# Electromyographic Muscular Activity Improvement in Class II Patients Treated with the Pre-Orthodontic Trainer

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***Objective:*** *A study was designed to determine changes in the amplitude of the EMG muscular activity of the Masseter and Temporalis muscles at clench in children with a Class II, division 1 malocclusion treated with the pre-orthodontic Trainer functional appliance, for 12 months.* ***Study Design:*** *36 Class II, division 1 malocclusion patients (mean age 7.6 ± 1.3 years) composed the treated group and wore the functional appliance; 22 children with a similar age and malocclusion composed the untreated controls; and, 20 children with no dental malocclusion participated as normal controls. Electromyographic (EMG) muscular activity of the Temporalis and Masseter muscles were recorded before and after treatment.* ***Results:*** *Subjects in the treated group reported a bilateral significant increase in the muscular electrical activity in the both tested muscles (p < 0.001). After treatment, they recorded values similar to those measured in normal controls, whereas the untreated controls remained on lower values.* ***Conclusion:*** *These results confirm that treatment with the pre-orthodontic Trainer functional appliance significantly increases the EMG muscular activity in the Temporalis and Masseter muscles at clench in patients with Class II, division 1 malocclusion.*

*Key words: Class II, malocclusion, electromyography, children*

## INTRODUCTION

The efficiency of the functional appliances on craniofacial growth modification is still under controversy. [1] Some reports suggest that functional appliances can stimulate mandibular growth, [2,3] while others deny such effect. [4,5] Studies investigating on the efficiency of the functional appliances have failed to demonstrate there is mandibular growth. However, treatment with functional appliances should modify muscular activity in order to improve mandibular posture. [6,7] In that context, the literature is lacking on studies evaluating changes in the muscles holding the mandible and performing the mandibular movements when evaluating functional appliances' efficiency.

One of the functional appliances reported in the literature (Pre-orthodontic Trainer, Myofunctional Research Co, Helensvale, Queensland, Australia), has demonstrated to posture the mandible forward in patients with Class II, division 1; [8] and, to increase the transverse dimensions of the maxillaries. [9] Those effects must be associated to changes in the masticatory muscles' biology. The latter statement has been partially supported by recent electromyographic studies, where six months of treatment with the functional appliance positively influenced the masticatory and perioral musculature. [10,11]

Those previous studies evaluated the EMG's frequency in some masticatory muscles, [10,11] which refers to the rate at which a muscle fatigue. So, they demonstrated the functional appliance reduces the EMG's frequency at the Temporalis and Masseter, evidencing the pre-orthodontic appliance reduces the fatigue in those muscles. On the other hand, the amplitude is a measurement of the force produced by a muscle during its contraction. [12] It is necessary to elucidate if the appliance may change the EMG's amplitude of the masticatory muscles. Such information is important, as changes in the force produced by a masticatory muscle consequently changes the load delivered by that muscle on the maxillaries.

The following hypothesis was proposed: "The pre-orthodontic Trainer increases the amplitude of the EMG activity in the Temporalis and Masseter muscles at clench". Thus, a study was designed aiming to evaluate changes in the amplitude of the EMG muscular activity of the Masseter and Temporalis muscles at clench in children with a Class II, division 1 malocclusion treated with that functional appliance. Electrical muscular activities of both, Temporalis and Masseter muscles were determined by means of surface EMG, which is a non-invasive and reproducible method. [13,14]

## MATERIALS AND METHOD

Fifty-eight patients (mean age 7.6 ± 1.3 years) classified as Class II, division 1 dental malocclusion associated to mandibular retrognatism (SNB angle < 78 degrees; SNA angle 82 degrees ± 2) were selected from a group of 127 children examined. All selected patients were invited to participate in the study and, an informed

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consent following the policies of the Research Ethical Board of the I.I. Mechnikov North-Western State Medical University in Saint Petersburg, Russia, was delivered (Ethical approval number 68, November 21, 2009). The inclusion criteria involved children with no previous orthodontic treatment, no tonsils/adenoid hypertrophy (50% or less tonsils occupancy at the mouth faucets), and no malformations or systemic disease which could affect the response to treatment.

Out of the 58 children initially selected, 36 children and parents accepted to participate in the study and composed the treated group. Children in that group were instructed to wear the pre-orthodontic Trainer one hour during the daytime and at night when sleeping. The other 22 children refused to use a removable appliance, as they preferred to be treated with fixed appliances. The latter group was invited to participate as untreated controls. They did not use any appliance and the parents consented to start their fixed orthodontic treatment at the end of the study. Additionally, 20 children with a similar age and no dental malocclusion were invited to participate in the study as normal controls. Thus, three groups were defined for the study: Treated Group (n=36); Untreated group (n=22) and the normal control group (n=20). A record of appliance usage was maintained by the parents of those children in the treated group.

Surface EMG activities of the right and left Masseter and Anterior Temporalis muscles were recorded using an eight-channel electromyograph (Duo-Trode; Myotronics Inc., Seattle, WA, USA). Silver/silver chloride surface bipolar electrodes were positioned on the studied muscles parallel to the muscular fibers at the middle region. The skin was cleaned and then moisturized with a conductive paste prior to electrodes placement. EMG recordings were acquired 5-6 minutes later and the EMG signal was amplified, digitized (12b resolution, 2230 Hz A/D sampling frequency), and filtered (high-pass filter set at 30 Hz, low pass filter set at 400 Hz, band stop for common 50/60 Hz noise). EMG activity was recorded in microvolts (μV). During all recordings, the patients were seating with their head unsupported, maintaining a natural erect position with their feet on the floor.

## Statistical Analysis

A power analysis was performed using a statistical package (PROC, SAS Institute Inc, NC, USA), to determine the minimum sample size. Assuming a common standard deviation of 60 μV and 80% power, the power analysis reported a minimum of 27 subjects for the study.

EMG muscular activity for both of the tested muscles was recorded at three different times with intervals of 15 minutes

Figure 1. Intraoral photographs of a patient participating in the study (A) Frontal view of the dental occlusion before treatment; (B) Lateral view of the dental occlusion before treatment; (C) Frontal view of the dental occlusion after 12 months of treatment with the pre-orthodontic Trainer functional appliance; and (D) Lateral view of the dental occlusion after 12 months of treatment with functional appliance.

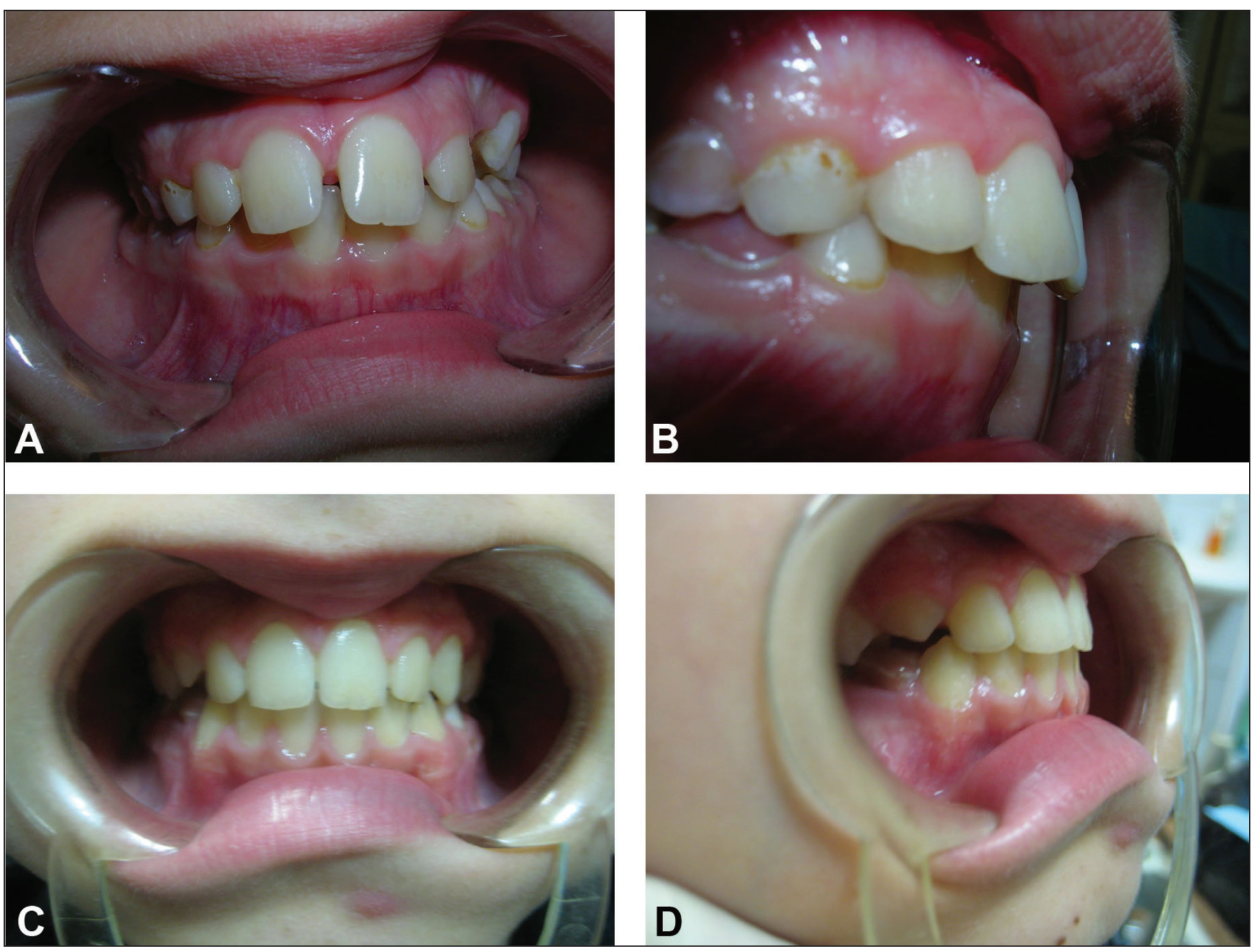

Table I. EMG activity of the studied muscles at clench expressed in micro-volts. Difference expresses the amount of improvement in micro-volts after 12 months of treatment with the functional appliance.

| Muscle | Before | SD | After | SD | Difference | SD | Statistics |
|---|---|---|---|---|---|---|---|
| **Group: Treated** | | | | | | | |
| Masseter Left | 472.90 | ± 26.24 | 695.40 | ±67.36 | 222.53 | ±68.82 | *** |
| Masseter Right | 474.70 | ±29.91 | 696.00 | ±68.29 | 221.28 | ±69.24 | *** |
| Temporalis Left | 494.60 | ±28.45 | 680.80 | ±71.21 | 186.22 | ±70.89 | ** |
| Temporalis Right | 494.60 | ±29.49 | 681.80 | ±69.34 | 187.19 | ±70.40 | ** |
| **Non-Treated** | | | | | | | |
| | Before | SD | After | SD | Difference | SD | Statistics |
| Masseter Left | 461.40 | ±24.39 | 434.50 | ±43.35 | - 26.95 | ±37.86 | NS |
| Masseter Right | 461.50 | ±23.84 | 434.20 | ±42.38 | - 27.36 | ±36.28 | NS |
| Temporalis Left | 478.70 | ±21.8 | 448.00 | ±42.27 | - 30.73 | ±37.53 | NS |
| Temporalis Right | 477.60 | ±21.64 | 449.70 | ±43.88 | - 27.91 | ±38.34 | NS |
| **Controls** | | | | | | | |
| | Before | SD | After | SD | Difference | SD | Statistics |
| Masseter Left | 721.00 | ±74.19 | 653.10 | ±50.89 | - 67.90 | ±45.07 | NS |
| Masseter Right | 721.20 | ±74.49 | 654.60 | ±49.97 | - 66.55 | ±45.76 | NS |
| Temporalis Left | 772.80 | ±71.72 | 653.00 | ±51.11 | - 69.75 | ±45.14 | NS |
| Temporalis Right | 722.90 | ±71.01 | 653.50 | ±51.58 | - 69.40 | ±45.16 | NS |

** = $p < 0.001$; *** = $p < 0.0001$; NS = No statistical significance

between each record. The average from the three records was calculated and used as final data. Statistical analyses were performed using a statistical package (Graphpad Prism 4.0, Microsoft, USA). First, the results within groups were individually contrasted by paired t-test to determine significant changes for each group. Then, the differences between those EMG values recorded before treatment and those after treatment were calculated. Differences in µV on each muscle between the three groups in the study were statistically analysed by one-way ANOVA. The level of confidence was set at 95 *per* cent (p-value=0.05).

## RESULTS

The records of appliance usage maintained by the parents showed that patients' compliance was good. All patients in the treated group regularly slept with the appliance maintaining it in the mouth overnight. A couple of patients failed to use the appliance during the daytime, but complied for the night usage. Some patients reported tooth soreness and facial tiredness early in the morning after removing the appliance from the mouth. That occurred over the first two-to- three weeks of treatment.

At the beginning of the study, all the subjects with a Class II, division 1 malocclusion recorded an EMG muscular activity approximately 1.5-fold less than those recorded for the normal controls. At the end of the study the subjects in the treated group reported a significant increase in the Temporalis and Masseter muscles' EMG activity on both sides ($p < 0.001$), reaching values similar to those measured in the normal controls. For both of the Masseter muscles, the increase in their muscular activity reached approximately a 50% were as for the Temporalis muscles such increase was around 37% cent of the pre-treatment amplitude values recorded in µV.

Conversely, the untreated controls reported a non-significant variation in the EMG activity and remained on similar values to those recorded at the beginning of the study. Also, the normal controls remained with similar values at the end of the study comparing with those recorded at the beginning, but significantly higher when contrasted against the untreated controls. All the EMG values for the three groups involved in the study recorded for the studied muscles at the beginning and the end of the study are presented in Table I.

## DISCUSSION

This study focused in determining the amplitude of the EMG muscular activity in the Temporalis and Masseter muscles at clench. In that way, the results from this study can infer changes in the load delivered by those masticatory muscles on the maxillaries when maximum intercuspation is reached in Class II, division 1 malocclusion patients. treated with the functional appliance.

These results showed that the EMG's amplitude in both, Temporalis and Masseter muscles, significantly increased in those patients treated over a 12-months period with the pre-orthodontic Trainer. So, it can be inferred that the loading produced by the muscles at clench on the mandible was significantly increased during the treatment period. Conversely, the amplitude of the EMG muscular activity in the untreated Class II, division 1 patients remained at the same level during the same period. In that context, this study confirms the results from others which reported that the pre-orthodontic Trainer positively influences the masticatory musculature. [10,11]

Those previous studies reported that the pre-orthodontic Trainer improves the muscular activity of some masticatory muscles based on the reduction observed in the frequency of the Temporalis and Masseter EMG muscular activity. [10,11] EMG's frequency expresses the risk of fatigue at the tested muscles, whereas the amplitude relates to the force produced by the muscle at contraction. [12] A reduction in the EMG's frequency at the two masticatory muscles reported earlier demonstrated that those muscles are less prone to fatigue. That is an important finding because as the muscle fatigues, bone loading and strain reduce. [15] The current results add to the previous ones. They demonstrate that there is also a significant increase in the EMG's amplitude when treating children with Class II, division 1 malocclusion with the pre-orthodontic Trainer. That infers bone strain increases and a higher force are delivered at clench after treatment. Therefore, the results from this and previous studies evidence that this functional appliance improves muscular activity of the Temporalis and Masseter muscles, which may increase the loads masticatory muscles are able to deliver on the mandible, while reducing the risk of muscular fatigue.

A previous study reported that the pre-orthodontic Trainer relocates the mandible forward in patients with a Class II, division 1 malocclusion, as the SNB and ANB angles significantly improved. [8] The current results help to understand those results, suggesting that those clinical changes observed in a short period of time when treating with the functional appliance are the result of an improvement in muscular activity and not from mandibular growth. In other words, those results are due to an improvement in the muscular activity, which permits to hold the mandible forward reducing the Class II sagittal relationship.

It was also noticed that patients treated with the pre-orthodontic Trainer significantly increased the EMG's amplitude in the Temporalis and Masseter muscles, reaching values similar to those recorded for patients with a normal dental occlusion. Conversely, those patients with a Class II, division 1 malocclusion in the untreated group did not report variations in the EMG's amplitude of the tested muscles, remaining between low values. As the latter subjects received no treatment, it corroborates that the muscular activity does not improve over the time when a malocclusion is present during the growing period. In that context, these results support other reports stating that there are not significant changes in those patients with a distal maxillo-mandibular relationship, and therefore, the altered sagittal relationship between the maxillaries is likely to be replicated in the permanent dentition. [16,17]

Up today, there is enough evidence to say an improvement in muscular activity may result in new bone apposition later. [18-20] A positive influence on the EMG muscular activity of the muscles elevating and protruding the mandible can lead to a sustained effect on the bone tissue kinematics at the mandible, as well as alter the mechanical environment by increasing bone loading and strain. [7,21-24] That would cause bone remodeling and modeling at the periostal and endocortical surfaces. [7,23,24] Beside that, mandibular advancement increases mechanical strain at the mandibular condyle inducing neurovascularization and osteogenesis, which leads to adaptive mandibular growth. [25] However, bone apposition is an event requiring more time than that necessary to produce changes in muscular activity. [6,26,27] The purpose of this study was to determine changes in the activity of the masticatory muscles in the treated group, but determining skeletal changes. In that context, the results from this and other studies with the pre-orthodontic Trainer permit to state that the functional appliance is able to produce a better condition in the activity of the Temporalis and Masseter muscles. [10,11] Such effect can increase bone loading and strain on the mandible in patients with a distal maxillo-mandibular relationship, which could initiate a cascade of events resulting in bone modelling or remodelling, [7,24,27] improving the dimensions of the dental arches. [9] However, further studies with prolonged follow up periods are required to confirm that statement, as well as to confirm that the reported modifications in the EMG muscular activity remain stable afterwards, so affecting maxillaries' growth.

## CONCLUSIONS

The hypothesis that treatment with the pre-orthodontic Trainer significantly increases the amplitude of the EMG activity in the Temporalis and Masseter muscles at clench in patients with Class II, division 1 malocclusion has been confirmed. This study also demonstrated that the functional appliance is able to improve EMG muscular activity during the treatment to levels similar to those recorded for patients with normal dental occlusion. Further studies are required to determine if those changes in the activity of the masticatory muscles may affect growth and development of the maxillaries.

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