EMG ACTIVITY OF THE MASSETER AND TEMPORAL MUSCLES IN CHILDREN WITH MALOCCLUSION CLASS II AND III

Marcio Guimarães dos Santos¹, Diego Galace de Freitas², Adilson Apolinário³, Fabio Navarro Cyrillo³, Paulo Garcia Roberto Lucareli⁴, Thiago Yukio Fukuda².

¹Irmandade da Santa Casa de Misericórdia de Diadema – Quarteirão da Saúde (ISCMD-QS), Diadema, São Paulo, Brazil.
²Irmandade da Santa Casa de Misericórdia de São Paulo (ISCMSP), Department of Physical Therapy, São Paulo, São Paulo, Brazil.
³Centro Universitário São Camilo, Physical Therapy Sector (CUSC), São Paulo, Brazil.
⁴Universidade Nove de Julho – (UNINOVE), Department of Physical Therapy, São Paulo (SP), Brasil.

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Introduction: Changes in facial muscle activity are very common findings in subjects with temporomandibular disorders, especially when associated with malocclusions classes II and III. The purpose of this study was to determine the root mean square (RMS) value of the EMG signal of the masseter and temporal muscles in children with normal occlusion, malocclusion classes II and III, as well as a possible clinical application for this parameter. Methods: We selected 44 children between 7 and 11 years of age, of both genders, with a diagnosis of normal occlusion and malocclusion classes II and III. Analyses were performed by quantitative EMG of the masseter and temporal at rest, during maximum bite (MB) conditions, and including the relationship between the RMS at rest and MB. Results: Our results demonstrated that children with class III malocclusion have abnormal masticatory muscle function when compared to normal occlusion. We found a hyperactivity of the masseter muscle in malocclusion class III at rest (increase RMS mean values, p<0.05) and decreased activity in MB (decreased RMS mean values, p<0.05) when compared to normal occlusion. These findings were corroborated by the relationship of MB/rest. There was no difference between the normal occlusion and class II malocclusion for the masseter, as well as the temporal muscle. Conclusion: We conclude that the masseter has hyperactivity at rest and decreased strength in MB, which would imply a functional deficit.

Key words: Facial muscles, Dental occlusion, Electromyography,

INTRODUCTION

There have been a high incidence of temporomandibular disorders (TMD) and they are characterized by intrinsic and extrinsic changes in the temporomandibular joint which can lead to functional

Corresponding e-mail: mguimaraes7@yahoo.com.br
disorders in the facial muscles. The masseter and temporal muscles are the most affected (Ali et al, 2003).

The temporal muscle performs the elevation of the jaw and participates in the closing phase of the masticatory cycle, acting as a mandibular stabilizer (Ringqvist, 1974). The masseter muscle provides the force necessary for proper mastication and is important for the occlusion movement at rest and during function (Dupont et al, 2009). Significant decrease in their activities can be observed in previous studies with TMD subjects (Vecchione et al, 2007; Santana-Mora et al, 2008).

Edward Angle, in 1907 described different types of occlusion, taking into account the sagittal plane. This classification is based on the antero-posterior displacement of the dental arches of the jaw in relation to the maxilla, allowing the characterization of different occlusions. The normal sagittal relationship is shown between both dental arches, i.e., the normal occlusion is indicated with the term class I. A dorsal position of the mandibular dental arch in relationship to the maxilla is specified as a class II malocclusion. An opposite situation with the inferior dental arch positioned ventrally to the superior, is characterized by a previous position of the mandibular arch in relationship to the maxillary arch, known as class III malocclusion (Angle, 1907).

Different methodologies have been used for the diagnosis and measurement of the TMD including: strength sensors in order to measure the isometric contraction of facial muscles, pressure applied to the lips (Lapatki et al, 2002; Castroflorio et al, 2006), studies using computerized tomography (Chan et al, 2008), three-dimensional analysis (Tardieu et al, 2009), and even electrical stimulation to assess the reflex response (Andersen et al, 2008). However, the most employed device in scientific studies is the surface electromyography (EMG) (Bergamini et al, 2008; Piancino et al, 2008). It consists of the graphic recording of the myoelectric signal and represents an important tool for quantifying muscle activity, both at rest and during contraction (Fridlund et al, 1986).

After receiving the EMG signal, the RMS (root mean square) value has often been chosen for measurement because it provides a better analysis of the levels of physiological activity of the motor unit during contraction. With respect to muscle activity, the RMS is an intrinsic parameter of the EMG signal which shows a linear relationship with the contraction force of the masseter and anterior temporal muscles (Buxbaum et al, 1996; Wang et al, 2000).

Thus, the purpose of this study was to determine the RMS value of the EMG signal of the masseter and temporal muscles in children with normal occlusion, malocclusion classes II and III, while seeking a possible clinical application for this parameter.

**METHODOLOGY**

According to the Human Research Ethics Committee regulations of UMC (003/2003), the subjects and their parents were fully informed regarding the procedures to be conducted. Thus, the parents signed the consent agreement before the beginning of tests.

Forty-four children between 7 and 11 years of age of both genders were included with diagnoses of normal occlusion (n=17, 6 males and 11 females, mean age of 10±1.2 years), malocclusion class II (n=14, 6 males and 8 females, 10±1.6 years) and malocclusion class III (n=13, 6 males and 7 females, 8±1.3 years), taking into account their availability to participate in this study.

The diagnoses and types of occlusions were provided by a single specialized dentist with sixteen years of experience in orthodontics. The specific procedures were intra-oral clinical evaluation, dental models, and X-rays to visualize the relationship between the teeth, maxillaries and temporomandibular joints. We excluded patients who had used any medication or orthodontic devices that could influence normal muscle activity and patients with crossbite. Normal occlusion was considered the normal antero-posterior relationship between the two dental arches; class II malocclusion was considered a dorsal position of the mandibular dental arch in relationship to the maxilla, whereas a ventral position was considered class III malocclusion (Angle, 1907).

**INSTRUMENTATION**

The acquisition and processing of the masseter and temporal muscles myoelectric signal were performed with a six-channel EMG system, a 3-way shielded cable, Ag/AgCl surface electrodes, and an isolator transformer specific for medical purposes (Isobox 600, Toroid-Brazil), which isolates the device from the power line (Fukuda et al, 2008).

Each channel of the amplifier displayed certain characteristics such as: an on/off switch, offset adjustment, adjustable gains varying from 1.000 and 50.000-fold, a differential input, and a BNC type output. The amplifying circuit had a high common rejection rate (CMRR) of 106 dB at 60Hz and high input impedance of 109Ω. The amplifier input impedance, CMRR and maximum peak-to-peak noise were, respectively 10MΩ, 48 dB (at 150 Hz) and 1µV. The bandwidth was adjusted through a high pass filter of 8 Hz, a 60 Hz notch filter, and a low pass filter of 10 kHz to minimize interference of low frequency noise that originates from unwanted movement of the cables and electrodes, and high frequency noise that originates from several sources (bandwidth ranging
Table 1: Mean (±SD) of the RMS value to the masseter and temporal muscles in the rest condition (RMSR) for the normal occlusion (class I), malocclusion class II and class III

<table>
<thead>
<tr>
<th></th>
<th>Masseter (µV)</th>
<th>Temporal (µV)</th>
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<tbody>
<tr>
<td></td>
<td>Right</td>
<td>Left</td>
</tr>
<tr>
<td>Class I</td>
<td>2.2 (±0.8)</td>
<td>2.1 (±0.8)</td>
</tr>
<tr>
<td>Class II</td>
<td>2.6 (±0.9)</td>
<td>2.6 (±0.8)</td>
</tr>
<tr>
<td>Class III</td>
<td>2.8 (±0.9)</td>
<td>2.9 (±0.8)</td>
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The positioning of the temporal muscle occurred with the palpation of the anterior portion while the patient voluntarily contracted these muscles. Soon afterwards, a point measuring 50 mm of the tragus was marked on his face. The first electrode was positioned 20 mm vertically above this point and the second electrode was positioned 20 mm from the first electrode, and toward the muscle fibers. The reference electrode was positioned in the superior and central area of the frontal bone of the subjects (Castroflorio et al, 2005).

The measurements of the RMS at rest (RMSR) and maximum bite (RMSMB) were performed bilaterally on the masseter and temporal muscles.

Table 2: Mean (±SD) of the RMS value to the masseter and temporal muscles in the maximal bite condition (RMSMB) for the normal occlusion (class I), malocclusion class II and class III

<table>
<thead>
<tr>
<th></th>
<th>Masseter (µV)</th>
<th>Temporal (µV)</th>
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<tbody>
<tr>
<td></td>
<td>Right</td>
<td>Left</td>
</tr>
<tr>
<td>Class I</td>
<td>200.2 (±127.0)</td>
<td>156.4 (±102.5)</td>
</tr>
<tr>
<td>Class II</td>
<td>165.7 (±69.0)</td>
<td>160.0 (±65.0)</td>
</tr>
<tr>
<td>Class III</td>
<td>114.0 (±49.0)</td>
<td>110.2 (±61.0)</td>
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PROCEDURES
The exams were performed in the masseter and temporal muscles of subjects with different occlusions. The subjects were seated in a dental chair with their heads supported and with a Frankfurt plane parallel to the ground. The proceeding was performed in an isolated and quiet room to provide total relaxation.

Initially, each subject’s facial skin was cleaned with cotton soaked with hydrated ethyl alcohol to remove excess oil and died skin cells. Afterwards, the electrodes were positioned and fixed with non-allergic adhesive tape.

The positioning of the electrodes in the masseter muscle was determined by palpation of the zygomatic bone and inferior angle of the jaw, with the purpose to determine the origin of muscular insertion, as well as the direction of the fibers. Soon afterwards, a palpation of the muscle while in contraction was performed, identifying the area or larger mass of the stomach muscle (Castroflorio et al, 2005).

The positioning of the temporal muscle occurred with the palpation of the anterior portion while the patient voluntarily contracted these muscles. Soon afterwards, a point measuring 50 mm of the tragus was marked on his face. The first electrode was positioned 20 mm vertically above this point and the second electrode was positioned 20 mm from the first electrode, and toward the muscle fibers. The reference electrode was positioned in the superior and central area of the frontal bone of the subjects (Castroflorio et al, 2005).

The measurements of the RMS at rest (RMSR) and maximum bite (RMSMB) were performed bilaterally on the masseter and temporal muscles.

STATISTICAL ANALYSIS
We used the unpaired t-test for side-to-side intra-group comparison of the RMS mean value (GraphPad statistical program) as well as the difference between genders. The data were submitted to a normality test (Kolmogorov-Smirnov), since the intergroup comparisons (occlusion class I and malocclusion class II and III) were performed by analysis of variance (ANOVA) - Kruskal-Wallis test for the temporal and Tukey test for the masseter muscle. For all analyses, we considered a significance level of 95%. From 8 to 10.000 Hz). The notch filter was used to decrease the incoming signal from the electric net.

Once the EMG signal was received, we obtained the RMS value during a period of 15 seconds. This capture and processing of the EMG device were applied and validated in a previous study (Fukuda et al, 2008).
RESULTS

First, we made an intra-group analysis to compare the gender influence in the three classes for the masseter and temporal muscles. There were no significant differences (p>0.95). The same analysis was performed by comparing the right and left sides at rest and the MB condition, which also showed no difference (p>0.92). Thus, the data were taken together for each specific group (Table 1 and 2).

Next, comparisons were performed between groups for the masseter and temporal muscles at rest (RMS₉). We observed a statistical difference only when comparing class III to class I for the masseter (p<0.001), i.e., subjects with malocclusion class III had a higher muscle tension at rest (Figure 1). In the MB condition, we found a significant weakness in the masseter in class III malocclusion in relationship to class I (p<0.05; Figure 2).

Finally, the relationship between RMS₉ and RMS₉₉ (RMS₉₉/RMS₉) was calculated for each subject and the same analysis was performed comparing the masseter and temporal muscles. It was observed that the masseter muscle showed a significant decrease for subjects with malocclusion class III compared to class I (p<0.001; Figure 3).

DISCUSSION

The aim of this transversal study was to show the EMG activity of the masseter and temporal muscles during rest, the maximum bite, and also the ratio of the MB/rest for children 7 to 11 years old who were diagnosed with normal occlusion (Class I) or malocclusion (Class II and III). The results showed that children with malocclusion class III had a hyperactivity of the masseter muscle at rest and decreased force during maximum bite.

The masseter and temporal muscles have been widely investigated for their important functions, such as during rest as well as during activity, exhibiting a strong relationship with occlusion changes. These findings were observed in other studies showing the importance of these muscles to the occlusion as well as the convenience of their superficial anatomic locations that facilitate the capture of EMG signals using surface electrodes (Ringqvist, 1974; Pancherz, 1980; Biasotto et al, 2005).

In the present study, we used the RMS value for processing the EMG signal in order to reproduce muscle activity levels at rest and during contraction. For this reason, it has been the most used parameter in other scientific studies (Buxbaum et al, 1996; Wang et al, 2000; Garcia et al, 2003).

Some authors have demonstrated increased muscle activity by EMG in both muscles at rest and MB in subjects with occlusion disorders compared to normal occlusion (Nuno-Licona et al, 1993; Thilander et al, 2002). However, in the present investigation, there were only changes to the masseter, and the RMS₉₉/RMS₉ ratio was different in children with class III malocclusion.

The increased RMS₉ and decreased RMS₉₉ in class III children can be explained by the anatomical positioning of the masseter muscle, which is anteriorly directed due to its insertion in the inferior edge of the mandibular arch. Nevertheless, we can suggest that children with class III malocclusion present a diminished muscle-arm lever of the masseter muscle, thus leading to an overload in the at rest condition, thus reducing the occlusion, and decreasing muscular activity during maximum bite (L. Vecchione et al, 2007).

Gavião et al, in 2001 evaluated children with normal occlusion, posterior cross bite and open bite, showing that the normal occlusion group had a better capacity of tablets fragmentation in relation to the other two groups.

The authors could conclude that normal occlusion is a preponderant factor to the mastication process (Gavião et al, 2001).

Based on our findings, it can be observed that children with class II malocclusion did not show changes in the mastication process when compared to normal occlusion. However, the class III children showed weakness of the masseter muscle during maximum bite and this can lead to changes in the normal mastication process.

Other authors have shown that children with the same demographic characteristics and diagnosis of cross bite present muscular asymmetry during MB of the masseter and temporal (Andrade et al, 2009). However, another study showed that children with normal occlusion have symmetry between right and left sides (Kecik et al, 2007), justifying our choice to consider both sides as the same group; however, the patients did not show cross-bit.

This side-to-side relationship was also demonstrated in a study by Piancino et al, in 2008, which evaluated masseter and temporal muscle activity during mastication. They observed increased activity on the mastication side. Nevertheless, the contra-lateral side also showed a significant increase in activity in accordance with increased mastication (Piancino et al, 2008).
Further, we suggest that increased activity in the contralateral side occurs in order to improve the stability and balance of the temporomandibular joint. Thus, this hyperactivity seems more linked with side-to-side joint stabilization than with the malocclusion.

Another important finding in the present study is that there was no difference with respect to gender in the intra-group analysis. These findings can be observed in the figures provided.

FIGURES

Figure 1: Mean (±SD) of RMS value (µV) obtained in the rest condition (RMSR) of the masseter and temporal muscles. Asterisks (*) denote significant difference between the two circumstances.

Figure 2: Mean (±SD) of RMS value (µV) obtained in the maximum bite condition (RMSMB) of the masseter and temporal muscles. Asterisks (*) denote significant difference between the two circumstances.
another study that evaluated mandibular asymmetry during skeletal maturation (Duthie et al., 2007).

Analyzing the myoelectric activity between adults and children with normal occlusion or class II malocclusion, Pancherz, in 1980 found differences between the groups. The results presented in this study do not agree with our findings, because there were not found significant differences for children with class II malocclusion when compared with the control group. This leads us to conclude that a retracted jaw does not significantly alter the muscle-arm lever of the masseter and temporal muscles (Pancherz, 1980).

Another author demonstrate that changes in patients with class II malocclusion are related initially to a high lip line and not to a stiffness of the perioral musculature. This may be related to findings in the present study, where no significant difference was found during the evaluations of patients with class II malocclusion (Lapatki et al., 2002). Gadotti et al., in 2005 have already demonstrated that subjects with normal occlusion (class I) tend to have hyperactivity in the masseter muscle when
compared to the temporal muscle. Similar findings were also found in the present study. However, the results demonstrate that subjects with class II malocclusion presented a more active temporal muscle than class I occlusion (Gadotti et al, 2005).

One limitation of this study was the lack of bite strength measurement by load cell device to correlate with the EMG findings. However, based on previous studies, there is a linear relationship between the contraction force and RMS value of the EMG signals in the specified muscles (Wang et al, 2000; Fukuda et al 2010).

These results indicate that quantitative EMG of masseter and temporal muscles in children of both genders can be a diagnostic support tool to clinical practice, especially if we consider the RMS value of these muscles.

CONCLUSION

Based on the obtained data, we conclude that children with Class III malocclusion showed hyperactivity of the masseter muscle during the rest condition and a decrease of force during maximum bite when compared to children with normal occlusion and Class II malocclusion. On the other hand, was not observed difference between groups in the temporal muscle. These findings could be confirmed by analysis of the RMS value of the EMG signal, and for the maximum bite/rest relationship, which enables clinical applicability of this diagnostic tool.

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REFERENCES


