Original Article

Electromyographic Activities of Masticatory Muscles in Class III Patients Treated by Facemask With Miniplate Anchorage

Demet Kaya, DDS, PhD[1,*] and İlken Kocadereli, DDS, PhD[2]

ABSTRACT

Aim: The aim of this study was to investigate electromyographic (EMG) activities of left and right anterior temporal, masseter, and anterior digastric muscles during resting, maximum voluntary clenching, and swallowing before and after facemask treatment.

Materials and Methods: Fifteen patients with Class III malocclusion (mean age, 12.1 ± 1.43 years) were included in this study. The patients were treated by means of facemask with miniplate anchorage after 8 weeks of alternate rapid maxillary expansion and constriction (Alt-RAMEC) protocol. Before and after treatment, EMG examinations during resting, maximum voluntary clenching, and swallowing were carried out on all subjects. Total treatment time was 9.9 ± 2.63 months. Changes in the activities of right and left anterior temporal, masseter, and anterior digastric muscles were tested by using the Wilcoxon signed rank test.

Results: The EMG activities of left and right anterior temporal, masseter, and anterior digastric muscles during resting, maximum voluntary clenching, and swallowing did not show any statistically significant changes after treatment ($p > .05$).

Conclusion: The EMG evaluation showed that facemask treatment with miniplate anchorage after the Alt-RAMEC protocol did not change the EMG activities of left and right anterior temporal, masseter, and anterior digastric muscles in patients with Class III malocclusion. (*Turkish J Orthod* 2013;26:65–71)

KEY WORDS: Class III, Electromyography, Facemask, Masticatory Muscles

INTRODUCTION

Patients with Class III malocclusion are often referred to orthodontic departments with the chief complaint of improper occlusion between the maxilla and mandible. It has been reported that in Class III malocclusion a crossbite between maxillary and mandibular teeth forces the mandible to move forward, thus causing a change in the activity of the muscles that position the mandible. Previous studies have shown that electromyographic (EMG) activity and muscle coordination could be both different and similar in patients with Class III malocclusion compared with patients with normal occlusal relationships.[1–5] Miralles *et al*.[3] stated that during swallowing, the EMG activity of the masseter muscle was greater in patients with Class III malocclusion than in subjects with Class I, whereas the EMG activity of the anterior temporal muscle was similar in subjects with Class I and Class III malocclusion. During maximal voluntary clenching, the EMG activities of these two muscle groups did not show any significant difference between the groups. It was found that at rest position, the EMG activities of both muscles were greater in patients with Class III malocclusion than in patients with Class I malocclusion.[3] In a study of 105 patients with different sagittal skeletal relationships, Cha *et al*.[1] emphasized that the anterior temporal muscle activity increased as Class III tendency increased, and there was no significant difference in the activity of masseter muscle between the groups during clenching and at rest. Moreno *et al*.[4] reported that in patients with

[1]Clinical Instructor, Karadeniz Technical University, Faculty of Dentistry, Department of Orthodontics, Trabzon, Turkey

[2]Professor and Head, Hacettepe University, Faculty of Dentistry, Department of Orthodontics, Ankara, Turkey

*__Corresponding author:__ Dr Demet Kaya, Karadeniz Teknik Üniversitesi, Diş Hekimliği Fakültesi, Ortodonti Anabilim Dalı, 61080, Trabzon, Turkey. Phone number: +90-462-377 47 59 E-mail: ortodem@hotmail.com

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Class III malocclusion, the EMG activities of anterior temporal and masseter muscles were higher during clenching at maximum intercuspation compared to patients with Class I malocclusion; however, this difference was not statistically significant. Moreover, the EMG activities of all muscles were similar between patients with Class I and Class III malocclusion during swallowing. Tecco *et al.*[5] showed that the EMG activities of anterior temporal and masseter muscles were higher in patients with Class III malocclusion than in patients with Class I malocclusion at mandibular rest position; however, no significant differences were observed in muscle activity between the groups during maximal voluntary clenching.

Even though the effects of early treatment of Class III malocclusion on dentition, skeletal structures, and soft tissue profile have been well documented,[6–10] the effects on masticatory muscles have not yet been investigated in detail. Only a few studies in the literature address this topic.[11–13] In these studies, the EMG activities of anterior temporal and masseter muscles were mainly evaluated. In a study of 10 patients with skeletal Class III malocclusion (mean age, 6 years 8 months), Nuno-Licona *et al.*[11] stated that there were no significant changes in the EMG activities of anterior temporal and masseter muscles with monoblock treatment. Deguchi and Iwahara[12] investigated superficial masseter muscle activity with electomyelography after chin cup treatment in 20 children with skeletal Class III malocclusion (mean age, 10 years) and found that there was a reduction in EMG activity of the masseter muscle at the end of treatment.

Facemask therapy is a commonly used method for the early treatment of Class III malocclusion. However, there is only one study investigating the EMG activity of the masticatory muscles after the treatment of Class III malocclusion with facemask. In that study, muscle pain and EMG activity of the masseter muscle were evaluated before, during, and after the application of an orthopedic facemask. No statistically significant difference was found in masseter muscle activity and muscle pain between these time periods.[13]

The aim of this study was to investigate the EMG activities of left and right anterior temporal, masseter, and anterior digastric muscles before and after facemask treatment with miniplate anchorage after the alternate rapid maxillary expansion (RME) and constriction (Alt-RAMEC) protocol.

MATERIALS AND METHODS

Fifteen patients (9 girls and 6 boys) with a mean chronological age of 12.1 ± 1.43 years were included in the study. The patients met the following criteria: no history of previous orthodontic/orthopedic treatment, no systemic diseases/congenital deformities, concave profile, skeletal (mean ANB angle, −1.3° ± 1.76°; mean Witts appraisal, −7.1 ± 3.09 mm; McNamara, −3.5 ± 1.56 mm; convexity, −2.1 ± 1.97 mm; maxillary depth angle [FH-NA], 86.6° ± 1.73°; SNB angle, 78.2° ± 2.93°; facial depth angle [FH-Npog], 88.7° ± 2.34°)[7] and dental Class III malocclusion, edge-to-edge/reverse incisor relationship, and symptom-free temperomandibular joint function. After a detailed explanation of treatment procedures, parents gave their written consent. The study was approved by the Ethical Committee of the Hacettepe University Medical School (institutional approval number LUT 06/91-20).

A bonded RME appliance was fabricated for each patient. The screw of the RME appliance was alternately opened and closed for 2-week period over the course of 8 weeks in order to disarticulate the circummaxillary sutures. The treatment protocol began with expansion, followed by final constriction. Daily activation for the expansion/constriction course was 0.5 mm. After the final constriction course, titanium miniplates (Multipurpose Implant, Tasarimmed, Istanbul, Turkey) were adapted to the lateral nasal wall of the maxilla under local anesthesia. Straight extensions of the miniplates were bent distally to avoid applying pressure to the attached gingiva and so that elastics could be applied. The miniplates were fixed with three screws (2-mm diameter, 5 or 7 mm in length, Mondeal, Tuttlingen, Germany). After soft tissue healing (10 days), a Delaire-type facemask was adjusted for the patients, and 100 *g* of force per side was applied via elastics between the miniplates and facemask. The force was increased by 350–400 *g* per side during the second week of treatment. The direction of force was 30° forward and downward to the occlusal plane so that the force vector was closer to the center of the resistance of the nasomaxillary complex. The patients were advised to wear the facemask full time. When the desired forward movement of the maxilla was achieved for a good profile, the miniplates and bonded RME appliance were removed. The details in the treatment protocol used in this study were explained in a previous study.[7] The treatment, including 8 weeks of Alt-RAMEC protocol, lasted 9.9 ± 2.63 months.

A surface EMG examination (BioPAK Version 2.03 System, BioResearch Inc, Milwaukee, WI, USA) was performed on all patients to evaluate the EMG activities of their masticatory muscles before (T0) and after treatment (T1). The EMG activities of right and left anterior temporal, masseter, and anterior digastric muscles were evaluated before and after treatment. Disposable bipolar surface electrodes and BioEMG 8-channeled amplifier (BioResearch Inc, Milwaukee, WI, USA) were used for EMG recording.

In order to locate the anterior temporal and masseter muscles, patients were asked to clench their teeth as strongly as possible, and in this position those muscles were identified by palpation. Patients were asked to slightly tilt their heads backward and swallow so that the anterior part of the digastric muscle group could be identified by palpating under the chin.

The skin was cleaned thoroughly with alcohol before positioning the electrodes on both the right and left anterior temporal, masseter, and anterior digastric muscles (parallel to the fibers). The anterior temporal muscle electrode was placed vertically along the anterior margin of the muscle. The masseter muscle electrode was placed parallel to the muscular fibers with the upper pole of the electrode at the intersection of the targus-labial commissure and exocanthion-gonion lines. The anterior digastric muscle electrode was placed bilaterally between the menton neck line. To avoid an electronic sound, the electrodes were not placed on hairy skin and were closely attached to the muscle. A reference electrode was positioned on the right shoulder for static grounding. The BioEMG 8-channeled amplifier was connected after the electrodes were placed, and the patients sat with the back upright and the feet flat on the floor, looking straight ahead and in a position in which they could not see the computer monitor during recording. The EMG activities of anterior temporal, masseter, and anterior digastric muscles were evaluated while the patient was in three different positions:

- Resting registration: The patient was asked to swallow and then to let his or her jaw relax. The doctor decided whether the patient was in resting position. The EMG activities of the muscles were recorded for 10 seconds after the patient had maintained this resting position for 1 minute.
- Maximal voluntary clenching registration: The patient was asked to clench as hard as possible in the intercuspal position and then to relax. This procedure was repeated three times for 10 seconds.
- Swallowing registration: The patient was asked to collect saliva in the mouth, and then the EMG activities of the muscles were recorded when the patient was asked to swallow.

The calibration values set in the program were not changed while the EMG records were taken. These values were 20 V for resting position and 200 V for maximal voluntary clenching and swallowing positions. When evaluating the EMG records at rest, 3 areas were marked randomly on the obtained activity images, and the mean EMG value was calculated for right and left muscle groups. When evaluating functional EMG records, 3 areas that showed maximum muscle activity were selected, and the mean EMG values in these regions were calculated. The EMG activities of the muscles were measured by one investigator (D.K.).

Normality of the data was tested with the Shapiro-Wilks test. Statistical evaluation was conducted using a Wilcoxon signed rank test. Descriptive statistics were given as means, SDs (standard deviations), medians, and minimum and maximum values. Statistical significance was set at the $p < .05$ level.

RESULTS

The EMG activities of left and right anterior temporal, masseter, and anterior digastric muscles at rest and during maximal voluntary clenching and swallowing did not change significantly after treatment. (Tables 1 through 3).

DISCUSSION

The EMG technique allows for the acquisition of electrical signals generated in muscle fibrils and transmitted along the tissues. It was used for the first time in dentistry by Robert E. Moyers.[14] The electrodes used for recording the electric signals are placed on the skin surface overlaying a muscle or subdermally next to or into a muscle with the help of pin electrodes. Electromyography can evaluate a single muscle fibril or muscle group when performed with pin electrodes; however, because the method is

Table 1. Comparison of EMG activities of anterior temporal, masseter, and anterior digastric muscles at rest before (T0) and after (T1) facemask treatment

Resting	Time	Mean	SD	Median	Minimum	Maximum	*p**
Anterior temporal muscle (μV)							
Right	T0	2.2	1.59	1.5	0.4	5.8	0.53
	T1	2.1	1.18	1.6	0.8	5.4	
Left	T0	3.1	1.84	2.4	0.4	5.2	0.70
	T1	2.9	1.68	2.2	1.3	6.1	
Masseter muscle (μV)							
Right	T0	3.1	2.08	2.1	0.7	7.0	0.17
	T1	2.1	1.59	1.4	0.7	6.0	
Left	T0	2.6	1.75	2.0	0.9	6.0	0.95
	T1	2.3	1.14	2.2	0.8	5.1	
Anterior digastric muscle (μV)							
Right	T0	3.9	1.38	4.2	1.5	5.5	0.93
	T1	3.7	1.98	5.0	0.9	6.0	
Left	T0	3.1	2.01	2.4	0.4	6.1	0.08
	T1	2.1	0.94	1.8	0.7	4.1	

* $p < 0.05$.

invasive, it is not used regularly. In addition, there is a risk of infection and application can be painful.

In contrast, the surface EMG technique evaluates whole muscle structure by way of bipolar electrodes placed on skin surface. Electrodes are placed on the midpoint between the point of origin and insertion through the longitudinal line of the muscle. Therefore, the electrode interacts with as many muscle fibrils as possible. Moreover, the possibility of recording the signals emitted by adjacent structures is minimized. It is a noninvasive method and does not cause discomfort or pain to the patients.[15] There is also no risk of infection. On the other hand, the disadvantage of the method is that misleading readings are recorded when there is a change in the distance between the electrode and the muscle during the muscle contraction. Recordings obtained with surface EMG were found to be repeatable with a high accuracy when a well-standardized protocol was used.[16]

Surface EMG is a commonly used method in the evaluation of anterior temporal, masseter, anterior digastric, and sternocleidomastoid muscles. In the present study the EMG activities of anterior temporal, masseter, and anterior digastric muscles were evaluated at rest and during maximal voluntary teeth

Table 2. Comparison of EMG activities of anterior temporal, masseter, and anterior digastric muscles during maximal voluntary clenching before (T0) and after (T1) facemask treatment

Maximal Voluntary Clenching	Time	Mean	SD	Median	Minimum	Maximum	*p**
Anterior temporal muscle (μV)							
Right	T0	58.4	45.89	54.5	0.5	146.5	0.84
	T1	55.4	32.84	52.7	0.2	114.5	
Left	T0	63.4	35.34	55.9	0.6	111.4	0.19
	T1	49.3	31.03	41.7	2.6	107.8	
Masseter muscle (μV)							
Right	T0	63.6	58.52	52.8	6.3	197.8	0.14
	T1	47.7	40.11	32.4	3.1	150.9	
Left	T0	64.9	53.38	65.6	3.3	197.7	0.17
	T1	53.9	43.12	43.9	10.8	182.2	
Anterior digastric muscle (μV)							
Right	T0	8.8	4.67	7.0	2.7	17.5	0.53
	T1	8.7	5.26	6.4	2.1	20.9	
Left	T0	10.0	9.37	6.2	0.3	33.1	0.33
	T1	9.8	8.84	7.1	2.3	33.4	

* $p < 0.05$.

Table 3. Comparison of EMG activities of anterior temporal, masseter, and anterior digastric muscles during swallowing before (T0) and after (T1) facemask treatment

Swallowing	Time	Mean	SD	Median	Minimum	Maximum	p*
Anterior temporal muscle (μV)							
Right	T0	6.2	5.18	4.8	0.5	18.8	0.92
	T1	5.7	5.91	3.9	0.2	25.0	
Left	T0	8.5	4.94	7.7	1.6	19.9	0.69
	T1	7.8	4.64	6.2	2.7	17.3	
Masseter muscle (μV)							
Right	T0	6.7	2.66	6.1	3.4	13.1	0.54
	T1	6.3	1.76	6.6	3.4	9.3	
Left	T0	8.0	4.88	6.4	3.6	23.6	0.87
	T1	7.2	2.76	6.2	3.9	14.3	
Anterior digastric muscle (μV)							
Right	T0	21.6	16.02	17.4	1.67	58.8	0.47
	T1	19.1	10.07	19.0	2.4	41.9	
Left	T0	26.5	23.79	16.9	0.3	80.6	0.77
	T1	20.9	12.06	19.9	3.2	54.4	

* $p < 0.05$.

clenching and swallowing. A control group was not included in the study because of ethical concerns.

It has been shown that in healthy subjects at rest, EMG values change between 0.5 and 1.4 μV for masseter muscle, 1.0 and 1.9 μV for anterior temporal muscle, and 1.0 and 1.5 μV for anterior digastric muscle.[15,17] In our study, muscle activity values before treatment were higher than values obtained in the literature. This finding is in agreement with studies stating that when the Class III tendency increases the activity of anterior temporal muscle at rest also increases, and that the activities of the anterior temporal and masseter muscles are higher in patients with Class III malocclusion.[1,3,5] Miralles *et al.*[3] indicated that the increased muscle activities of patients with Class III malocclusion could be related to the position of both jaws. Therefore, it seems normal that in our study patients had increased muscle activity at T0. In the present study, the EMG values of the muscles at rest decreased after the treatment protocol; however, the decrease was not statistically significant. Similarly, Ngan *et al.*[13] detected an insignificant decrease in the EMG activity of masseter muscle after facemask treatment. Although a Class I relationship was obtained in all patients after treatment, the EMG values of anterior temporal, masseter, and anterior digastric muscles were higher than those reported in the literature.[15,17] Ferrario *et al.*[17] and Burdette and Gale[18] reported that the EMG activity of anterior temporal muscle at rest was higher than that of masseter muscle in healthy subjects; therefore, it should consume more energy and be more active. In the present study, for both T0 and T1, this was found to be valid on the left side but masseter muscle was more active than anterior temporal muscle on the right side. The anterior digastric muscle contributes to the stability of the mandible at rest position less than other muscles and therefore shows lower activity.[19] However, in the present study the anterior digastric muscle showed the lowest EMG activity.

When the EMG activities were investigated during clenching at T0 and T1, the values obtained from masseter and anterior temporal muscles were lower than the values found in healthy subjects by Ferrario *et al.*[17] (161.7–181.9 μV for anterior temporal muscle and 156.8–216.2 μV for masseter muscle). As Helkimo *et al.*[20] stated, the reason for the low readings could be the small number of teeth contacting in the posterior area; hence, lower bite forces may have been generated. In this context, the decreased contact between posterior teeth due to spacing between posterior teeth at the end of treatment could explain the insignificant reduction in T1 values of anterior temporal and masseter muscles compared to T0. Another explanation could be that although all patients were given the same instructions, some clenched their teeth more strongly than others, as Algren *et al.*[21] stated. Kerstein[22] reported that the activity of masseter muscle was higher than that of the anterior temporal muscle during clenching of the teeth. Ferrario *et al.*[17] showed that during clenching of the teeth, the masseter muscle was more active than the anterior temporal muscle in healthy males, whereas in healthy females the anterior temporal muscle was more active than the masseter muscle. Moreno *et al*.[4] stated that during clenching at maximum intercuspation, the anterior temporal muscle was more active than the masseter muscle. In the present study, at the beginning of treatment the EMG activity of the masseter muscle was higher than that of the anterior temporal muscle. At the end of treatment this relationship was protected on the left side, but the anterior temporal muscle became more active than the masseter muscle on the right side. The higher activity of the anterior temporal muscle compared with the masseter muscle could be associated with fewer posterior contacts on that side.[18,22] We detected that the lowest EMG values at T0 and T1 were for the anterior digastric muscle. Although Class III malocclusion was corrected to Class I at the end of treatment, no significant change was observed in the EMG values of the muscles from T0 to T1. Similarly, Nuno-Licona *et al*.[11] found that the EMG activity of temporal and masseter muscles did not change significantly after the treatment of Class III patients. On the other hand, Miyamoto *et al*.[23] reported that when a change occurred in the occlusal relationship, it would affect the EMG activity of the masseter muscle.

During swallowing, the anterior temporal and the masseter muscles on both sides should be symmetrically active, and the masseter muscle should show the highest electrical activity. Meanwhile, the anterior digastric muscle should show lower activity than the anterior temporal and the masseter muscles. The reason for this is that swallowing requires the teeth to come into occlusion. Once the occlusal contact is obtained, the activity of the anterior digastric muscle increases.[15] In the present study, EMG records taken when swallowing had just occurred showed that the anterior digastric muscle had the highest EMG activity. It was detected that during swallowing, the EMG activities of anterior temporal and masseter muscles were within the normal range[15] at T0 and T1. There is no study in the literature showing the EMG activity of anterior digastric muscle during swallowing before and after orthopedic facemask treatment. With this treatment approach, no significant changes were observed in the EMG activities of anterior temporal, masseter, and anterior digastric muscles during swallowing.

When EMG findings were evaluated as a whole, there were no changes in the EMG activities of anterior temporal, masseter, and anterior digastric muscles with this treatment protocol. This could be due to the small number of patients in the study group as well as the lack of proper tooth contacts as muscle activities were measured before fixed appliance therapy. Furthermore, functional adaptation to a newly formed morphologic structure requires time; therefore, it is important to evaluate the long-term results of the treated group.

CONCLUSION

From our study conducted on 15 patients (mean age, 12.1±1.43 years) who had Class III malocclusion, it can be concluded that the EMG activity of anterior temporal, masseter, and anterior digastric muscles at rest and during maximum voluntary clenching and swallowing did not change significantly after facemask therapy with skeletal anchorage following Alt-RAMEC protocol.

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