Activity of Temporal and Masseter Muscles in Children with a Lateral Forced Bite

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Cuspal interference causing lateral deviation of the mandible during its movement from retruded contact position to intercuspal position have been reported to disturb muscle function considerably in adults.[12,13] Cuspal interferences are sometimes seen in children in so-called lateral forced bite, which often manifests itself morphologically as unilateral crossbite. Children with cuspal interferences often have an irregular pattern of movement during mastication[3] or a "chopping masticatory stroke."

Troelstrup and Møller[14] also found that muscle activity in postural position and during maximal bite in children with unilateral crossbite differed from what was seen in those with normal occlusion. They interpreted the deviation as an adaptation to the crossbite. Similar findings of the activity in postural position and during maximal bite in children with unilateral crossbite have been reported by Haralabakis and Loutfy.[7]

Quantitative electromyographic investigations of the muscle activity during chewing and swallowing in children with lateral forced bite have not been reported. The purpose of the present investigation was to find out whether and, if so, to what extent the activity of the temporal and masseter muscles with the mandible in postural position and during chewing, maximal bite, and swallowing deviated from normal in children with cuspal interference in the retruded position (so-called lateral forced bite).

Material

The material consisted of 19 children, 8 boys and 11 girls, aged 8 years 1 month to 12 years 11 months. The mean age was 9 years 7 months. The number of erupted permanent teeth was, on the average, 15.7 (range 8-27). Clinical examination of the children showed a lateral deviation on movement of the mandible between the retruded contact position and the intercuspal position (lateral forced bite). In twelve cases the mandible was forced to the right and in seven to the left. In nine cases there was unilateral crossbite on the right side in the intercuspal position and in seven on the left, while three had no crossbite in spite of the lateral deviations.

The lateral deviation on movement of the mandible between the retruded contact position and intercuspal position was measured with a modified gnathothesiometer. The apparatus and the recording procedure have been described previously.[8] The lateral deviation ranged from 0.3 mm to 3.7 mm (mean 1.3 mm). In ten of the cases the deviation was 1.0 or more.

Despite the cuspal interference none of the children had clinical or subjective symptoms of functional disorders of the masticatory system.

Methods

The electromyographic recording was done with a three-channel DISA electromyograph (No. 14 A 30). One of the EMG-amplifiers was replaced by a double mean voltage unit (14 C 20), which permitted simultaneous recording of the mean voltage amplitude in the two remaining direct EMG-channels. The EMG-activity was recorded on photographic paper fed at a rate of

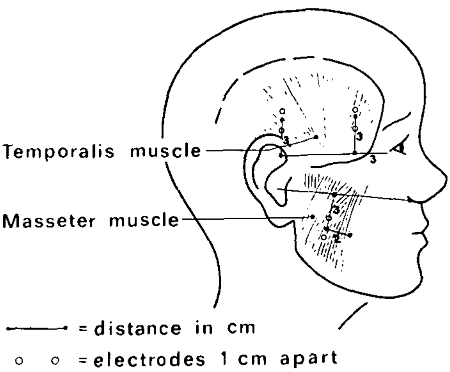

Fig. 1 Diagram of standardized positions of electrodes.

5 cm/sec.

Two types of bipolar electrodes were used, surface electrodes (tin-plates 10 × 3 × 1.5 mm)[10] for the masseter muscle, and hook-electrodes for the temporal muscle. The hook electrodes consisted of a platinum wire.[2] The positions of the electrodes are given in Figure 1. An earth electrode was fastened to the tip of the ear.

The muscle activity was recorded bilaterally from the posterior and anterior parts of the temporal muscle and from the masseter muscle. The anterior temporal muscle on the right side was used as a reference muscle throughout in one of the channels, and the other muscles (test muscles) were connected successively to the other channel. Thus, five acts of chewing and swallowing were recorded for each subject. During the recording the subject was sitting upright holding the head in a natural position without a neck support.

The following recordings were made: a) muscle activity in postural position of mandible, calibration 50 μV/cm; b) chewing and swallowing of five peanuts, calibration 300 μV/cm; c) maximal bite in intercuspal position, calibration 500 μV/cm; d) new recording of muscle activity in postural position.

The following measurements were made of the EMG-recordings:

1) EMG-activity, as judged with a five-grade scale (Fig. 2) with the mandible in postural position. Two estimations were made of each of the recordings *a* and *d*.

2) EMG-activity during the act of chewing a) maximal mean voltage amplitude of the chewing cycle, every third cycle was measured; b) duration of EMG-activity in the closing phase of the chewing cycle, every third cycle was measured; c) time of beginning of activity in the test muscle relative to that in the reference muscle (right anterior temporal muscle), every third cycle was measured; d) duration of chewing cycle, every third cycle was measured; e) duration of the act of chewing; and f) number of chewing cycles per act of chewing.

3) The average mean voltage amplitude during maximal bite. Measurement was made of the "typical" activity during one second.

4) EMG-activity during swallowing: a) maximal mean voltage amplitude; b) duration of EMG-activity; and c) time of beginning of activity in the test muscle relative to that in the reference muscle.

An act of chewing was defined as trituration of five peanuts to swallowing threshold. A chewing cycle was defined as the opening and closing phase of a masticatory movement of the mandible. Measurements of the electromyograms were made to the nearest 0.5 mm.

In the analysis of the muscle activity a comparison was made between the activity on the side to which the mandible was guided by cuspal interference (the side of forced bite, in most cases there was crossbite on this side) and the opposite side (nonforced bite side). Comparisons were also made with the muscle activity in 52 children (25 boys

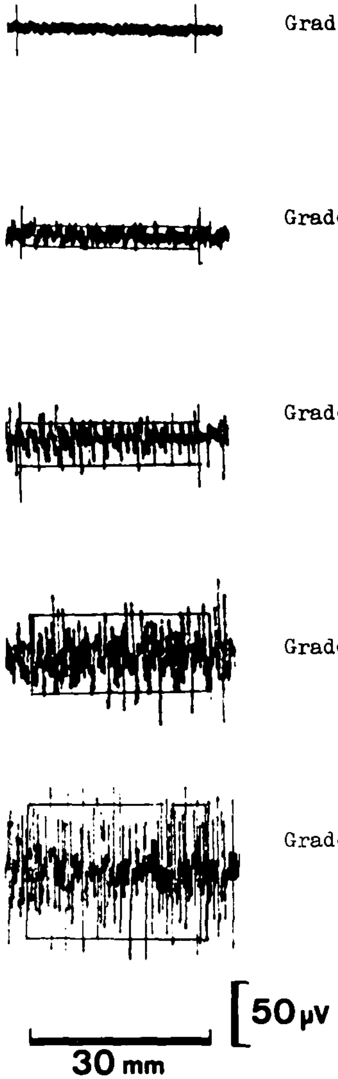

Fig. 2 Criteria for classification of the EMG activity in postural position.

and 27 girls) with normal occlusion.[9] The age and sex distribution of the children with normal occlusion corresponded to that of the present material. The children with normal occlusion were examined in the same way as those with forced bite.

Differences between distributions were tested with Wilcoxon's matched-pairs signed-ranks test and those between means with the t-test. Differences between variances were tested with the F-test.

Results

Muscle activity in postural position

The muscle activity in postural position was assessed from the mean of the activity found in recordings *a* and *d* and is given in Table I. No significant difference of the postural activity was found between the side of forced bite and the nonforced bite side in the en-

TABLE I

Mean and standard deviation of EMG-activity in postural position as judged according to a five-grade scale (0 = no activity, 4 = strong activity)

Muscle	Lateral forced bite (n = 19)				Large lateral deviation (n = 10)				Normal occlusion (n = 52)	
	Side of forced bite		Non-forced bite side		Side of forced bite		Non-forced bite side			
	M	SD	M	SD	M	SD	M	SD	M	SD
Anterior temporal	0.51[1]	0.56	0.41	0.58	0.40	0.45	0.22	0.36	0.21	0.36
Posterior temporal	1.38	0.92	1.09	0.82	1.35	0.91	0.80[I,1]	0.61	1.38	0.78
Masseter	0.44	0.58	0.42	0.40	0.17	0.31	0.37	0.33	0.34	0.48

I $0.01 < P < 0.05$ compared with side of forced bite
1 $0.01 < P < 0.05$ compared with children with normal occlusion

tire group of children with forced bite. In children with a large lateral deviation (1 mm), however, the activity in the posterior temporal muscle on the nonforced bite side was significantly lower than that on the side of forced bite ($0.01 < P < 0.05$).

Compared with children with normal occlusion the entire group of children with forced bite (19) showed a significantly greater activity of the anterior temporal muscle on the side of forced bite, while that in the posterior temporal muscle on the nonforced bite side in children with large lateral deviation was lower.

Muscle activity during chewing

The duration of the act of chewing in children with a forced bite was, on the average, 15.3 seconds (SD 6.0) and the average number of chewing cycles 21.1 (SD 6.6). Both the duration and the number of cycles agreed well with the corresponding means in the children with normal occlusion (13.5 seconds and 21.7 cycles, n = 52). No significant difference was found in the average duration of the chewing cycle between the two groups (M = 745 ms, SD 100 ms, respectively, M = 701 ms, SD 186 ms). Neither did children with a large lateral deviation differ from the other children regarding the duration and number of cycles.

The maximal mean voltage amplitude of the chewing cycle is given in Table II. In the entire group with a forced bite the amplitude in the anterior temporal muscle was smaller on the nonforced bite side than on the side of forced bite ($0.01 < P < 0.05$). This applies also to the posterior temporal muscle ($0.001 < P < 0.01$). In children with a large lateral deviation the difference in amplitude between the side of forced bite and the nonforced bite side was significant only for the posterior temporal muscle ($0.001 < P < 0.01$).

TABLE II

Mean and standard deviation (in μV) of the maximal mean voltage amplitude during ***chewing***

Muscle	Lateral forced bite (n = 19): Side of forced bite M	SD	Non-forced bite side M	SD	Large lateral deviation (n = 10): Side of forced bite M	SD	Non-forced bite side M	SD	Normal occlusion (n = 52) M	SD
Anterior temporal	184.4	61.7	160.0[I,1]	54.3	183.2	51.9	172.8	53.6	208.7	77.9
Posterior temporal	136.4	58.2	98.1[II,2]	55.1	148.7	57.6	99.8[II,1]	51.6	134.2	42.3
Masseter	67.5	38.6	66.3	44.7	65.6	46.7	66.2	27.6	87.7	44.6

I $0.01 < P < 0.05$ compared with side of forced bite
II $0.001 < P < 0.01$ compared with side of forced bite
1 $0.01 < P < 0.05$ compared with children with normal occlusion
2 $0.001 < P < 0.01$ compared with children with normal occlusion

Compared with children with normal occlusion, the children with a forced bite had a lower amplitude in the anterior and posterior parts of the temporal muscle on the nonforced bite side, while no statistical difference was found for the masseter muscle.

To find out whether the variation in the maximal mean voltage amplitude differed between the forced bite and the nonforced bite sides, the standard deviation was calculated for the amplitude of the chewing cycle in the *individual children* on either side. No difference in standard deviation was found in the anterior temporal muscle and the masseter muscle. The amplitude in the posterior temporal muscle, however, varied less on the nonforced side than on the side of forced bite ($0.001 < P < 0.01$). On comparison with the variation in children with normal occlusion a difference was found only for the posterior temporal muscle. The variation on the nonforced bite side was smaller than in children with normal occlusion ($0.01 < P < 0.05$). During chewing, children with forced bite were thus characterized by only slight variation in the amplitude of the posterior temporal muscle on the nonforced side, probably because of the low average activity level.

Neither in the entire group of children with forced bite nor in children with a large lateral deviation was any difference found between the side of forced bite and the nonforced side in the average duration of the EMG-activity during the closing phase of the chewing cycle (Table III). The duration was largely the same in children with a large lateral deviation as in the entire group with a forced bite. The variation of the duration of the EMG-activity of the posterior temporal muscle was larger on the nonforced side than on the side of forced bite ($0.01 < P < 0.05$) and also larger than in children with normal occlusion ($0.001 <$

TABLE III

Mean and standard deviation (in ms) of duration of EMG-activity during the closing phase of the chewing cycle

	Lateral forced bite (n = 19)				Large lateral deviation (n = 10)				Normal occlusion (n = 52)	
	Side of forced bite		Non-forced bite side		Side of forced bite		Non-forced bite side			
Muscle	M	SD	M	SD	M	SD	M	SD	M	SD
Anterior temporal	409.8[1]	99.4	422.0[3]	78.4	435.8[1]	119.6	430.6[2]	72.8	354.4	73.2
Posterior temporal	427.4[2]	88.0	446.2[1]	126.6	434.4[1]	80.8	487.0[1]	147.6	371.7	71.4
Masseter	356.4	74.4	358.6	76.2	356.8	86.6	365.8	81.0	319.6	81.3

[1] $0.01 < P < 0.05$ compared with children with normal occlusion
[2] $0.001 < P < 0.01$ compared with children with normal occlusion
[3] $P < 0.001$ compared with children with normal occlusion

TABLE IV

Mean and standard deviation (in μV) of the mean voltage amplitude during maximal bite

	Lateral forced bite (n = 19)				Large lateral deviation (n = 10)				Normal occlusion (n = 52)	
	Side of forced bite		Non-forced bite side		Side of forced bite		Non-forced bite side			
Muscle	M	SD	M	SD	M	SD	M	SD	M	SD
Anterior temporal	213.0[2]	71.8	198.5[3]	70.0	216.3	73.3	250.0	74.3	289.6	130.3
Posterior temporal	147.5	73.5	111.8[I,3]	48.5	171.3	87.3	116.3[I,1]	57.3	177.1	82.3
Masseter	88.8[2]	54.6	68.8[3]	43.3	78.8[1]	65.5	70.0[3]	42.0	135.1	82.6

[I] $0.001 < P < 0.01$ compared with side of forced bite
[1] $0.01 < P < 0.05$ compared with children with normal occlusion
[2] $0.001 < P < 0.01$ compared with children with normal occlusion
[3] $P < 0.001$ compared with children with normal occlusion

TABLE V

Mean and standard deviation (in μV) of the maximal mean voltage amplitude during swallowing

	Lateral forced bite (n = 19)				Large lateral deviation (n = 10)				Normal occlusion (n = 52)	
	Side of forced bite		Non-forced bite side		Side of forced bite		Non-forced bite side			
Muscle	M	SD	M	SD	M	SD	M	SD	M	SD
Anterior temporal	85.4	67.8	65.4[1]	57.2	69.0	65.6	51.0[1]	46.4	108.6	114.7
Posterior temporal	71.7	64.8	63.9	59.9	46.5	45.8	65.3	78.0	77.0	60.1
Masseter	24.0[1]	22.8	31.5	29.6	16.5[2]	17.6	28.5	35.4	42.4	51.6

[1] $0.01 < P < 0.05$ compared with children with normal occlusion
[2] $0.001 < P < 0.01$ compared with children with normal occlusion

$P < 0.01$). The EMG-activity in the anterior and posterior temporal muscle was of significantly longer duration in children with a forced bite than in children with normal occlusion.

In none of the muscles did the average time of the beginning of activity in the closing phase of the chewing cycle relative to that in the reference muscle differ between the sides. Nor was any significant difference found in this respect between children with a forced bite and with normal occlusion. The variation in the time of the beginning of activity in the anterior temporal muscle was greater on the side of the forced bite than on the nonforced bite side ($0.01 < P < 0.05$) and also greater than in children with normal occlusion ($0.001 < P < 0.05$).

Muscle activity during maximal bite

In the forced bite group and the children with a large lateral deviation the amplitude in the posterior temporal muscle during maximal bite was significantly lower on the nonforced bite side than on the side of forced bite ($0.001 < P < 0.01$), while no difference with sides could be found in any of the other muscles. In all the muscles the amplitude during maximal bite was lower in children with a forced bite than in those with normal occlusion (Table IV).

Muscle activity during swallowing

The maximal mean voltage amplitude during swallowing is given in Table V. No significant difference in amplitude during swallowing was found between the muscles on the side of forced bite and the nonforced bite side. In children with a forced bite the amplitude during swallowing was, for all muscles, lower than in children with normal occlusion. But the difference was significant only for the anterior temporal muscle on the nonforced bite side and for the masseter muscle on the side of forced bite.

Both in the children with a forced bite and in those with a normal occlusion the amplitude was greatest during maximal bite, somewhat lower during chewing, and lowest during swallowing.

The duration of muscle activity during swallowing is given in Table VI. Only for the anterior temporal muscle in the entire group with a forced bite was a significant difference found in the duration of the activity during swallowing between the forced bite and the nonforced bite sides ($0.01 < P < 0.05$).

The duration in children with a forced bite did not differ significantly from that in children with normal occlusion.

As during chewing, the time of the beginning of activity during swallowing was measured relative to that in the reference muscle. In none of the muscles was any difference in the time of beginning of activity found between the side of forced bite and the nonforced bite side. Neither was any significant difference found between children with a forced bite and those with normal occlusion.

Discussion

In all the functions examined the muscle activity in the group with a forced bite differed from that in children with normal occlusion.

The functions studied (postural position, natural chewing, maximal bite, and swallowing) have been previously examined in children[1,9] and in adults,[10] and have been found to be characterized by symmetric muscle activity. Children with a forced bite often had asymmetric muscle activity; the activity deviated also in degree and duration from that in children with normal occlusion.

The lower activity in the posterior temporal muscle on the nonforced bite side compared with the side of forced

TABLE VI

Mean and standard deviation (in ms) of duration of EMG-activity during swallowing

Muscle	Lateral forced bite (n = 19)				Large lateral deviation (n = 10)				Normal occlusion (n = 52)	
	Side of forced bite		Non-forced bite side		Side of forced bite		Non-forced bite side			
	M	SD	M	SD	M	SD	M	SD	M	SD
Anterior temporal	578.2[1]	438.2	383.0	334.4	507.0	452.8	238.0	218.4	394.1	336.5
Posterior temporal	522.0	361.4	558.4	390.6	481.0	407.6	451.0	310.2	511.5	303.7
Masseter	360.0	378.2	470.0	507.8	334.0	387.0	407.0	525.8	340.2	293.7

1 $0.01 < P < 0.05$ compared with non-forced bite side

bite and the high activity in the anterior temporal muscle on the side of the forced bite (compared with that in normal occlusion) can be explained by the significance of the temporal muscle as a postural muscle.[5,9] The asymmetric postural activity in the temporal muscle is compatible with a postural position in which the mandible is displaced toward the side of forced bite. This is probably to avoid cuspal interferences during closure. The asymmetric postural activity in the posterior temporal muscle was seen also in Troelstrup and Møller's[14] investigation of children with unilateral crossbite.

During chewing, the muscle activity was asymmetric both in the anterior and posterior portions of the temporal muscle. The maximal mean voltage amplitude was greater on the side of forced than on the nonforced bite side. Since no difference was found in the amplitude of the activity of the masseter muscle, the asymmetric temporal activity can hardly be interpreted as evidence of unilateral chewing. Unilateral chewing is characterized by a substantial difference in masseter activity between the chewing and the nonchewing sides. Natural chewing is bilateral; the subject either shifts the bolus from one side to the other[10] or chews simultaneously on both sides.[1] Children with a forced bite probably chew bilaterally, for which reason the greater activity of the temporal muscle on the side of forced bite than on the nonforced side may be regarded as an adaptation to avoid cuspal interferences in the same way as the asymmetric activity in the postural position.

In all the muscles examined, the amplitude during maximal bite was lower in the children with a forced bite than in those with normal occlusion. No explanation can be offered for the bilaterally low amplitude in the muscles in the group with a forced bite. The lower amplitude in the posterior temporal muscle on the nonforced bite side than on the forced bite side during maximal bite is, however, compatible with what was to be expected on biting in a lateral position of the mandible.[6,11] Also Troelstrup and Møller found that, during biting, children with unilateral crossbite had a smaller amplitude in the posterior temporal muscle on the normal side than on the crossbite side and also lower amplitude than in individuals with normal occlusion.

The muscle activity during swallowing appeared to be less affected by a forced bite than the activity in the other functions. A possible explanation is that the occurrence of cuspal interference caused a higher frequency of swallowing *without* tooth contact than in persons with normal occlusion. The lower amplitude of muscle activity during swallowing in children with a forced bite than in children with a normal occlusion suggests that this is the case. Møller[10] found that swallowing without tooth contact occurred with a lower amplitude of activity in the anterior temporal muscle and in the masseter muscle than swallowing with tooth contact.

The larger deviation from normal muscle activity during chewing than during swallowing in children with a forced bite agreed with Ahlgren and Posselt's[4] finding while Ramfjord[12,13] found the swallowing pattern to be affected more than the chewing pattern. The difference may be due to the differences in the ages of the individuals examined because Ramfjord used adults while Ahlgren and Posselt, like us, studied children.

The degree of lateral deviation between retruded contact position and intercuspal position does not seem to be of essential significance for the effect on the muscle function pattern because the children with a large lateral deviation did not differ substantially from the entire group with a forced bite. This is in agreement with what was seen in adults.[12]

The asymmetries recorded in the muscle activity can, like the difference from children with normal occlusion, be regarded as an adaptation to the morphology of the bite. None of the children examined had symptoms from the temporomandibular joints or muscles. Further investigations are necessary to decide whether the asymmetries in muscle functions observed can cause symptoms with time. It would also be of interest to find out whether treatment of the malocclusion can normalize muscle function.

Summary

The activity of the temporal and masseter muscles with the mandible in postural position and during chewing, maximal bite in the intercuspal position, and swallowing were recorded electromyographically in nineteen children with laterally forced bite. Of the children, aged 8-12 years, sixteen had unilateral crossbite. In all of the individuals there was lateral deviation between the retruded contact position and the intercuspal position. The magnitude of the lateral deviation was measured with a modified gnathothesiometer. The muscle activity was recorded bilaterally from the anterior and posterior parts of the temporal muscle and from the masseter muscle.

In the postural position asymmetric activity was found in the temporal muscle suggesting that the mandible in postural position was still displaced to the side of forced bite.

During chewing the activity was asymmetric both in the anterior and the posterior temporal portions. This asymmetric muscle activity was interpreted as an adaptation to avoid cuspal interferences.

Also in maximal bite the muscle activity was asymmetric, while the activity during swallowing was affected less

than in the other functions. The swallowing activity was, however, less in children with a forced bite than in children with normal occlusion.

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REFERENCES

1. Ahlgren, J.: Mechanism of mastication. *Acta Odont. Scand.*, 24:suppl. 44, 1966.
2. ————: An intercutaneous needle electrode for kinesiologic EMG studies. *Acta Odont. Scand.*, 25:15, 1967a.
3. ————: Pattern of chewing and malocclusion of the teeth. *Acta Odont. Scand.*, 25:3, 1967b.
4. Ahlgren, J. and Posselt, U.: Need of functional analysis and selective grinding in orthodontics. *Acta Odont. Scand.*, 21:187, 1963.
5. Ahlgren, J., Ingervall, B. and Thilander, B.: Muscle activity in normal and postnormal occlusion. *Amer. J. Orthodont.*, 64:445, 1973.
6. Greenfield, B. E. and Wyke, B. D.: Electromyographic studies of some of the muscles of mastication. *Brit. Dent. J.*, 100:129, 1956.
7. Haralabakis, V. and Loutfy, S.: An electromyographic analysis of a series of fifty treated posterior crossbites. *Europ. Orthodont. Soc. Trans.*, 40, 1964.
8. Ingervall, B.: Recording of retruded positions of mandible in children, *Odont. Revy.*, 19:65, 1968.
9. Ingervall, B. and Thilander, B.: Relation between facial morphology and activity of the masticatory muscles. *J. Oral Rehab.*, 1:131, 1974.
10. Moller, E.: The chewing apparatus. *Acta Physiol. Scand.*, 69:suppl. 280, 1966.
11. ————: Tyggeapparatets naturlige funktioner. In Krogh-Poulsen, W. and Carlsen, O. (ed.): *Bidfunktion/ Bettfysiologi, Part I.* Munksgaard, Copenhagen, 1973.
12. Ramfjord, S. P.: Dysfunctional temporomandibular joint and muscle pain. *J. Prosth. Dent.*, 11:353, 1961a.
13. ————: Bruxism, a clinical and electromyographic study. *J.A.D.A.*, 62:21, 1961b.
14. Troelstrup, B. and Møller, E.: Electromyography of the temporalis and masseter muscles in children with unilateral crossbite. *Scand. J. Dent. Res.*, 78:425, 1970.