

# Effect of occlusal splint thickness on electrical masticatory muscle activity during rest and clenching

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**Abstract:** The extent of separation between the maxillary and mandibular teeth in the fabrication of interocclusal splints designed to achieve efficiency and muscle relaxation is controversial and undefined in the literature. Based on this premise, the aim of this study was to evaluate the effect of interocclusal splint thicknesses of 3 and 6 millimeters on the electrical activity of the anterior temporal and masseter muscles during rest and dental clenching. Twenty asymptomatic individuals (10 males and 10 females) were selected using the Research Diagnostic Criteria (RDC). Electromyography (EMG) was performed both with and without the 3- and 6-mm splints using the Bio EMG software package, which recorded values given in microvolts ( $\mu\text{V}$ ). The results, which were assessed using analysis of variance (ANOVA) to a 5% significance level ( $p < 0.05$ ), showed increased electrical activity of the masticatory muscles during dental clenching compared with at rest, with greater activity in the masseter muscle. The electrical activity did not differ according to the thickness of the splints or between males and females. We can conclude that both splint thicknesses are effective in treating muscle hyperactivity given their similar clinical behavior for asymptomatic individuals.

**Descriptors:** Electromyography; Temporal Muscle; Masseter Muscle; Occlusal Splints; Dental Occlusion.

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## Introduction

Interocclusal appliances are devices designed to reestablish vertical dimension and reduce muscle hyperactivity. They create a temporary occlusal condition that allows the temporomandibular joints (TMJ) to orthopedically adopt a more stable position.<sup>1</sup> They can also be used to provide an ideal occlusal condition to reorganize neuromuscular reflex activity, reducing parafunctional activity while stimulating normal muscle function. The occlusal splint is designed to eliminate any orthopedic instability between the occlusal and articular positions, thereby preventing this instability from causing temporomandibular disorders (TMD).<sup>2</sup>

Electromyography (EMG) is defined as a graphic record of the electrical potential of muscles, and has been used to study the behavior of muscles both during static and dynamic functions.<sup>3</sup> The characteristics of the electrical activity of the muscles depend on the length of the muscle fibers, electrode positioning in relation to the muscle fibers, area and

distance between the electrodes and the thickness of the fat layer between the skin and muscles.<sup>4,5</sup>

The muscle parameters frequently studied by EMG include postural position or rest, as well as activity during maximum tooth clenching. Such parameters have been used to evaluate the effect of occlusion on normal muscle function, both with and without an interocclusal splint. They are also used to assess the effect of different interocclusal splints on dysfunctional muscles and to monitor deleterious habits.<sup>3</sup>

Only a limited number of studies in the literature<sup>6-9</sup> have attempted to connect these elements in patients with TMD. They have mostly assessed the electromyographic effects of splints with only minimal interocclusal separation, with conflicting results among them. Some studies have reported an increase in muscle electrical activity, while others did not observe changes or any decrease in muscle activity. However, all patients in these studies generally displayed significant improvements.<sup>6-9</sup>

The objective of this study was to evaluate the thickness of occlusal splints and the associated electrical activity of the anterior temporal and masseter muscles during rest and dental clenching, as well differences between genders, considering the normal physiological and functional state of the muscles and the asymptomatic condition of the selected individuals.

## Methodology

### Selection of individuals

Twenty young adults (10 for each gender) with an average age of 22 years old were selected according to the following inclusion criteria, with occlusion considered as normal or physiologic:<sup>10</sup>

- a. No signs or symptoms of TMD;
- b. Absence of muscle tenderness;
- c. Absence of parafunctional activities;
- d. Female patients currently not in their premenstrual period.

Patient selection was made by anamnesis and physical examination using the Research Diagnostic Criteria (RDC), Axis I for standardization and establishment of asymptomatic conditions. All indi-

viduals agreed with the rules of the Ethics Committee in Human Research of the School of Dentistry of Araçatuba, São Paulo State University - UNESP (FOA Process 2008-00803).

### Preparing the occlusal splint

After selecting the subjects, models were obtained through diagnostic impressions of the maxillary and mandibular dental arches, resulting in special plaster casts. The maxillary model was mounted employing a face bow on a semi-adjustable articulator; the mandibular model was assembled by juxtaposition.<sup>11</sup> A 3-mm interocclusal separation of the incisal guide pin was recorded. An occlusal splint was made using the distance on the upper jaw model, with a 1.5-mm thickness plate of polyvinyl chloride (PVC). Acrylic resin was added on the occlusal surface of this plate with the models mounted in the articulator. Occlusal adjustments were performed to establish simultaneous contacts in all teeth and to guide the teeth along lateral-protrusion jaw movements. Then, the same procedure was repeated with a separation of 6 mm to fabricate another occlusal splint of greater thickness. As such, two splints were fabricated with 3- or 6-mm distances as shown by the articulator anterior pin.

### Electromyographic evaluation (EMG)

The subjects were instructed not to perform masticatory function and to avoid the use of caffeine within two hours before the test. Prior to the test, the subjects washed their faces with soap and water in the areas corresponding to the muscles to be analyzed; 70% alcohol was used to remove skin oils and enhance the conductivity of the electrical signals. The subjects were comfortably installed in a chair inside a room with a controlled temperature (22 °C) for 30 minutes. Bipolar surface electrodes (Kendall MedTrace 100 Conductive Adhesive ECG Electrodes, Tyco Healthcare Group LP, Pointe-Claire, Canada) were placed with a distance of 18 mm between them, following the long axis of the muscle fibers of the masseter and anterior temporal muscle on both sides<sup>4,5</sup> (Figure 1). These electrodes were linked by wires to an amplifier connected to a computer for recording and analysis of muscle activity



**Figure 1** - Arrangement of electrodes placed in the masseter and anterior temporal muscles for EMG.

using the Bio EMG (Biopack - Bio-System Research, Inc., Milwaukee, USA) software package.

Electrical activity was recorded at five different time points. The first recording occurred during the initial examination before occlusal splint use, at mandibular rest and during teeth clenching, both for 30 seconds (1<sup>st</sup> record). After this, the 3-mm occlusal splint was placed in the mouth for another reading (2<sup>nd</sup> record). After 24 hours of use, the patients returned for a reassessment of electrical activity; with the occlusal splint properly positioned, records were obtained both at rest and during dental clenching for 30 seconds (3<sup>rd</sup> record).

A one-week washout time without occlusal splint use was performed before the next test. The patients then returned for delivery of a 6-mm-thick occlusal

splint and 4<sup>th</sup> and 5<sup>th</sup> records were obtained following the same criteria used for the 2<sup>nd</sup> and 3<sup>rd</sup> records.

The analysis of the EMG recordings in the mandibular rest position was obtained at 1, 3, 5 and 7 seconds, allowing an average of four readings over the 30-second period, measured in microvolts ( $\mu\text{V}$ ). During teeth clenching, measurements were recorded at 5-second increments over the same 30-second period.

### Statistical analysis

Data from each of the four muscles (left temporal - LT, right temporal - RT, left masseter - LM and right masseter - RM) were assessed using analysis of variance (ANOVA) with a significance level set at  $p < 0.05$ . Two variables were used:

1. gender (female and male) and
2. treatment (the different thicknesses of the employed splints).

### Results

The results are displayed in Figures 2 (at rest) and 3 (during clenching) for the four analyzed muscles. Their respective mean values and standard deviations for EMG are presented below.

At rest:

- RT ( $F = 2.34 \pm 0.05$  /  $M = 2.84 \pm 0.16$ ),
- LT ( $F = 2.24 \pm 0.11$  /  $M = 2.78 \pm 0.04$ ),
- RM ( $F = 2.44 \pm 0.11$  /  $M = 2.66 \pm 0.15$ ),
- LM ( $F = 2.4 \pm 0.12$  /  $M = 2.94 \pm 0.11$ ).

During dental clenching:

- RT ( $F = 62.42 \pm 3.60$  /  $M = 49.56 \pm 5.28$ ),
- LT ( $F = 58.48 \pm$  /  $M = 45.32 \pm 3.34$ ),
- RM ( $F = 92.48 \pm 9.55$  /  $M = 84.5 \pm 8.73$ ),
- LM ( $F = 99.3 \pm 7.74$  /  $M = 92.18 \pm 9.65$ ).

The bilaterally measured EMG activity, collected as the sum of the data obtained from the right and left masseter muscles and right and left temporal muscles, is presented in Table 1 (at rest) and Table 2 (during clenching). No statistically significant differences were found between females and males as well as between treatments with different splint thicknesses. Greater activity was also noted in the masseter muscle for both genders.

**Table 1** - Bilateral muscle activity at rest (mean ± sd).

EMG (μV)	Right	Left	(R+L)	
Temporal	5.8 ± 0.35	5.02 ± 0.38	10.2 ± 0.11	NS
Masseeter	5.1 ± 0.15	5.34 ± 0.38	10.44 ± 0.16	NS
T+M	10.28 ± 0.05	10.36 ± 0.22	20.64 ± 0.05	NS

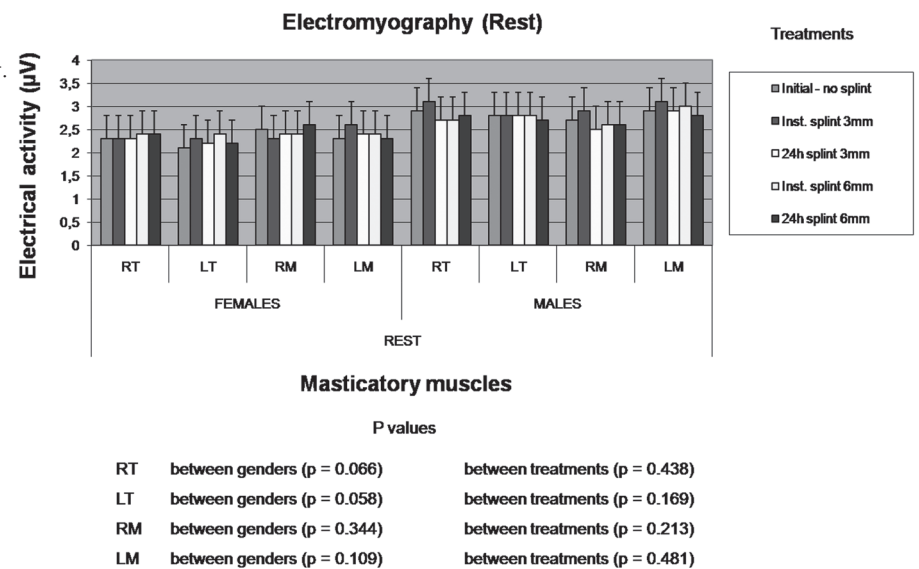
NS = non-significant difference.

**Table 2** - Bilateral muscle activity during dental clenching (mean ± sd).

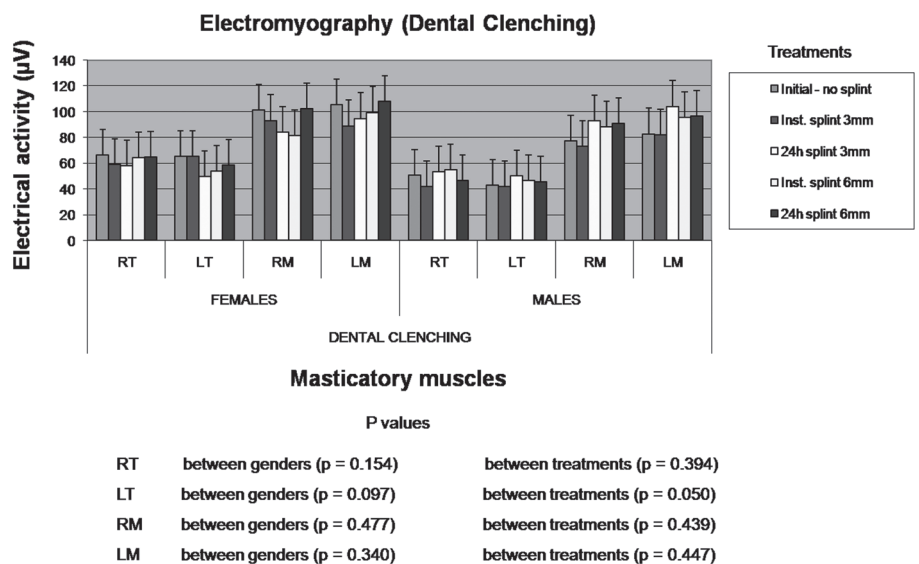
EMG (μV)	Right	Left	(R+L)	
Temporal	111.98 ± 9.09	103.8 ± 9.3	215.78 ± 5.78	NS
Masseeter	176.98 ± 5.64	191.48 ± 5.03	368.46 ± 10.25	NS
T+M	288.96 ± 45.96	295.28 ± 61.99	584.24 ± 4.46	NS

NS = non-significant difference.

**Figure 2** - EMG records at rest.



**Figure 3** - EMG records during dental clenching.



## Discussion

The masseter and anterior temporal muscles are the masticatory muscles that are most frequently studied using EMG given their easy accessibility via surface electrodes. Many studies have obtained recordings and assessed the relationship between these muscles with TMDs.<sup>12</sup> The clinical position of rest is currently characterized as a condition of muscle activity in the stomatognathic system that adapts relatively well to moderate changes in the occlusal vertical dimension (OVD).<sup>13,14</sup>

However, some authors have suggested that increasing OVD would be responsible for the appearance of muscle symptoms and that this increase would lead to the worsening, rather than the amelioration, of symptoms. Nevertheless, if this change reaches the freeway space, stimulated neuromuscular spindles may induce dental clenching, resulting in muscle hyperactivity.<sup>15</sup>

A study analyzed the influence of increased effectiveness of OVD chewing using anatomical splints with thicknesses of 2, 4 and 6 mm. This study used subjective criteria based only on symptoms reported by the patients, who reported absence of pain, discomfort or tension in the masticatory muscles and no changes in masticatory performance.<sup>16</sup> Similar results were observed in our study, in which an objective analysis was conducted using EMG. We also observed no differences between the tested splint thicknesses (3 and 6 mm).

In contrast, Suvinen *et al.*<sup>17</sup> reported a gradual reduction in the electrical activity of the masseter when the OVD was increased. The difference found between their study and ours can be attributed to the different OVDs that were used. These authors reported an interocclusal separation of approximately 14 mm, while our study utilized a thinner interocclusal separation (the greatest thickness was 6 mm).

The effect of voluntary contractions (of both short and long duration) on EMG activity among asymptomatic patients in our study confirmed that

some physiologic changes occurred after 20 s and 30 s due to dental clenching. These patients reported an onset of masseter muscle fatigue after 30 s.<sup>18,19</sup> This apparent fatigue depends on contraction time and the level of force exerted during clenching.<sup>20</sup>

Muscle fatigue is a risk factor for TMD. The EMG results showed that male subjects have greater resistance to muscle fatigue, suggesting that this gender difference may influence the larger susceptibility of TMD among females.<sup>21</sup> Apart from muscle physiology, sex hormones may be related to the gender difference in the prevalence of TMD.<sup>22</sup> However, our EMG results showed no evidence of difference between genders in the activity of the anterior temporal and masseter muscles during dental clenching, which can be explained by the screening of asymptomatic individuals. They were patients who avoided prolonged exercise and used splints for prolonged periods.

Decreased electrical activity of the muscles with occlusal splints during dental clenching may be directly related to the number of occlusal contacts on the splint.<sup>23,24</sup> However, the precise mechanism responsible for the observed changes is still unclear and may be due to correlated factors such as changes in sensory information from peripheral receptors. These receptors that are susceptible to external stimuli are sensitized to TMJ, muscles, and periodontal ligaments, as well as regions of the tongue, lips and oral mucosa.<sup>25</sup> Other characteristics of splints that may reduce symptoms associated with TMD are cognitive awareness and the placebo effect.<sup>2</sup>

## Conclusion

Considering the results observed and within the limitations of our study, we conclude that the electrical activity did not differ between the two different occlusal splint thicknesses that were analyzed or between males and females. Therefore, both occlusal splints may be used in the treatment of muscle hyperactivity considering their similar clinical behavior in asymptomatic individuals.

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