

## Masticatory muscle activity evaluation by electromyography in removable partial denture users

Avaliação da atividade dos músculos da mastigação por eletromiografia em usuários de prótese parcial removível

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### ABSTRACT

**Objectives:** The aim of this study was to evaluate by electromyography the activity of the temporalis and masseter muscles in removable partial dentures (RPDs) users, before and after new RPDs installation. **Material and Methods:** Ten patients were selected for this study. All subjects were edentulous in the posterior mandibular region (Kennedy class I or II), fully dentate in the antagonist arch, and dental prosthesis users, which needed to be replaced. The electromyographic activity (EMG) recorded the superficial masseter and temporalis muscles, during the maximum voluntary bite force and the rest position. Maximum mouth opening was also verified. The measurements were recorded at four specific times: using the old prosthesis (T0), right after the new prosthesis installation (T1), two weeks (T2) and four weeks (T4) after installing the new prosthesis. All the RPDs were made by an experienced dentist and the same laboratory. Data were statistically analyzed by ANOVA and Tukey tests ( $\alpha = 0.05$ ). **Results:** EMG values had high standard deviation at the time T0. Generally, the mean values decreased after new prosthesis installation, especially after two weeks from the installation (T2). During the rest position, the left masseter and left temporalis muscles showed statistically significant gradual decrease in their activities over time. **Conclusion:** New prostheses have positive effect on the patient's muscular activity. However, an adaptation period of the muscle fibers to the new prosthesis is needed.

### KEYWORDS

Electromyographic activity; Dental occlusion; Masseter; Removable partial dentures; Temporalis.

### RESUMO

**Objetivo:** O objetivo deste estudo foi avaliar, através de eletromiografia, a atividade dos músculos masseter e temporal em usuários de próteses parciais removíveis (PPR), antes e depois da instalação da nova prótese. **Materiais e Métodos:** Dez pacientes foram selecionados para este estudo. Todos os indivíduos eram edêntulos na região mandibular posterior (Classes I e II de Kennedy), totalmente dentados no arco antagonista, e usuários de próteses removíveis, com necessidade de substituição. A atividade eletromiográfica (EMG) dos músculos masseter superficial e temporal foi verificada, durante as posições de contração máxima voluntária e repouso. A abertura bucal máxima também foi mensurada. As mensurações foram efetuadas em quatro momentos: durante a utilização da prótese antiga (T0), logo após a instalação da nova prótese (T1), duas semanas (T2) e quatro semanas (T4) após a instalação da nova prótese. Todas as próteses foram fabricadas por um único dentista com experiência e no mesmo laboratório. Os dados foram analisados estatisticamente pelos testes de ANOVA e Tukey ( $\alpha = 0,05$ ). **Resultados:** Os valores de EMG tiveram um alto desvio padrão no momento T0. Em geral, a atividade dos músculos mastigatórios sofreu uma diminuição após a instalação da prótese, especialmente após duas semanas da instalação (T2). Durante a posição de repouso, os músculos masseter e temporal esquerdos demonstraram um decréscimo gradual estatisticamente significativo em suas atividades ao longo do tempo. **Conclusão:** Novas próteses desempenham efeito positivo sobre a atividade muscular dos pacientes. Ainda, um período de adaptação das fibras musculares com a nova prótese se faz necessário.

### PALAVRAS-CHAVE

Atividade eletromiográfica; Oclusão; Masseter; Próteses parciais removíveis; Temporal.

## INTRODUCTION

Dental losses can generate severe changes on the masticatory system, including changes on maxillo-mandibular interaction, teeth positioning and dental arch shape, which may decrease the effectiveness of the system. Even after the teeth replacement by dental prosthesis, it is unlikely that the biting force and the masticatory ability will return to their normal capacity [1-3]. This may occur due to decrease on the masticatory muscles activity [4], which act in synergy [5]. Also, the decrease of muscular activities can cause alterations on the type of muscle fibers, which tend to adapt to the new physiological state [6]. The aim of dental prostheses is prevent these changes with the oral tasks' reestablishment (chewing, swallowing, speaking and aesthetic).

Electromyography is an exam indicative of the muscle's performance and their interrelation, based on the analysis of electrical signals produced during each muscle contraction [7,8]. Injured muscles result in altered electromyography findings, allowing some correlation between pain and performance during, for example, masticatory activity [9,10]. Therefore, electromyography is an useful tool to evaluate the behavior of masticatory muscles. This method has been used to evaluate muscle alterations after oral rehabilitation with complete denture prosthesis and dental implants [11,12], as well as to compare patients with natural dentition and complete denture users [1]. Although the muscles evaluation on these situations is important, the high number of removable partial denture (RPD) users around the world suggests a necessity to completely understand the masticatory muscles behavior after this rehabilitation, especially during the adaptation period.

There are some studies [13,14] in the literature evaluating the masticatory performance of removable partial denture

(RPDs) users. However, information concerning muscular activity (obtained by electromyography) in partially dentate individuals and the RPDs effects on muscles activity are still needed. Thus, this study aimed to evaluate by electromyography the activity of temporalis and masseter muscles in removable partial dentures (RPDs) users, before and after new RPDs installation.

## MATERIAL AND METHODS

This study was performed at the prosthodontics clinic of Sao Jose dos Campos Dental School, under approval of Ethical in Research Committee, protocol #025/2011-PH/CEP. All patients signed an informed consent form, accepting the terms of the investigation. Ten individuals were selected for this study: 2 males and 8 females, with age > 45 years. Patients were edentulous in the posterior mandibular region (Kennedy class I or II), fully dentate (natural or prosthetic denture) in the antagonist arch, and dental prosthesis users, which needed to be replaced. The remaining teeth and the patients clinical situation were accessed by radiography exams prior to the treatment.

After the clinical examination, the electromyographic activity (EMG) was recorded from the superficial masseter and temporalis muscles, at four time periods: with old prosthesis (T0), right after the new prosthesis installation (T1), two weeks (T2) and four weeks (T4) after installing the new prosthesis. All the RPDs were made by an experienced dentist, and the same laboratory.

Data were collected with an eight-channel electromyographic equipment (EMG 800C, EMG System do Brasil Ltda, São José dos Campos, SP, Brazil), previously set to use five channels, with surface active disposable electrodes. Each channel matched to one specific muscle: channel #1- anterior portion of the left temporalis (LT); channel #2- superficial portion

of the left masseter (LM); channel #3- anterior portion of the right temporalis (RT); channel #4- superficial portion of the right masseter (RM). Channel 5 was attached to a goniometer (G - EMG System do Brasil Ltda, Sao Jose dos Campos, SP, Brazil), used for maximum mouth opening measurements. In order to minimize procedure differences, all measurements were taken by the same operator.

During measurements, the patients were seated, as close as possible to 90° angle between their back and the inferior members, with steady head. Subjects were instructed to look at a reference front point, avoiding movements during the measurements. Facial skin surface was gently wiped with a cotton ball moistened in alcohol (70%) to remove the excess of oiliness and to reduce the superficial tension, allowing better electrode signal conduction.

EMG was performed using self-adhesive Ag-AgCl double contact electrodes, made of polyethylene foam with hypoallergenic adhesive. These EMG electrodes were connected to an amplifier (20 × gain) and placed on the skin surface over the masseter and temporalis region, and the reference electrode was placed on the wrist surface (Figure 1). The instrument was validated by measuring the EMG activity of a patient for five times.

Muscle activities were recorded in the following situations:

1. Maximum voluntary isometric contraction: The patient was instructed to clench the teeth as much as possible. Three consecutive recordings of 10s each were taken.

2. Mandibular rest position: The patient was relaxed; his jaw was in a relaxed position, without teeth contact. Three consecutive recordings of 10s each were taken.

Maximum mouth opening was also recorded. The mandibular goniometer was adapted between the incisal edges of the anterior teeth. The patient was instructed to open and close the mouth three times in 10s. The signals

allowed one graph with three peaks, and the highest peak was recorded as the maximum mouth opening value.

EMG signals were converted using the software EMGLab V1.1 (EMG System do Brasil Ltda), and the data was processed and analyzed using Matlab 7.0 (MathWorks, Massachusetts, USA). Data were statistically analyzed using 1-way ANOVA, RM ANOVA and Tukey test ( $\alpha = 0.05$ ).

## RESULTS

### Maximum voluntary isometric contraction

The comparison of the EMG values obtained during the maximum voluntary contraction is presented in Table 1 and Figure 2. Differences in the mean results of each muscle were not significant when the four evaluation times were compared (RM:  $p = 0.14$ ; LM:  $p = 0.09$ ; RT:  $p = 0.19$ ; LT:  $p = 0.1$ ). The EMG values tended to decrease between the first measurement (T0) and the last measurement (T4). This situation was more evident for left masseter and left and right temporalis. Right masseter showed the highest values at T4, statistically different from the other muscles ( $p = 0.001$ ). A balance of the muscles activity can be observed during T2 (Figure 2).

The comparison of the EMG values obtained during the rest position is presented in Table 2 and Figure 3. EMG values of right masseter and right temporalis were not statistically different, when the four situations were compared (RM:  $p = 0.21$ ; RT:  $p = 0.18$ ). Left masseter and left temporalis muscles showed statistically significant gradual decrease in their activities over time (LM:  $p = 0.027$ ; LT:  $p = 0.008$ ). The greatest balance was detected at T2 (Figure 3).

Figure 4 shows the comparison of the maximum mouth opening of the patients at each time. There was no statistically significant difference in the maximum mouth opening between the groups ( $p = 0.061$ ). The highest

**Table 1** – Mean, standard deviation and statistics group values\* ( $\mu\text{v}$ ) of each muscle during maximum voluntary contraction, at each recording time.

	T0	T1	T2	T4
RM	44.11 $\pm$ 16.79 Aa	35.32 $\pm$ 10.23 Aa	32.47 $\pm$ 13.08 Aa	42.4 $\pm$ 12.97 Aa
	LM	40.29 $\pm$ 20.91 Aa	37.86 $\pm$ 13.18 Aa	30.54 $\pm$ 9.52 Aa
RT		38.33 $\pm$ 22.08 Aa	44.33 $\pm$ 22.16 Aa	30.93 $\pm$ 11.19 Aa
	LT	45.1 $\pm$ 32.7 Aa	39.18 $\pm$ 11.09 Aa	29.13 $\pm$ 10.92 Aa

\* Same capital letter in the same row shows differences not statistically significant; same lower case in the same column shows differences not statistically significant (Tukey test;  $\alpha = 0.05$ ).

**Table 2** – Mean, Standard Deviation and statistics group values\* ( $\mu\text{v}$ ) of each muscle during rest, at each recording time.

	T0	T1	T2	T4
RM	38.67 $\pm$ 10.89 Aa	37.38 $\pm$ 16.02 Aa	27.23 $\pm$ 10.01 Aa	35.07 $\pm$ 12.05 Aa
	LM	36.64 $\pm$ 11.12 Aa	34.25 $\pm$ 7.49 ABa	29.04 $\pm$ 9.3 ABa
RT		35.12 $\pm$ 12.24 Aa	34.73 $\pm$ 8.07 Aa	26.96 $\pm$ 8.69 Aa
	LT	41.96 $\pm$ 17.17 Aa	34.1 $\pm$ 7.35 ABa	29.40 $\pm$ 9.86 Ba

\* Same capital letter in the same row shows differences not statistically significant; same lower case in the same column shows differences not statistically significant (Tukey test;  $\alpha = 0.05$ ).



**Figure 1** – EMG measurement.

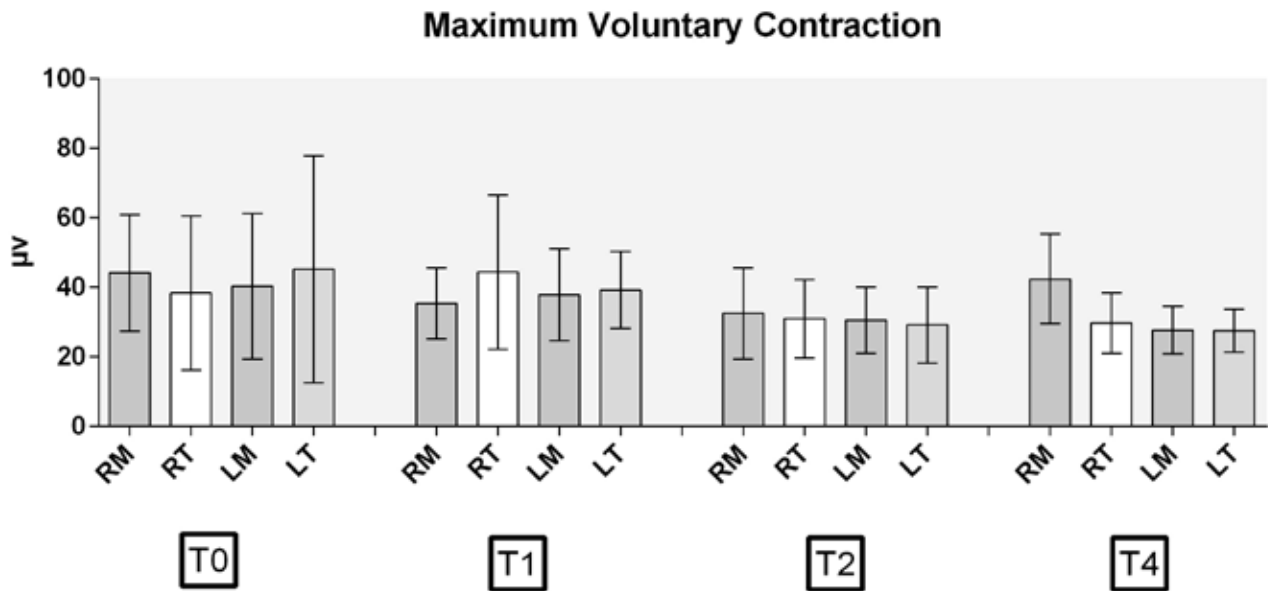


Figure 2 – Graph comparing values of the muscle activities during maximum voluntary contraction at the four recording times.

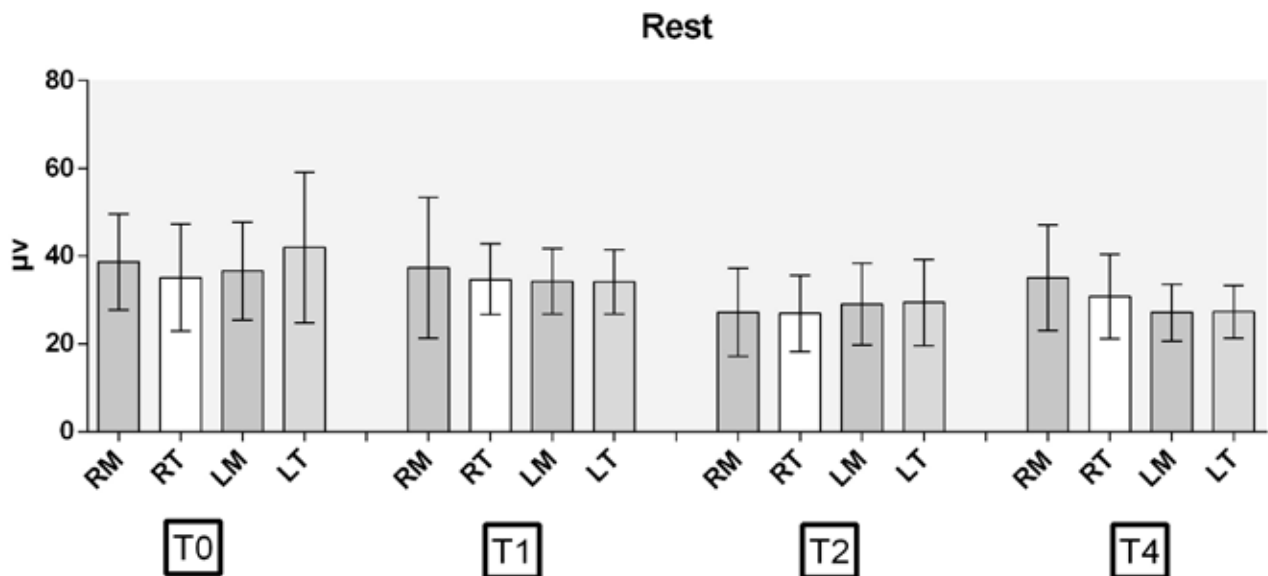
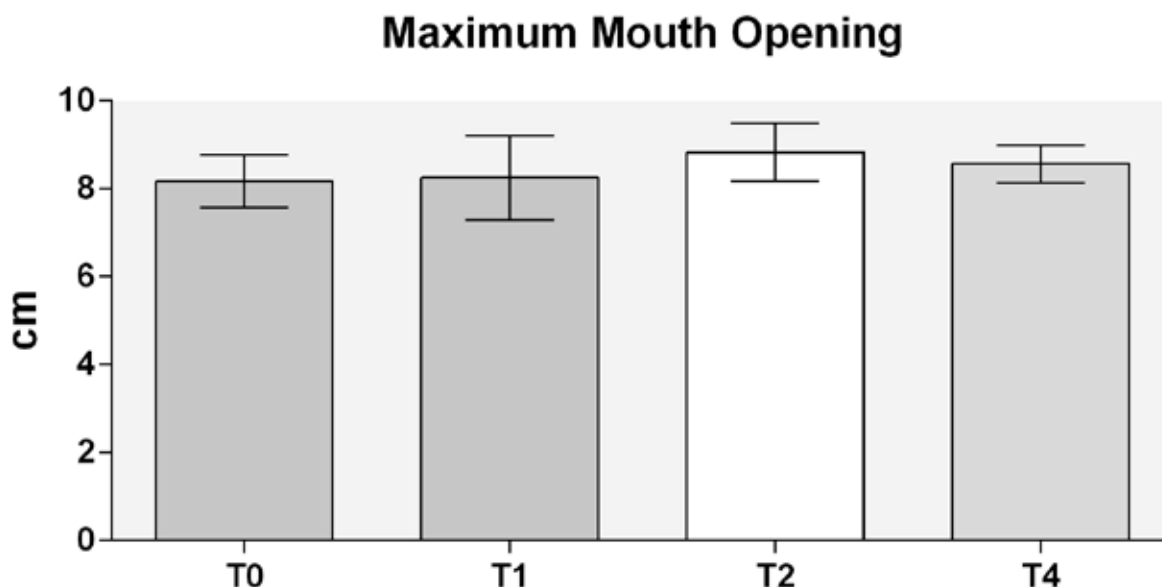


Figure 3 – Graph comparing values of the muscle activities during rest at the four recording times.





**Figure 4** – Graph comparing maximum mouth openings at each measurement time.

mean value was at T2 ( $8.83 \pm 0.66$  cm).

## DISCUSSION

The reestablishment of a correct masticatory function by dental prosthesis is essential to improve the patient quality of life. RPDs can be a successful treatment if performed with appropriate design and fabrication concepts in mind [15]. All RPDs of this study were made following the concepts for an ideal rehabilitative treatment. Heterogeneous values and high standard deviation were observed in the initial data for both rest position and maximum voluntary contraction. Four weeks after installing the new dental prosthesis, standard deviation values decreased and all groups showed homogeneous values, which may be related to occlusion contact reestablishment.

EMG measurements of masseter and temporalis muscles during the rest position and maximum voluntary isometric contraction have already been reported in the literature, mainly related to implant researches [16,17]. In this study, during maximum isometric voluntary contraction, there was a trend of decreasing muscular activity when the initial measurements

and the final measurements were compared, although differences between the groups were not statistically significant. This finding is similar to those found by Ferreira et al. [18] in total prosthesis users. According to Grubwieser et al. [19] the reduction on the muscle activity may contribute to prevent parafunctional habits and articular dysfunctions. The muscular activity reduction usually occurs due to the afferent nociceptors activation, and may end up inhibiting the muscle contraction as a protection reflex due, for example, a new prosthesis installation [11]. Because of adaptation period to the new prosthesis (the first days), greater attention was recommended to the patients during chewing. They were instructed to choose soft foods and eat small bites. These instructions were probably determinant for the better balance of the muscle activities 2 weeks after the RPDs installation (T2 - figures 2 and 3), either in maximum voluntary contraction and rest position. Furthermore, the highest mean values of maximum mouth opening were at T2, which were in accordance with the EMG results.

The masseter is the most active muscle during the chewing process. This activity was noticed in this study at the fourth week

after dental prosthetic rehabilitation, during maximum voluntary contraction. Therefore, the difference between right and left masseter muscles was recorded. This difference may be found in most of cases, since patients usually prefer one side rather than the other during chewing, independently of age, gender or food type, even after myofunctional therapy [20].

In the rest position, left masseter and left temporalis muscles showed statistically significant gradual decrease on their activities with the time. For this reason, the effects of the dental prosthesis were beneficial. The slight difference between T0 and T1 values in the rest situation can be associated with the occlusal interferences of the old prosthesis, which may affect muscle rest pattern and last for few days even after the interferences removal [21]. Therefore, the rehabilitation with RPDs is beneficial to patients, allowing aesthetic, functional and physiological improvements with relatively low cost.

The size and relative heterogeneity of the sample constitutes some limitations of this study. The sample selection for clinical studies is always a challenge, since most of the patients are excluded during this step. Moreover, some patients give up during the treatment or shortly after the RPD installation, which determine their elimination due to the necessity of the follow-up period.

## CONCLUSION

Within the limitations of this study, it was possible to conclude that the new prostheses have positive effect to the subjects' muscular activity, since lower muscular effort is required in both evaluated situations. Furthermore, muscle fibers need an adaptation period of at least 2 weeks after the new prosthesis installation.

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