lip and tongue function in the mixed dentition period. Various appliances have been presented for the treatment of this problem.[1-7] The main purpose of these appliances, called oral or vestibular screens, has been to eliminate the oral dysfunction and to establish muscular balance. Another purpose has been to correct or diminish maxillary incisor protrusion. Excessive dental protrusion is characteristic of these cases, particularly in connection with thumb- or lip-sucking and tongue-thrust. Cheney[8,9] introduced a myofunctional appliance, called an oral shield, that was designed to activate the lip and facial muscles to move the maxillary incisors into a more favorable position, and to establish lip function that would counterbalance the force of the tongue against the teeth.

The malrelationship of teeth is often the result of variations in tissue growth and development and the interplay of forces within the oral environment. The goal of orthodontic treatment is to produce a more ideal dental alignment and to produce or maintain a stable balance of forces. We have only a partial understanding of these forces and how to modify them.

The activity of some circumoral and jaw-closing muscles in children with various types of malocclusion and oral dysfunction has been studied electromyographically by several authors.[10-14] Furthermore, in a study of oral screen treatment in children with lip incompetence,[15]

Abstract

The aim of the study was to examine the effect of an oral shield treatment on orofacial muscle activity and facial morphology in children with lip and/or tongue dysfunction. The sample consisted of 7 girls and 2 boys, 7 to 12 years old. EMG recordings with and without the shield in situ were obtained when the shield was placed, and 3, 6, and 12 months later. Lateral cephalograms were obtained at the initial and 1-year stages. The lip muscles showed dominant activity when the subjects were sucking on an empty straw and during swallowing; this was strongest during the first 3 months. The mentalis, buccinator, and digastric muscles generally showed weaker activity. The anterior temporal muscle showed dominant activity during maximal clench, but after the 3-month stage a significant decrease was noted. After 1 year of treatment, no significant changes in overjet or overbite were observed. Most of the craniofacial growth changes were normal for the age group. The results indicate that treatment with an oral shield caused a decrease in orofacial muscle activity during oral functions. Although there was a slight average retraction of the maxillary incisors, the change in position was not statistically significant.

Key words

Oral dysfunction • Oral shield treatment • Electromyography • Cephalometrics.

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Figure 1
Survey of the sample and stages of electromyographic recordings.

Figure 2
Frontal view of the oral shield in situ.

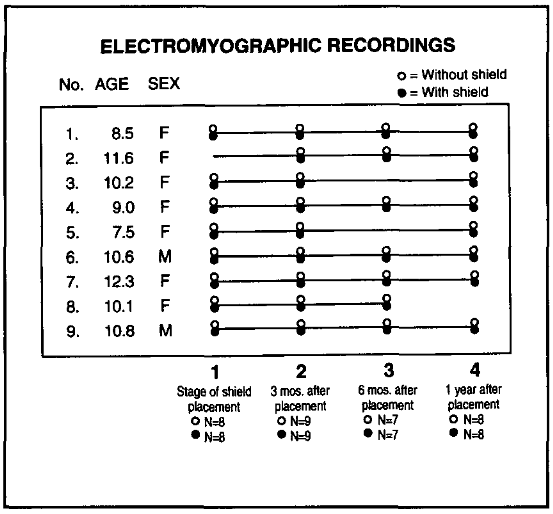

Figure 1

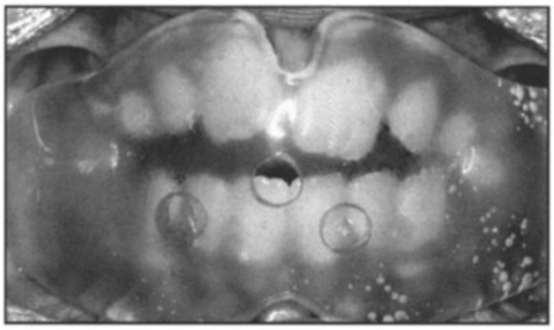

Figure 2

the strength and EMG activity of the lips during chewing and swallowing of test food was recorded.

The aim of the present 1-year longitudinal study was to examine the effect of treatment with a myofunctional appliance on orofacial muscle activity and changes in craniofacial morphology in a sample of children with oral dysfunction.

Materials and methods

Sample

The study sample consisted of 9 Caucasian children (7 girls and 2 boys) with lip and/or tongue dysfunction. These patients were to be treated orthodontically with a myofunctional appliance. The age range of the sample at the first stage of observation was 7.5 to 12.3 years, with a mean of 10.1 years (Figure 1).

The oral dysfunction was characterized by increased lip activity in connection with maxillary incisor protrusion and marked overjet. Increased lip activity was seen also in patients with openbite. Regarding the vertical relationship of the incisors, four of the subjects had a negative overlap, i.e., an openbite ranging from -2 mm to -3.9 mm, and five subjects had a positive overbite ranging from 0.3 mm to 4.9 mm. Three of the subjects with openbite showed incompetent lip seal. Increased tongue activity or tongue thrust was seen in some of the 9 subjects.

The recording of lip and tongue dysfunction was made clinically and by inspection of lateral cephalograms taken in centric occlusion and in postural position of the mandible. In selecting the sample, no consideration was given to the type of molar occlusion. All subjects were in the mixed dentition stage of development. Four subjects had Class I malocclusion and five had mild (2 to 3 mm) Class II malocclusion. There were no apparent signs or symptoms of temporomandibular joint dysfunction in the study sample.

Stages of observation

Electromyographic (EMG) recordings were made at four stages: at the initial stage of shield placement, 3 months after placement, 6 months after placement, and 1 year after placement.

At each session, two EMG recordings were made, one without the shield in place and another with the shield in situ. The electrodes were not moved between recordings. A survey of the sample and the stages of electromyographic recordings without and with the shield in situ is given in Figure 1. EMG recordings are missing for one subject at stage 1 and for one subject at stage 4 due to EMG technical problems and for two subjects at stage 3 because of illness. This explains the reduced data available for computing differences in muscle activity between stages of observation.

Fabrication of the myofunctional appliance

The myofunctional appliance, here referred to as the oral shield, was fabricated according to Cheney.[9] The appliance was made of 1/8-inch Plexiglas, cut and finished to fit the oral vestibulum outside the dentition (Figure 2). Relief was made for the muscle and frenulum attachments. The anterior portion was adapted tightly to the work model, but the posterior segments were positioned 3 mm away from the gingival mucosa. Maximal vertical height was used to prevent vertical shifting of the appliance, but it was trimmed so that it did not impinge upon the alveolar mucosa or mucobuccal folds. The oral shield was activated by having the patient close his or her lips tightly over the appliance. The patient was instructed to wear the appliance every night during sleeping and was told that it would take about 3 weeks to fully accommodate to the oral shield.

Method of electromyographic (EMG) recordings

The muscles studied electromyographically were the right anterior temporal (RAT), right upper orbicularis oris (RUO), right lower orbicularis oris (RLO), right buccinator (buccal wall, RBu), right mentalis (RMe), and anterior digastric (suprahyoid muscle group, DIG). Bipolar silver disk surface electrodes, 9 mm in diameter, were taped in the main direction of the muscle fibers as ascertained by palpation of the muscles. The electrodes were placed on the right anterior temporal, right buccinator, and anterior digastric, as shown in Figure 3. The electrodes on the buccinator muscle (buccal wall) were placed on a line joining the tragus of the ear and the commissure of the lips, halfway between the anterior border of the masseter muscle and the lip commissure. Placement of the electrodes on the right side upper and lower lips and on the right m. mentalis is shown in Figure 4. The position of the electrodes at the first session was marked on each patient's chart, and the chart was used as a guide at each subsequent recording session.

The equipment used for the EMG recordings was a Grass polygraph and amplifier (Models 78 and 7P511, respectively, Grass Inc, Quincy, Mass). The amplified signals were recorded simultaneously on paper and analog FM magnetic tape (Model 3955, Hewlett Packard, Palo Alto, Calif). Each direct EMG trace was converted to a mean voltage trace by an electronic averaging circuit connected to the polygraph.

Electromyographic recordings were made of maximal clench in centric occlusion (four clenches), swallowing of saliva (two swallows), and sucking on an empty straw (six suckings). The swallowing recordings were made when the patient indicated that a sufficient amount of saliva had accumulated. To produce the sucking recordings, the patient was instructed to suck on a plastic straw, keeping it in front of the teeth and shield with one finger closing the open end of the straw. During the recording procedure, the patient was seated in a dental chair in an upright, relaxed position with the head unsupported and in its natural balance. The speed used for the recordings was 25 mm/sec. Calibration tests and baseline recordings were performed at the beginning and end of each recording.

Computer analyses of electromyograms

The quantitative assessments of the amplitudes of muscle activity during different oral functions and of the duration of swallowing were made according to Møller,[17] as described by Tallgren et al.[16,18] The peak levels of the amplitudes in relation to the baseline were marked directly on the mean voltage traces. In the swallowing recordings, the onset and cessation of the muscle activity were determined from the direct electromyograms and marked on the mean voltage traces (Figure 5). The onset of activity in the right anterior temporal muscle (RAT) was assessed as time zero. The x- and y-coordinates of the reference points were recorded with a Summagraphics Supergrid digitizer (Summagraphics Corp, Fairfield, Conn) and a check of the recordings was performed by comparison of the calculated values of the recorded points against the measured values from the mean voltage traces.

The values of the EMG variables were calculated from the x- and y-coordinates of the reference points using the program EXTRACT (Center for Human Growth and Development,

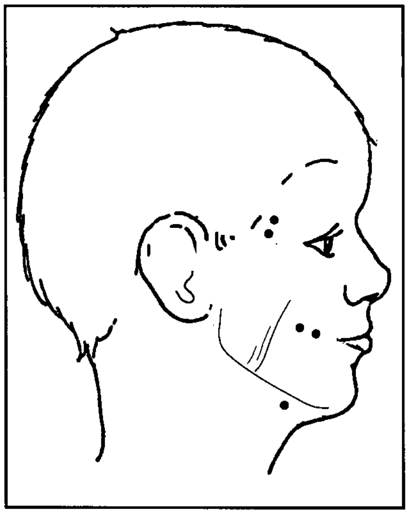

Figure 3

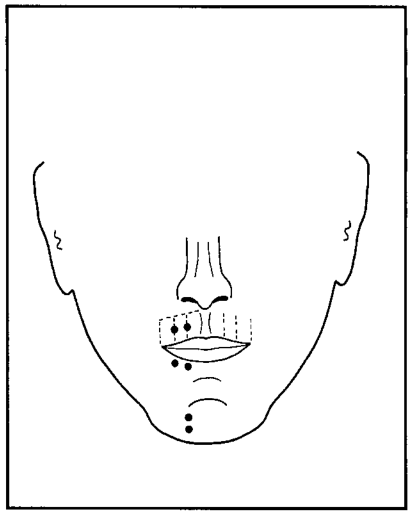

Figure 4

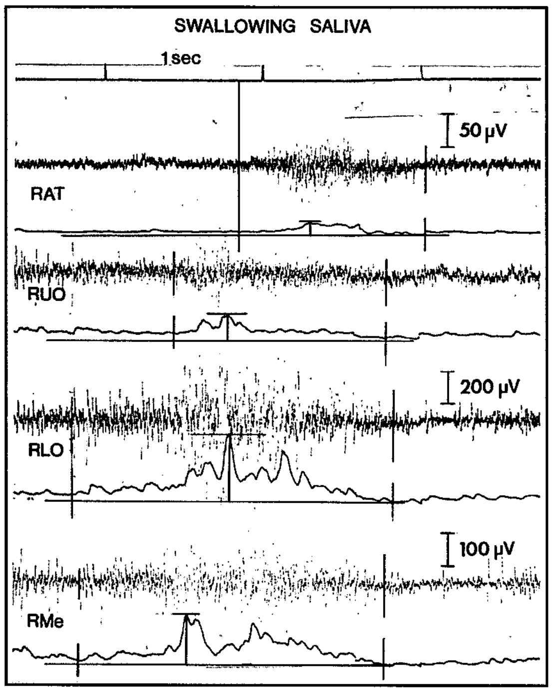

Figure 5

Figure 3
Placement of bipolar surface electrodes on the anterior temporal, buccinator, and anterior digastric muscles.

Figure 4
Placement of bipolar surface electrodes on the right side upper and lower lips and on the right mentalis muscle (modified from Tallgren and Tryde[16]).

Figure 5
Measurements of electromyographic recordings of swallowing saliva. Onset and cessation of the muscle activity were determined from the direct electromyographic traces and marked on the mean voltage traces. The onset of activity in RAT was assessed as time zero. Measurements of the peak mean voltage amplitudes in relation to the base line are indicated (from Tallgren and Tryde[16]).

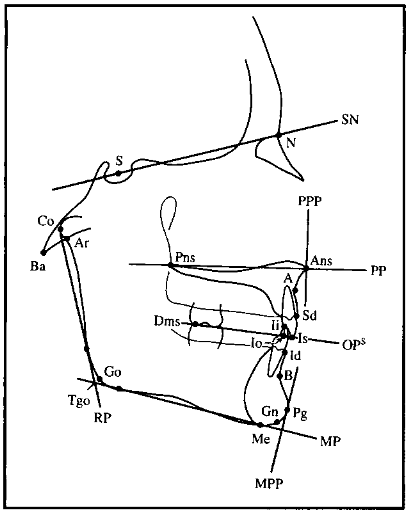

Figure 6

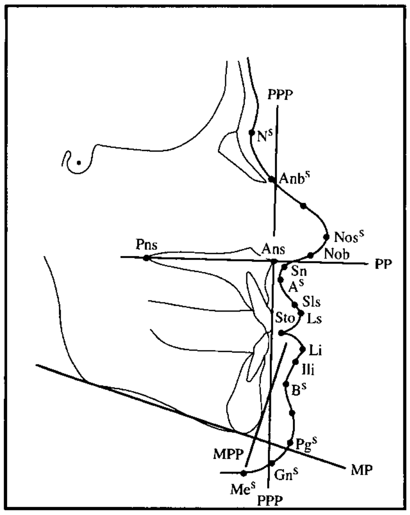

Figure 7

Figure 6
Skeletal reference points and lines on the profile cephalometric films.

Figure 7
Soft tissue reference points and skeletal reference lines on the profile cephalometric films.

University of Michigan, Ann Arbor; Michigan Terminal System). Clenching activity was assessed as the average of three clenches, sucking activity as the average of three suckings, and swallowing activity as the average of two consecutive swallows.

Roentgencephalometric method

Standardized lateral cephalometric headfilms (8 x 10 inches) were obtained for each subject with the teeth in centric occlusion and the lips relaxed. A Wehmer cephalostat with an enlargement factor of 12.26% was used for the study. Two headfilms were taken at the stage of shield placement (stage 1) and two headfilms after 1 year of treatment (stage 4). At both stages, one headfilm was taken without the shield and one with the shield in situ. In order to check the position of the tongue and lips, lateral cephalograms were also taken with the mandible in the postural position.

The reference points and lines for measurements of the skeletal facial morphology and the soft-tissue profile were according to Tallgren et al.[19] The reference points are illustrated in Figures 6 and 7. The measuring points were marked on individual tracings of the craniofacial structures from each headfilm. The tracings were made by one person and checked by superimposition of basal skeletal structures. The x- and y-coordinates of the reference points were recorded by a Summagraphics ID digitizer (Summagraphics Corp, Fairfield, Conn), and a check of the recorded points was performed using full-size plots of the points, produced by the computer program ACQUIRE PLOT (Center for Human Growth and Development, The University of Michigan, Ann Arbor, Mich; Michigan Terminal System).

The values of the variables were calculated from the x- and y-coordinates of the reference points using the program EXTRACT. No corrections were made for the roentgenographic enlargement.

The skeletal craniofacial variables are shown in Table 1 and Figure 6. The soft tissue variables (Figure 7), e.g., vertical position of the nose, upper and lower lips, and soft tissue chin, were expressed as the perpendicular distance from the respective reference points to the palatal plane, PP; the horizontal position was expressed as the distance from the reference points to the palatal plane perpendicular, PPP.

Statistical analysis of the electromyographic and cephalometric data was performed using the Michigan Interactive Data Analysis System (MIDAS).[20] A paired *t*-test was used to test the significance of the mean differences of the cephalometric variables between the observation stages. To test the mean differences of the electromyographic variables, a paired *t*-test and the nonparametric Wilcoxon test were used.[21]

Results

Facial morphology

The skeletal craniofacial morphology of the sample at the initial stage of observation (stage 1) is described statistically in Table 1. The craniofacial morphology and soft-tissue profile at stage 1, before and after placement of the shield, are illustrated by the mean facial diagram, Figure 8. Analysis of mean changes in the soft tissue profile at stage 1 (Table 2) showed that the upper and lower lips were situated significantly more forward with the oral shield in place (mean change about 4 mm). A slight forward placement of the mandible with the shield in situ was also noticed (Figure 8), but this change was not significant.

The mean changes in skeletal facial morphology between the pretreatment stage (stage 1) and the 1-year stage without the oral shield (stage 4) are given in Table 3 and illustrated in Figure 9. Total anterior face height (N-Me) showed a mean increase of 3.1 mm, with a somewhat greater increase in upper facial height (N-Ans) than lower (Ans-Me). Posterior facial height (S-Tgo) showed a mean increase of about the same amount as anterior height. The length of the mandible (Gn-Co) increased by a mean of about 4 mm, and the anterior cranial base (S-N) lengthened by 1.2 mm. The majority of these changes were significant at the 1% level (Table 3). Palatal plane (Ans-Pns) showed a nonsignificant increase of 0.7 mm.

The inclinations of the maxilla (SN/PP) and of the mandible (SN/MP and PP/MP) showed no significant changes, which apparently was related to the same amount of increase in anterior and posterior face heights. Moreover, the sagittal jaw relationships (A-N-B, S-N-Pg) showed no significant changes.

Regarding occlusal changes (Table 3), the upper and lower incisal points showed significant vertical increases of about 1 mm from the jaw bases (Is to PP and Ii to MP), and the upper molar point (Dm^s) a significant increase of 1.6 mm from PP. The upper incisor point showed a mean retrusion of -0.76 mm (Is to PPP), but the difference was not statistically significant (range -2.12 mm to 0.92 mm). Overjet (Is-Io) showed a nonsignificant change of 0.07 mm (range -3.5 mm to 2.7 mm). Overbite (Ii-Io) showed a nonsignificant increase of 0.6 mm.

The soft tissue changes in facial profile closely followed the skeletal changes (Figure 9).

Electromyographic findings

Maximal clench

The mean values and standard errors of the means (SEM) for the peak mean voltages of the muscles during maximal clench without and with the shield in situ are given in Figure 10.

The anterior temporal muscle showed dominant clenching activity. At the initial and the 3-month stages, the mean voltages of the temporal activity without and with the shield in situ were around 140 μV. Thereafter, a mean decrease in temporal activity was observed at the 6-month stage, the total decrease from stage 1 in clenching with the shield (-44.7 μV) being significant at the 5% level. After 1 year of treatment, temporal clench activity without the shield showed a total mean decrease of 47 μV, but the difference was not significant. The differences in temporal clenching activity without and with the shield in situ, which were very small up to the 6-month stage, showed a mean increase at the 1-year stage (Figure 10). However, this difference was not statistically significant. Furthermore, a comparison of the differences in temporal activity without and with the shield in situ between stages 1 and 4 did not prove to be significant either.

The facial muscles and m. digastricus generally showed low clenching activity both without and with the shield in situ and generally did not display any significant changes during the observation period. However, lower lip activity (RLO) without the shield in situ showed a tendency to decrease during the observation period, the mean difference between stages 1 and 2 (x = -27.8 μV) being significant at the 5% level.

Table 1
Statistical description of craniofacial morphology in the sample at Stage 1, before treatment with an oral shield. Values are given in degrees and mm. N=9.

	Mean	SD	Min	Max
Angular variables				
N-S-Ba	134.23	4.78	127.02	141.04
SN/PP	8.25	2.92	4.03	12.76
SN/MP	35.09	4.87	29.48	44.77
PP/MP	26.85	3.49	24.81	35.08
S-N-Pg	76.28	3.11	71.78	81.27
A-N-B	4.71	2.94	-0.04	8.22
RP/MP	130.83	4.80	123.17	139.69
OP^s/PP	10.71	2.59	7.37	14.78
Linear variables				
N-Ans	52.45	3.67	47.53	58.01
N-Me	114.04	5.82	105.03	121.25
Ans-Me	64.33	3.16	59.92	69.32
S-N	72.90	4.46	61.90	76.38
Ans-Pns	53.60	3.43	47.22	58.18
S-Tgo	70.50	5.90	59.06	80.37
Gn-Co	108.61	7.14	93.64	118.87
Overjet (Is-Io)	5.43	2.12	3.32	10.54
Overbite (Ii-Io)	-0.12	2.96	-3.87	4.94

Sucking on a straw

The peak mean voltages of the facial and digastric muscles during sucking are shown in Figure 11. The upper and lower lips displayed dominant activity, and no significant differences in mean voltages were noted between sucking without the shield and with it. At the initial and 3-month stages, the mean voltages of the upper lip ranged from 95 to 129 μV, and the values for the lower lip ranged from 136 to 151 μV. At the 6-month and 1-year stages, sucking activity of the lip muscles showed significant mean decreases both without and with the shield in situ (Table 4).

The other muscles showed markedly less sucking activity than the lip muscles, with the buccinator muscle being, for the most part, the least active (Figure 11). No significant changes in mean voltages of these muscles were observed during the observation period, and there were no significant differences in sucking activity, without and with the shield in situ. The anterior temporal muscle showed minimal activity during sucking.

Swallowing saliva

The peak mean voltages of the muscles investigated during swallowing of saliva are shown

Table 2
Mean changes in soft-tissue profile (mm) at the initial stage (1) after placement of the oral shield (Figures 7 and 8). N=9.

	Mean diff.	SD
Nose and upper lip		
Horizontal changes in relation to PPP		
Subnasale (Sn)	2.46**	1.54
Soft-tissue A-point (A^s)	3.89**	2.70
Superior point on upper lip (Sls)	3.92**	2.54
Labrale superius (Ls)	3.24**	2.90
Stomion (Sto)	3.47**	3.29
Lower lip and chin		
Horizontal changes in relation to PPP		
Labrale inferius (Li)	4.30*	4.47
Inferior point on lower lip (Ili)	3.92**	2.74
Soft-tissue B-point (B^s)	0.88	2.61
Soft-tissue pogonion (Pg^s)	-0.17	2.54
Distances from lips to incisors parallel to PP (Is) and to MP (Ii)		
Labrale superius (Ls) to Is	2.96**	3.03
Labrale inferius (Li) to Ii	3.53**	2.76

* $p \leq 0.05$
** $p \geq 0.01$

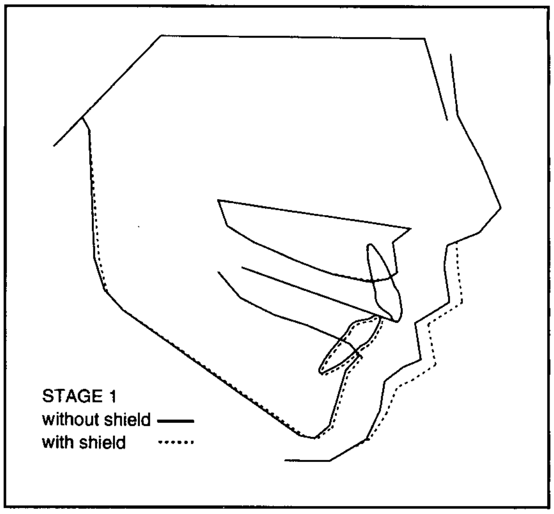

Figure 8

Figure 8
Mean facial diagrams (N=9) illustrating differences in soft tissue profile and mandibular position at stage 1, without and with the oral shield in situ.

in Figure 12. At the initial and the 3-month stages, lip activity in swallowing without the shield in situ was, on average, stronger than with the shield, with the mean difference of 36.5 µV for the upper lip (RUO) at stage 1, significant at the 5% level. The mean voltages at stages 1 and 2 for swallowing without the shield were around 50 µV for RUO and 59 to 74 µV for RLO. Thereafter, lip activity in swallowing without the shield showed noticeable mean decreases, but the differences did not reach the level of significance. At stages 3 and 4, no significant differences in lip activity without and with the shield in situ were noted.

The mean durations of lip muscle activity in swallowing at the initial stage before shield placement were 2991 msec for RUO and 3078 msec for RL0. The mean durations of the swallows with the shield in situ were somewhat longer, although no significant differences in duration were noted. Moreover, no significant changes in duration of the swallowing activity of the lips were observed during the year of treatment.

Of the other muscles investigated, the mentalis and digastric muscles showed fairly marked swallowing activity by amplitude, while the buccinator muscle was less active (Figure 12). The anterior temporal muscle showed very low swallowing activity. The mean voltages of these muscles in swallowing without and with the shield in situ showed no significant differences, and no significant changes in mean voltages were noted during the observation period. The mean durations of activity for these muscles in swallowing without and with the shield in situ were close to those noted for the lip muscles, and generally no significant changes were observed during the year of treatment.

Discussion

The present longitudinal study of a sample of nine children with oral dysfunction was designed to gain some information on the effect of treatment with a myofunctional appliance on orofacial muscle activity and the possible effect of the treatment on facial morphology. The size of the sample may seem small. However, a longitudinal analysis is statistically much more sensitive than an analysis of changes based on a cross-sectional sample.

The reliability of the skeletal craniofacial measurements from lateral cephalometric films has been evaluated in previous studies,[22-24] and the reliability of various soft-tissue points has also been described.[24] The method errors for linear and angular skeletal and soft-tissue facial variables have been found to be small in relationship to the intersubject variation.

A comparison of the pretreatment craniofacial morphology in the present subjects with American cephalometric standards of Caucasian girls and boys in the same age range[25,26] showed that the angular and linear morphologic variables were within the normal range of variation.

Analysis of growth changes in the facial skel-

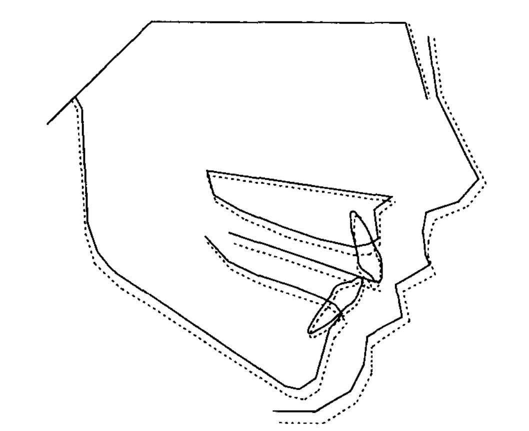

Figure 9

eton after 1 year of treatment showed that for most of the craniofacial variables, the changes were within the normal range of variation.[25,26] Only the increases in upper, lower, and total anterior face heights and in the length of the mandibular base showed some larger values. Whether these departures from normal growth variations had any relationship to the oral shield treatment can not be determined by the present study.

As might be expected, the soft tissue facial contours upon placement of the oral shield in the mouth showed a marked forward placement of the upper and lower lips, the mean changes in both lip contours being close to 4 mm.

The effect of the shield treatment on orofacial muscle activity was studied from electromyographic recordings of three different oral functions: maximal clench, sucking on an empty straw, and swallowing saliva. The reliability of the electromyographic measurements of elevator and facial muscle activity during oral functions have been evaluated in previous studies.[27,17] The error variances for the EMG variables generally constituted only a small part of the total biologic variances.

The recordings of maximal clench in the present sample showed dominant activity by amplitude of the anterior temporal muscle both without and with the shield in situ. The facial muscles showed only low activity. This is in accordance with observations in other studies of children with various oral dysfunctions[10,15] and indicates that the lip and facial muscles generally are not much activated during maximal clench.

The marked anterior temporal activity during maximal clench, which averaged 140 µV during the initial and 3-month stages, showed a significant decrease after 6 months use of the shield. Whether the decrease in temporal activity was influenced by the shield treatment or possibly associated with occlusal changes in the mixed dentition cannot be determined by the present data.

In sucking on an empty straw, the upper and lower lip muscles showed dominant activity, particularly marked at the initial and 3-month stages. No significant differences in sucking activity without and with the shield in situ were noted. During the continued treatment, significant decreases in sucking activity of the lips were observed at the 6-month and 1-year stages. This finding indicated a decrease of the marked initial lip activity and may suggest a favorable effect of the shield treatment.

The mentalis muscle showed markedly less sucking activity than the lip muscles both without and with the shield in situ, and the activity of the buccinator muscle was surprisingly low. A relatively low buccinator activity has been observed also in studies of thumb- and finger-sucking children.[10,28]

In the recordings of swallowing saliva, the facial muscles, particularly the lip muscles, showed marked activity by amplitude, while the

Table 3
Mean changes in craniofacial morphology between the pretreatment situation (Stage 1) and after 1 year of treatment (Stage 4). Values are given in degrees and mm. N=9.

	Mean diff.	SD	Min	Max
Angular variables				
SN/PP	0.42	1.34	-1.07	2.65
SN/MP	-0.93	1.33	-2.63	0.93
PP/MP	-1.35	1.89	-4.60	1.52
S-N-Pg	0.43	0.79	-0.58	1.78
A-N-B	0.06	0.54	-0.50	1.12
OL^s/PP	-0.68	2.27	-5.18	1.95
Linear variables				
N-Ans	1.67^{**}	1.27	-0.24	3.79
N-Me	3.09^{**}	1.85	0.05	5.66
Ans-Me	1.41^{*}	1.57	-0.32	3.57
S-N	1.17^{**}	0.75	0.29	2.79
Ans-Pns	0.68	1.27	-0.51	3.76
S-Tgo	3.44^{**}	1.24	1.59	6.09
Gn-Co	3.94^{**}	2.03	0.92	6.58
Is to PP	1.13^{*}	1.27	-1.08	2.94
Ii to MP	0.90^{**}	0.60	0.11	1.65
Dm^s to PP	1.61^{**}	0.94	-0.59	2.96
Is to PPP	-0.76	1.10	-2.12	0.92
Is-Io (overjet)	0.07	1.90	-3.54	2.71
Ii-Io (overbite)	0.62	1.11	-1.05	1.94

* $p \leq 0.05$
** $p \geq 0.01$

Figure 9
Mean facial diagrams (N=9) showing changes in skeletal and soft tissue profiles without shield between the initial observation (stage 1) and after 1 year of treatment (stage 4). Figures 8 and 9 superimposed on nasion-sella planes with sella points coinciding.

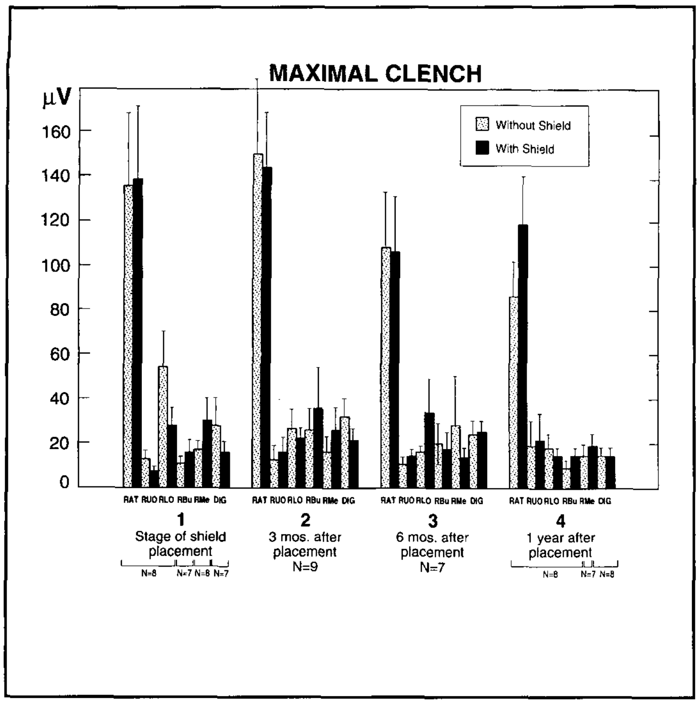

Figure 10

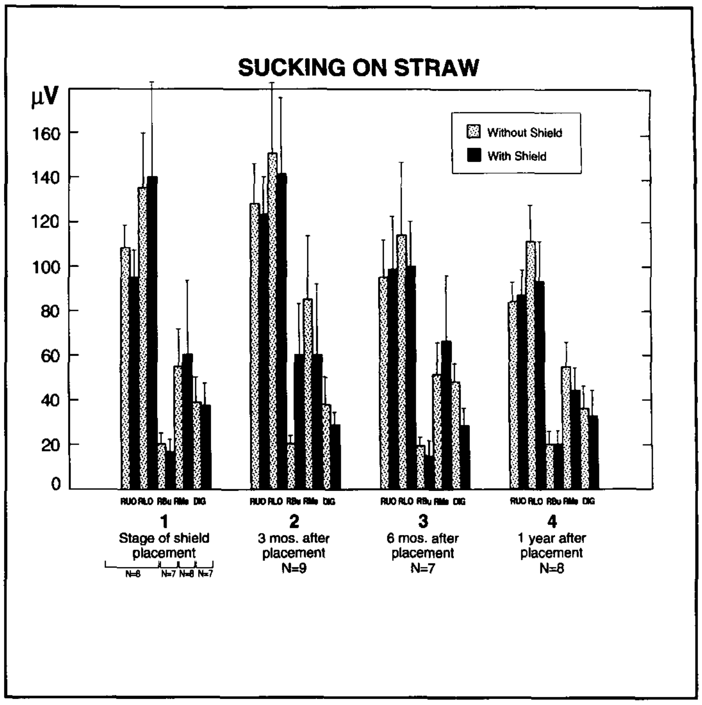

Figure 11

Figure 10
Maximal clench without and with the shield in situ. Mean values and SEM for peak mean voltages (µV) of the right anterior temporal (RAT), right upper lip (RUO), right buccinator (RBu), right mentalis (RMe) and anterior digastric (DIG) at the different observation stages.

Figure 11
Sucking on a straw without and with the shield in situ. Mean values and SEM for peak mean voltages (µV) of the right upper lip (RUO), right lower lip (RLO), right buccinator (RBu), right mentalis (RMe) and anterior digastric muscles (DIG) at the different observation stages.

anterior temporal muscle displayed only weak activity. This may imply that the visceral or tooth-apart type of swallowing was dominant in the sample studied. However, since masseter muscle activity was not recorded, this suggestion cannot be substantiated.

An interesting observation was that during the first 3 months of treatment, lip activity in swallowing without the shield was significantly stronger than with the shield. The average peak mean voltages in swallowing without shield were around 50 µV for the upper lip (RUO) and 59-74 µV for the lower lip (RLO). A comparison with studies of children[29] and young adults[17] with normal occlusion indicates that in the present subjects with oral dysfunction, swallowing activity of the upper lip was, on average, stronger than in the above-mentioned normal samples, while the lower lip activity was of the same order of magnitude. The strong activity of the upper lip in the present subjects was most likely related to increased overjet and proclination of the upper incisors due to the oral dysfunction.

At the 6-month and 1-year stages, swallowing activity of the upper and lower lips without the shield in situ displayed noticeable decreases in mean voltages but, due to great individual variations, the differences were not statistically significant. A decrease in lip activity after 6 months of treatment, which was found significant for the sucking activity, suggests that treatment with the oral shield had reduced the marked initial activity of the lip muscles, at least to some degree.

In swallowing with the shield in situ, activity of the upper and lower lips showed mean decreases and increases, respectively, between observation stages, but the changes were not statistically significant. This may explain the finding that the upper incisors did not display any significant change in lingual direction after the year of shield treatment and overjet did not decrease. Six subjects showed slight retraction of the upper incisors, whereas two subjects showed further protrusion, and one subject had no change. A study of oral screen treatment in children with incompetent lips[15] likewise did not show any significant changes in EMG activity of the lips in recordings of chewing and swallowing of test food. On the other hand, a significant retroclination of the proclined maxillary incisors and a decrease in overjet was observed. Perhaps this finding was associated with an increase in measurements of lip strength. The increase in lip strength probably was the result of special lip training exercises with the oral screen.

Except for the lip muscles, the mentalis muscle was found to be more active than the other facial muscles. This observation was most likely related to a synergistic activity with the lower lip in sealing the swallow.[10] Very high activity of the mentalis muscle during swallowing has been observed in a study of children with incompetent lip seal.[11]

In the present sample, the buccinator muscle displayed low activity during swallowing, which

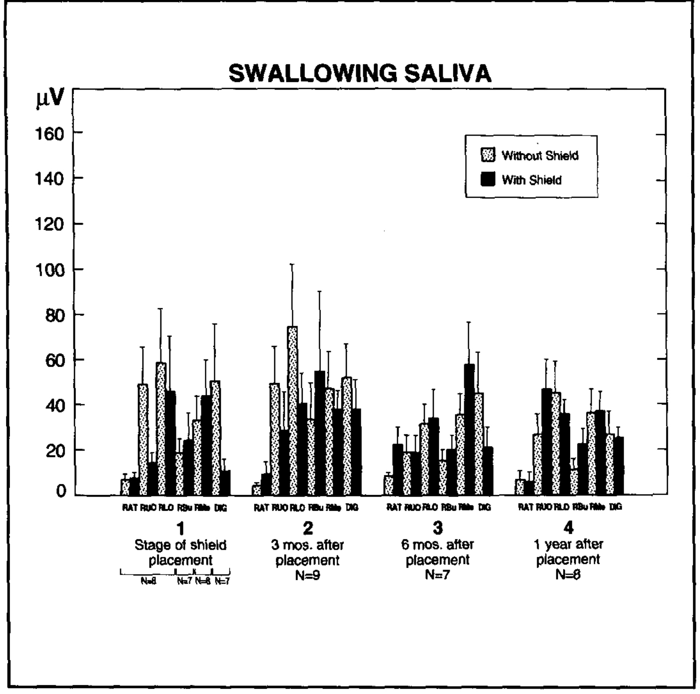

Figure 12

Table 4
Sucking on straw. Mean differences in peak mean voltages of the upper and lower lips (RUO and RLO) between observation stages

	Stages 1 to 2 N=8		Stages 2 to 3 N=7		Stages 2 to 4 N=8	
	Mean	SEM	Mean	SEM	Mean	SEM
Without shield						
RUO	14.43	18.35	-40.76*	11.76	-46.51*	18.34
RLO	-12.28	25.82	-50.86*	18.85	-44.73	23.14
With shield						
RUO	22.91	15.23	-28.97	22.59	-37.52*	15.46
RLO	-25.25	32.90	-44.20	23.21	-46.95	28.99

* $p \leq 0.05$

Stage 1: Stage of shield placement
Stage 2: 3 months after shield placement
Stage 3: 6 months after shield placement
Stage 4: 1 year after shield placement

was observed also in the sucking recordings. This would indicate that the buccinator muscle did not have any marked effect in treatment of oral dysfunction with an oral shield. Similar findings of relatively low buccinator activity in swallowing and sucking have been reported in various studies of children with malocclusion and oral dysfunction.[10,15,28] On the other hand, studies of adult subjects with normal occlusion[30,31] have reported marked buccinator activity during various functions, such as mastication, swallowing, smiling, blowing, and sucking on a straw.

Conclusions

The findings from the present electromyographic and cephalometric follow-up study of a sample of children with lip and tongue dysfunction, such as increased lip activity and tongue-thrust, indicated that treatment with an oral shield caused a decrease of orofacial muscle activity during oral functions. Although there was a slight average retraction of the maxillary incisors, the difference in position was not statistically significant.

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Figure 12
Swallowing saliva without and with the shield in situ. Mean values and SEM for peak mean voltages (µV) of the right anterior temporal (RAT), right upper lip (RUO), right lower lip (RLO), right buccinator (RBu), right mentalis (RMe) and anterior digastric muscles (DIG) at the different observation stages.

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