Electromyographic investigation of chin cup therapy in Class III malocclusion

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Previous studies employing simultaneous bilateral surface electromyography (EMG) of the anterior temporal muscle and superficial masseter muscle have been conducted in adult females with normal occlusion, younger females with Class II malocclusion, and adult females with Class III malocclusion.[1,2] The findings indicate that EMG activity and muscle coordination in subjects with Class II or Class III malocclusion is different than in subjects with normal occlusion. Grossman et al.[3] reported that electromyography of the muscles of mastication has proven useful in determining the maxillomandibular relationship and could be useful in accompanying orthodontic treatment objectives. Clinical information as to the usefulness of EMG records in evaluating the effects of orthodontic[4,5] or surgical treatment[6-9] is lacking.

The correction of anterior crossbite is a primary objective in the early treatment of skeletal Class III malocclusion.

The purpose of this study was to test the hypothesis that the correction of anterior crossbite produces improved masticatory function with normally balanced EMG activity in patients treated with a chin cup.

Materials and methods

The sample consisted of 10 girls and 10 boys with Class III malocclusion characterized by anterior crossbite. The mean developmental age was 10 years, with a range of 8 years 1 month to 11 years 10 months. Pretreatment EMG and cephalometric records were compared with results obtained at the end of phase 1 chin cup treatment. The primary objective of the phase 1

Abstract

Electromyographic activity was evaluated in 20 patients (10 girls and 10 boys, mean age 10 years) with Class III malocclusion who were treated with a chin cup appliance. The posttreatment data were obtained at the end of phase 1 chin cup treatment when the anterior crossbite had been corrected. EMG activity of the masseter and temporal muscles for each subject were studied during unilateral chewing using the following parameters: mean cumulative voltage (MCV), mean maximum peak voltage (MMPV), and rotational direction of the differential lissajous EMG (DL-EMG).

The ANB angle improved from -1.0° (mean) to 0°. The electromyographic study revealed a decrease in masseter muscle activity on both the working (chewing) and balancing sides, with no improvement in the coordination of bilateral masseter and anterior temporal muscles.

Key Words

EMG • Skeletal Class III • Anterior crossbite • Chin cup

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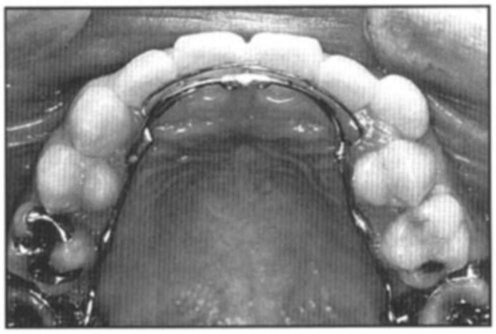

Figure 1A

Figure 1B

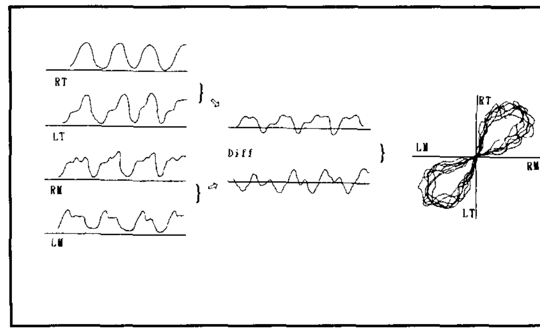

Figure 2

Table 1
Characteristics of 20 patients with Class III malocclusion

Case no.	Sex	Pretreatment age	Posttreatment occlusal condition	Period of chin cup use
1 (KK)	F	11 years 9 months	good	16 months
2	F	9 years 4 months	fair	21 months
3	M	8 years 1 month	bad	15 months
4	M	8 years 7 months	fair	13 months
5	M	9 years 6 months	good	19 months
6	M	10 years 8 months	bad	22 months
7	M	10 years 9 months	fair	12 months
8	F	11 years 1 months	good	21 months
9	M	8 years 3 months	good	12 months
10	F	9 years 0 months	good	17 months
11	F	10 years 8 months	fair	18 months
12	F	11 years 8 months	fair	18 months
13	F	11 years 3 months	fair	24 months
14	M	11 years 10 months	fair	16 months
15	F	9 years 1 month	fair	19 months
16 (RF)	M	10 years 1 month	fair	24 months
17	M	8 years 4 months	bad	21 months
18	F	9 years 0 months	good	20 months
19	F	10 years 5 months	fair	13 months
20	M	10 years 6 months	fair	12 months

Figure 1A-B
Lingual arch and chin cup appliances

Figure 2
Differential lissajous EMG pattern obtained from unilateral gum chewing. Refer to Deguchi T, et al. Angle Orthod 1994;65:151-160.

treatment was correction of the anterior crossbite (Figure 1A-B).This objective was fulfilled with the use of a chin cup and a modified Mershon lingual arch.

Cephalometric analysis was used to assess improvement of the skeletal discrepancy during treatment. EMG recordings were obtained for the anterior temporal and the superficial masseter muscles during unilateral gum chewing.

Patients were instructed to wear the chin cup appliance at night, for at least 7 to 8 hours. Chin cup use lasted for a mean of 17 months and ranged from 12 to 24 months (Table 1).

Dental model analysis

Severity of crowding and total arch-length discrepancy were estimated to classify the occlusal condition of the posttreatment dental model into three categories: good, fair, and bad (Table 1).

EMG recordings

Surface EMG activity was recorded simultaneously from the superficial masseter and the anterior temporal muscles during unilateral gum chewing. A detailed description of conventional EMG recordings and the differential lissajous EMG (DL-EMG) has been publised elsewhere.[1,2]

For each subject, the following parameters were evaluated on the right and left sides during chewing pre- and posttreatment: mean cumulative voltage (MCV), mean maximum peak voltage (MMPV) of EMG signals for the bilateral masseter and anterior temporal muscles, and the DL-EMG pattern.

The MCV was obtained by dividing total cumulative voltage by the number of cycles for each subject, and the MMPV was calculated from the original integrated EMG during chewing on each side. The rotational direction of the DL-EMG pattern during each cycle of right- and left-side chewing was assigned by the investigator after inspecting the loop pattern on the oscilloscope (Figure 2).

The data obtained before and after chin cup use were compared using Student's t-test and confirmed using the Wilcoxon's test after the F-test in the analysis of variance (ANOVA).

Results

Change in ANB angle

Cephalometric values for ANB angle were obtained from the cephalometric radiographs pre- and posttreatment. The mean pretreatment ANB angle was -1.0 degree (range -4.5 to 2.0 degrees), and the mean posttreatment angle was 0 degrees (range -4.0 to 3.5 degrees).

Dental model analysis

The anterior crossbite was corrected in all patients, and no teeth were extracted during phase 1 chin cup treatment (Figure 3A-F and Figure 4A-F).

Mean cumulative voltage (MCV)

MCV data are presented in Tables 2 and 3. The MCV of the masseter muscle on the working side tended to decrease posttreatment during chewing on the left side (from 26.62 mV to 20.63 mV), and the MCV of the masseter muscle on the balancing side decreased significantly during right-

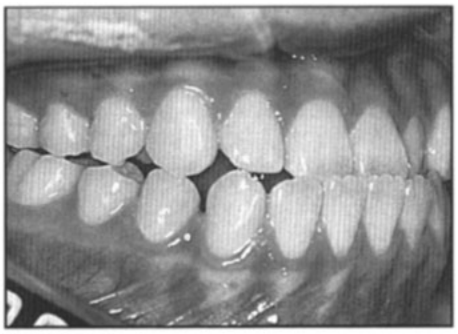

Figure 3A

Figure 3B

Figure 3C

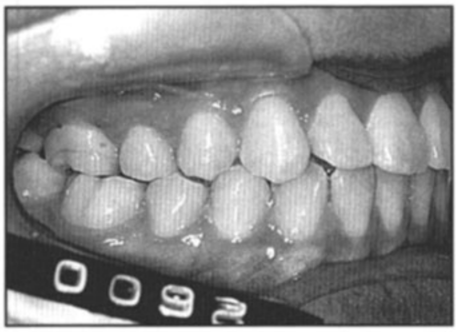

Figure 3D

Figure 3E

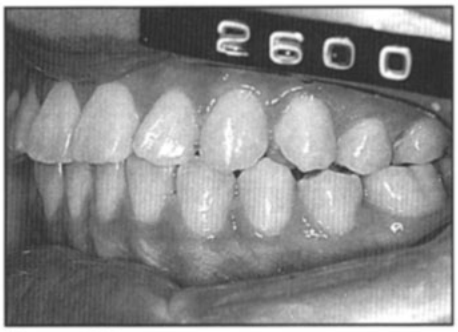

Figure 3F

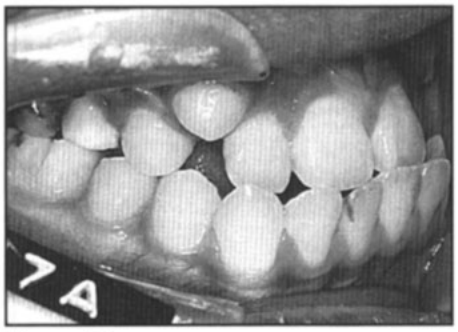

Figure 4A

Figure 4B

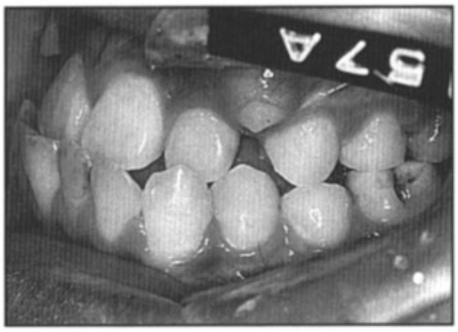

Figure 4C

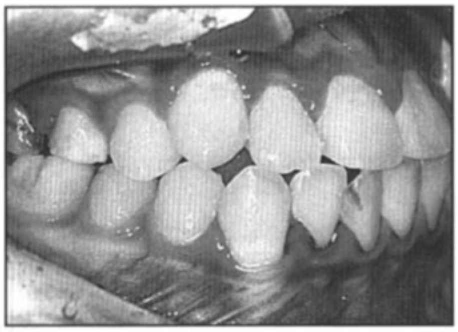

Figure 4D

Figure 4E

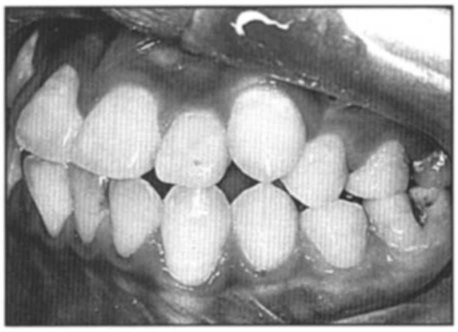

Figure 4F

Case No.1
Figure 3A-F
Pre- and posttreatment intraoral photographs

Case No.16
Figure 4A-F
Pre- and posttreatment intraoral photographs

side chewing (from 17.29 to 12.08, $p<0.05$). Posttreatment, the masseter muscle showed significantly lower activity ($p<0.01$) on the balancing side than the temporal muscle (13.59 vs. 18.78) during left-side chewing. During both pre- and posttreatment the masseter muscle showed consistently higher activity ($p<0.01$) on the working side than on the balancing side during unilateral chewing.

Mean maximum peak voltage (MMPV)

MMPV data are presented in Tables 4 and 5. Masseter muscle MMPV tended to decrease posttreatment, similar to MCV. However, MMPV pre- and posttreatment consistently showed significant differences between the working and balancing sides for EMG activity of the masseter and temporal muscles.

Table 2
Mean cumulative voltage (MCV) of EMG signals during right-side chewing pre- and posttreatment

Variation between groups	MCV, mean (SD) Pretreatment		Posttreatment	
Temporal right (working)	24.29 (13.11)		24.51 (12.87)	
Temporal left (balancing)	23.65 (15.69)		19.17 (13.54)	
Masseter right (working)	27.25 (13.01)	** (right vs. left)	25.46 (12.60)	** (right vs. left)
Masseter left (balancing)	17.29 (11.52)	* (pre vs. post)	12.08 (8.47)	

**p<0.01; *p<0.05
unit: mV

Table 3
Mean cumulative voltage (MCV) of EMG signals during left-side chewing pre- and posttreatment

Variation between groups	MCV, mean (SD) Pretreatment		Posttreatment	
Temporal right (balancing)	17.67 (10.51)	* (temporal right vs. left)	18.78 (10.59)	** (temporal right vs. masseter right)
Temporal left (working)	26.52 (19.81)		23.10 (15.47)	
Masseter right (balancing)	16.30 (10.01)	* (masseter right vs. left)	13.59 (9.16)	* (masseter right vs. left)
Masseter left (working)	26.62 (16.75)		20.63 (11.37)	

**p<0.01; *p<0.05
unit: mV

Rotational direction

For the three rotational direction patterns, statistical analysis disclosed no significant difference between pre- and posttreatment phases. A low percentage of normal clockwise rotation and a high percentage of indeterminate rotation were observed both before and after phase 1 chin cup therapy (Table 6).

Discussion

Although postural EMG activity was not obtained in the present EMG study, there was no significant difference between normal and anterior crossbite groups at rest,[10] or between Class II and Class III malocclusions[11] at rest. There was also no clear relationship between the severity (good, fair, or bad) of dental arch discrepancy in the present dental cast analysis. The present posttreatment EMG data could have been obtained after phase 2 treatment was complete. The prolonged chin cup use, however, may complicate the effect of chin cup therapy only because EMG activity is affected by aging.

Traditionally, orthodontic treatment goals fall into four categories: good dental alignment, improvement of skeletal profile, good soft tissue profile, and normal function. Electromyography is one method of evaluating masticatory function. However, we are not sure how EMG activity is related to orthodontically treated occlusion.

This EMG study found that masseter muscle EMG activity tended to decrease posttreatment on both the working and balancing sides. We speculated that masticatory muscle activity and bite force could increase with age,[12,13] and this might account for the increased EMG activity of the masseter muscle.

But why does EMG activity of the masseter muscle decrease posttreatment? Several studies support either decreased or increased EMG activity of masticatory muscles after orthodontic treatment. For example, subjects with Class III malocclusion continued to show low masseter muscle activity after orthodontic treatment,[14,15] but out of retention, activity rebounded.[14] The postural (pseudo) skeletal Class III group showed higher activity of the masseter muscles in the protruded position of the mandible,[14,15] particularly after correction of anterior crossbite by the monobloc[15] or unchanged by orthodontic treatment.[10] In mandibular advancement, 6-month use of an activator showed no increase in masseter muscle activity and decreased temporal muscle activity[16] and decreased postural EMG activity of the masseter with gradual return toward the initial phase in monkeys.[17]

The learned path of closure in the mandible[18] may be controlled by receptors in and around the oral structures, such as muscle spindles, periodontal mechanoreceptors, and baroreceptors in the oral mucosa and the temporomandibular joint.[15] The masticatory muscles contain the largest number of these receptors.[19] Periodontal mechanoreceptor stimulation may have a powerful influence on EMG activity of the anterior temporal and masseter muscles.[20] The patients with combined functional and true skeletal Class III malocclusion in the present study induce an anteriorly forced position of the mandible associated with avoiding edge-to-edge incisor contact from physiological rest position to habitual occlusion,[21] serving to regulate abnormal masticatory function[11] through the receptors. In the present study, this incisor contact influenced EMG activity and muscle coordination. Correction of the anterior crossbite, however, did not improve the DL-EMG pattern associated with muscular coordination and also decreased EMG activity of the masseter muscle posttreatment. Decreased masseter muscle activity posttreatment may depend on dominance of learned path of closure[18] (endogenous protrusive mandibular position), forced distal position of the mandible (which induces low activity of the anterior masseter muscle[3]), or functionally unstable occlusion in the late mixed dentition.

Another question is how masticatory muscle activity could increase during and after orthodontic treatment. The answer might lie in the fact that muscle thickness[22] and activity[23] are significantly correlated with bite force, occlusal tooth contact, and skeletal morphology.[24] From a clinical point of the view, decreased activity of the masseter muscle posttreatment could be improved to get higher bite force and muscle training, as early as possible, through mastication. The use of a monobloc[14] or bite block may be a choice during early Class III treatment.

The assumption behind use of the bite block could be that the magnitude of muscle force is strongly associated with localization of physiologic equilibrium (biting point[25] of the mandible), whose location is different among Class I, II, and III occlusal relationships.[26]

Conclusion

The present EMG findings fail to support the hypothesis that correction of the anterior crossbite increases the EMG activities of the masseter and anterior temporal muscles or improves coordination of the bilateral masseter and anterior temporal muscles. Decreased activity and lack of improvement in the coordination of masticatory muscles may suggest the importance of muscle training associated with a bite force during or after orthodontic treatment.

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Table 4
Mean maximum peak voltage (MMPV) of EMG signals during right-side chewing pre- and posttreatment

	MMPV, mean (SD)	
Variation between groups	Pretreatment	Posttreatment
Temporal right (working)	1.99 (0.81)	2.19 (0.88)
Temporal left (balancing)	1.54 (0.81)	1.33 (0.69)
Masseter right (working)	1.87 (0.98)	1.83 (1.11)
Masseter left (balancing)	1.20 (0.84)	0.96 (0.50)

**p<0.01; *p<0.05
unit: mV

Table 5
Mean maximum peak voltage (MMPV) of EMG signals during left-side chewing pre- and posttreatment

	MMPV, mean (SD)	
Variation between groups	Pretreatment	Posttreatment
Temporal right (balancing)	1.59 (0.82)	1.70 (0.84)
Temporal left (working)	1.89 (1.17)	1.67 (0.94)
Masseter right (balancing)	1.00 (0.66)	0.84 (0.46)
Masseter left (working)	2.02 (1.18)	1.82 (0.93)

**p<0.01; *p<0.05
unit: mV

Table 6
Rotational direction of differential lissajous EMG figures pre- and posttreatment

	Rotational direction (%); mean (SD)		
Chewing side	Clockwise	Counterclockwise	Indeterminate
Pretreatment			
Right	17.7 (23.2)	6.89 (11.6)	75.4 (21.8)
Left	12.4 (19.0)	8.28 (13.4)	79.3 (21.3)
Posttreatment			
Right	26.9 (26.4)	3.73 (7.96)	69.4 (25.2)
Left	20.2 (25.8)	4.84 (12.2)	74.9 (25.5)

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