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Research Article

Comparative Evaluation of Masticatory Muscle Activity Using Conventional and 3D Printed Occlusal Splints Using Electromyography

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Abstract

The use of the occlusal device has been widely used for many years for treatment for the temporomandibular disorder. Surface electromyography examination has been used in research in order to recognize the effects of the different treatments on the patients and to define their mode of action. The aim of this is study is to evaluate the masticatory muscular activity response, comparing conventional and 3D printed Michigan type occlusal device using electromyography. Eighteen patients participated in this study and were evaluated using electromyography to test masticatory muscles activity (masseter and temporalis muscles). It was possible to conclude the equivalent masticatory muscle activity with both devices.

Keywords: Temporomandibular Disorder; Occlusal Device; CAD/CAM; 3D Print; Electromyography

Abbreviations

TMD: Temporomandibular Disorder; CODD: Center of Occlusion, TMD and Orofacial Pain; CEPI: Center of Excellence in Prosthesis and Implant; FOUSP: School of Dentistry at the University of São Paulo; S.E: Standard Error

Introduction

The use of the occlusal device has been widely used for many years as a non-invasive treatment for temporomandibular disorder (TMD) worldwide [1]. Reports in scientific journals on the use of device date from the 1960s, and the first article available in the Pubmed database was written in 1967 by Block [2], relating the use of the device for the treatment of temporomandibular disorders and myofascial pain with a focus on occlusion.

The occlusal device has also been used to restore optimal occlusion patterns and to protect against tooth and bone wear caused by undesirable occlusal forces in patients with bruxism [3]. Considering the activity response of the masticatory muscles, especially the masseter and temporal muscles, there may be changes related to central (neural) or local (occlusal conditions) responses caused by the occlusal devices. Surface electromyography examination (graphical record of the variations of electric potential of the muscles according to the performed activity) and magnetic resonance imaging have been used in research in order to recognize the effects of the different treatments on the patients and to define their mode of action.

Studies of the cerebral response pattern to the use of the occlusal device were performed in order to seek a response to the results obtained with the use of the occlusal device. A study using functional magnetic resonance image to determine if there were differences in the brain´s activation pattern during occlusion, with and without the occlusal device, found significant differences in the analysis of contacts (tap-tap), which suggests that occlusion on the occlusal device reduces brain activation and may lead to muscle relaxation [4]. A complementary study of the same group of researchers was able to verify the activated brain areas with and without the occlusal device, concluding that, the greater activation of the parietal sensorimotor integration areas and cerebellar areas may be associated with the therapeutic effects of the occlusal device [5].

The nociceptive trigeminal inhibition conception is based on feedback from periodontal proprioceptors, densely located around the central upper and lower incisors. Occlusal contact on a partial device on the anterior teeth would reduce the activity of the masticatory muscles by central inhibitory response generated by the trigeminal system [6].

In order to better understand the role of mandibular positioning and occlusion in patients with TMD in muscle response, a clinical study was developed evaluating for 3 months a group of patients who used device adjusted in centric relation with another group of patients who used device adjusted at the maximum usual intercuspation. It was concluded that there were no statistically significant differences between the groups when evaluated clinically and by electromyography [3].

In another study, the difference in muscle activity of the masseter and anterior temporal muscles was evaluated by electromyography, considering one night of device use and comparing with one night without device use. It was possible to conclude that the muscular activity during sleep with the use of the device was significantly reduced and thus the mechanism of action could be related to the muscle relaxation caused by it [7,8].

The aim of this is study is to evaluate the masticatory muscular activity response, comparing conventional and 3D printed Michigan type occlusal device.

Materials and Methods

The present study was developed in the Center of Occlusion, TMD and Orofacial Pain (CODD) and Center of Excellence in Prosthesis and Implant (CEPI), located in the Department of Prosthesis - School of Dentistry at University of São Paulo (FOUSP). This research was approved by the FOUSP Research Ethics Committee –registration number: 48318215.8.0000.0075 and the study participants were informed and signed the Informed Consent Term.

Eighteen patients were selected for this study, and the inclusion criteria were: diagnostic of (muscle disorders (group 1) on Axis I of the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) diagnosis questionnaire, both gender; maximum of 2 teeth lost per arch (excluding the third molars), no occlusal discrepancies (maximum of 1 mm teeth extrusion), no teeth mobility (no periodontal issues).

The conventional device was made in a dental prosthesis laboratory. Initially, cast models were obtained from alginate impression (Jeltrat type II - Dentsply - Brazil); on the articulator mounted casts, with 2 mm thickness between the 2nd molars, the occlusal device was waxed (Lysanda - Produtos Odontológicos LTDA - São Paulo - Brazil) according to the criteria of the Michigan type device (30), included in a muffle and heat polymerized using thermoplastic acrylic resin (Jet - Classico, Brazil), finished and polished (Figure 1A).

Figure 1A: Conventional device intraoral positioned.

Meshmixer software (Autodesk, USA) was used for the 3D printed device, the same criteria were used for the conventional Michigan type device, with a minimum thickness of 2 mm in the 2nd molar region. After the virtual planning of the device, they were printed using stereolithographic printer Form 2 (Formlabs, Somerville, Massachusetts, USA) and photosensitive polymer based on methyl methacrylate (Dental Clear LT - Formlabs, USA) (Figure 1B).

Figure 1B: Printed device intraoral positioned.

The two devices were installed in the same patient in order to evaluate and compare technical criteria. The adjustments of the device were made by two researchers, trained and calibrated, and the evaluations were made by another researcher to reduce the risk of bias. For the evaluation of the results, the surface electromyographic analysis of the mandibular movements was performed in the patients with the use of the Aequilis-wireless EMG/Biofeedback electromyograph (Dental Balancing Solutions, USA). The electrodes were installed in the right and left masseter muscles and right and left temporal muscles (4 channels and 1 ground point) (Figure 2).

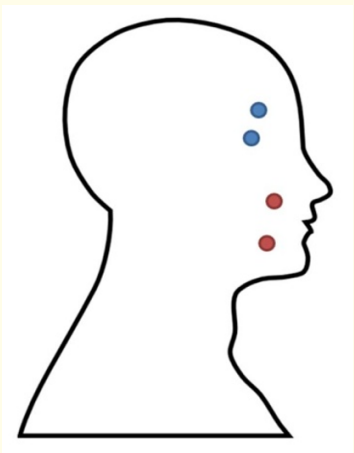

Figure 2: Schematic representation of the electrode's installation during the electromyography (muscles masseter in red and temporalis in blue).

The examination began with the patient being monitored for 5 minutes at rest without the use of the device; then one of the devices was inserted and monitored for 5 minutes at rest; followed by 3 repetitions of the opening, closing, left and right laterality and protrusion movements. The device was then removed, and the patient was monitored at rest for a further 5 minutes (wash- out). This process was repeated with the second device (rest for 5 minutes followed by 3 repetitions of the mandibular movements). In order to avoid bias in the result, the order of use of the device was alternated, if the first patient used the conventional device in the examination first, followed by the 3d-printed device, the next patient examined first used the printed device, followed by the conventional device and so on among the 18 patients. The mean value of the electric potential variation of muscle activity in each period was recorded for each muscle. Statistical analysis of the results was performed using the Wilcoxon test (77) and the means of the 2 to 2 combinations of the variables of interest were compared.

Results and Discussion

The results obtained are presented in table 1 below, showing the mean values (in millivolts) of each muscle during movement or rest and comparing the devices (conventional versus 3D-printed).

Studies have already evaluated the difference between different designs of the device in altered muscle activity [2,5,6]. The Michigan type device is the most used model and follows the occlusal stabilization patterns with centric contact points of the opposing teeth´s support cusps on the device and lateral and anterior guidance in canine [4].

	Right Masseter			Left Masseter			Right Temporal			Left Temporal		
	Mean	S.E.	p-value[1]	Mean	S.E.	p-value[1]	Mean	S.E.	p-value[1]	Mean	S.E.	p-value[1]
Mandibular Moviments – 3D printed device	0,022	0,015	0,162	0,003	0,010	0,717	0,002	0,004	0,569	-0,027	0,021	0,125
Mandibular Moviments – conventional device	0,002	0,008		0,006	0,010		0,002	0,006		-0,016	0,019	
Rest – 3D printed device	0,001	0,005	0,717	0,000	0,003	0,875	-0,001	0,002	0,083	-0,005	0,006	0,268
Rest – conventional device	-0,010	0,011		0,007	0,008		0,002	0,003		-0,039	0,048	

Table1: Electromyographic mean values according to muscles and device used, and comparative statistical analysis.

[1]Wilcoxon test. Values are presented in millivolts (S.E. – Standard Error)

There are no studies that evaluate the characteristics of muscular activities comparing the same device design with different materials and different techniques, as in the case of the device printed by the 3D method.

The result presented in this research shows that the despite any difference between the materials of the conventional and printed devices they were not enough to cause lower or higher activation of the masticatory muscles activity in the patients evaluated.

More studies are necessary to evaluate the new materials long-term stability compared with the conventional materials as well as other its mechanical characteristics, fulfilling the knowledge about this emerging procedure.

Conclusion

The electromyographic evaluation showed equivalent results of the conventional and 3D printed occlusal devices in the masticatory muscle activity. Considering the advantages of the 3D technologies as accuracy, patient comfort, speed, and repeatability, the study results demonstrating equivalent or superior results of the new 3D-printed occlusal devices are important to give to dentists security when adopting the new technologies.

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Conflict of Interest

The authors report no conflicts of interest and no financial support for this study.

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