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MUSCLE ACTIVITY EVALUATION OF MAXILLARY BILATERAL BOUNDED PARTIAL DENTURE FABRICATED BY BRE-FLEX VERSUS PEEK: A RANDOMIZED CLINICAL TRIAL

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ABSTRACT

Aim: In this research, we aimed to use an electromyogram to look at the muscle activity of people who were wearing a maxillary class III modification 1 removable partial denture made from two distinct materials: Bre-flex and PEEK.

Subjects and methods: Twenty patients with Kennedy class III modification 1, exhibiting maxillary partial edentulous ridges and a full dentulous mandibular arches, were placed into two similar groups for the fabrication of thermoplastic materials. The Bre-Flex material was given to the first group. The PEEK material was given to the other group. We evaluated the muscular activity of each studied group using an electromyogram at the time of denture insertion, three weeks later, and four weeks later, according to the follow-up recall visit schedule. The data were organized into tables and subjected to statistical analysis.

Results: The two groups' differences regarding muscular activity values were statistically significant

Conclusion: Bre-flex RPD shows better adaptability of the neuromuscular system during follow-up periods.

KEYWORDS: PEEK; Bre-flex; thermoplastic materials; muscle activity; Electromyogram

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INTRODUCTION

The removable partial dentures significantly enhance the process of mastication not only by offering more teeth to take part in the action, but also by re-establishing oral functions as a whole. Partial loss of teeth can induce significant alterations in the masticatory system that includes modifications in maxillo-mandibular interaction, tooth positioning, and dental arch morphology, potentially reducing the system's efficacy. The muscle activity may be affected by replacement of the missing teeth with partial dentures.[1, 2]

The fundamental concepts of stability, support, retention and cost-effectiveness must all be followed to create a successful removable partial denture. Moreover, it is essential to restore both functionality and aesthetics. Metallic and/or acrylic components fabricate most removable partial dentures, which replace missing natural teeth.[3, 4]

The anterior region esthetics can be achieved through the use of a removable partial denture in conjunction with a fixed restoration, particularly in cases involving the loss of soft or hard tissues around the abutment teeth. The termination of a metal clasp arm of a denture in the undercut of a tooth located in an aesthetic zone will lead to inadequate aesthetics. Metal-free removable partial dentures utilize thermoplastic materials that exhibit biocompatibility, nonirritant properties, nontoxicity, comfort, biological inertness, and enhanced esthetics. Various non-metal clasp dentures exist, each offering enhanced esthetics and a lower risk of allergic reactions to metals. The dentures exhibit flexibility and high elasticity, which reduce stress on abutment teeth.[5]

Bre.flex is a thermoplastic material composed of nylon. The original nylon is classified as PA 12 (polyamide). Bre.flex demonstrates superior flow properties attributed to its low melting temperature. The thermoplastic material is processed at a pressure of 7.0 bar. The elevated pressure reduces the shrinkage and ensures prolonged dimensional stability, leading to accurately fitting dentures.[6-8]

Polyaryletherketones (PAEKs) represnts a family of powerful semicrystalline thermoplastic resins that vary in how many keto and ether groups they contain. As the ratio and order of keto groups get higher, the polymer chain and glass become more rigid, and the melting point goes up.[9, 10]

PEEK denture clasps show reduced retentive forces in comparison to cobalt–chromium (Co–Cr) clasps. Nonetheless, given that the study was performed on metal crowns in vitro, the effectiveness of esthetic PEEK clasps for denture retention in a clinical environment remains uncertain.[11]

PEEK is primarily utilized in dental applications such as dental implants and implant abutments, fixed crowns and bridges, and removable dentures.[12, 13]

Electromyography (EMG) involves the graphical representation of the electrical activity of muscles. During function, the masticatory muscles activities are influenced by factors like body position, emotional stress, physiological function, parafunctional activity, the electrode type employed (surface or needle electrodes), the food texture, the state of the teeth, and the presence of prosthetic appliances.[14]

Surface EMG is commonly employed to record the activity of the masseter muscles in both sides, thereby minimizing variations in recorded muscle activity that may arise from individual preferences in mastication side.[15]

The loss of one or more teeth has been associated with a decrease in masticatory efficiency and an increase in muscular activity, indicating a potential need for improvement. A partial removable dental prosthesis (PRDP) is a great way for people who have lost back teeth to improve their masticatory performance by noninvasive and cost-effective method.[16, 17]

The point of this study was to use an electromyogram to look at the muscle activity of people who were wearing a maxillary class III modification 1 removable partial denture constructed from two distinct material types: Bre-flex and PEEK.

MATERIALS AND METHODS

Twenty patients were chosen from the clinic of Removable Prosthodontics department, Faculty of Dentistry, Cairo University. The patients were diagnosed with Kennedy class III modification 1 maxillary partial edentulous ridges, accompanied by fully dentulous mandibular arches.

The selected patients are of both genders with age range (35-40), in a good medical condition, free from any temporomandibular joint disorders, free from any neuromuscular disorder that might affect the chewing efficiency of the masticatory muscles and without any abnormal habits like bruxism and clenching.

The patients were chosen with missing one or two bilateral maxillary premolars, with intact remaining teeth with no signs of attrition or gingival recession or periodontal problems. The selected patients should have skeletal Angle's class I maxilla -mandibular relationship with preserved vertical dimension and have sufficient inter arch distance. The occlusion of the natural teeth was assessed and corrected if needed.

This study was structured as a parallel randomized controlled trial. When executed properly, randomized clinical trials serve as the most scientifically rigorous study design for internal validity. They effectively control bias, serve as the benchmark for assessing treatment efficacy, and are widely regarded as possessing the maximum degree of confirmed scientific evidence.

Sample size calculation was achieved using PS: Power and Sample Size Calculation software version 3.1.2 (Vanderbilt University, Nashville, Tennessee, USA), the sample size was set to be 10 patients for each group.

The patients were assigned to one of two groups randomly using a web-based tool for randomization known as Research Randomizer (https://www.randomizer.org/).

Only a single investigator, who was not engaged in the selection and treatment of the patients, possessed knowledge of the randomization sequence. The initial group consisted of patients who were provided with a maxillary removable partial denture constructed from injectable Bre.Flex second edition (Bredent2nd, Germany) resin material, which was reinforced with a metal framework. The remaining group of patients got a maxillary removable partial denture made from injectable polyetheretherketone (PEEK) (GMbH&Co.KG, Germany) and reinforced with a metal framework.

A maxillary partially edentulous ridge (Kennedy Class III with Modification 1) exhibiting favorable tooth anatomy was selected due to the superior esthetics of the maxillary arch compared to the mandibular arch. The premolar region was selected due to its significance in ensuring the retention of the prosthesis. Additionally, a clasp positioned on the canine is preferable to be fabricated from aesthetic materials as it may be visible when the patient smiles.

Irreversible hydrocolloid (alginate) was used to create initial impressions of the patient's maxillary and mandibular arches (Cavex CA37 Alginate impression material, Holland BV). Primary surveying was conducted on the diagnostic casts, followed by mounting the maxillary cast on a semi-adjustable articulator (A7 plus, Bio-Art Dental Products, São Carlos, SP, Brazil) by the use of a face-bow record. Mounting the diagnostic casts on a semi adjustable articulator is to assess for any dental interferences. Evaluating interarch distance was essential for accommodating the future prosthesis. The mounted casts were also utilized to evaluate the antero-posterior jaw relationship.

Panoramic and periapical radiographs were conducted as a comprehensive mouth survey to assess the bone and the crown-root ratio. The patients selected were made aware about their participation in scheduled follow-up for one month after receiving the removable partial denture through

written informed consent. Each patient signed an informed consent, a crucial aspect of bioethics that ensures they comprehend the advantages as well as the risks associated with any medical procedure.

Medium-bodied elastomeric impression material (AquasilMonophase, DENTSPLY CAULK, USA) was utilized to obtain the final impression which boxed and poured in extra hard dental stone (Elite® rock dental stone, Zermack, Italy). The design for the palatal strap major connector was marked on the master cast. Aker's clasps were applied on the molars, and Aker's arm was positioned on the canine. The design was copied into a refractory cast using silicon (Technosil, Bredent, Germany) to make the metal framework. General dentists are quickly adopting removable partial dentures made from a mix of metal and thermoplastic resin. These are thought to be better in terms of both comfort and appearance than traditional metal-clasp retained removable partial dentures with metal clasps. This is because the rigidity of the metal framework evenly distributes forces, and the thermoplastic clasps improve the appearance. This means that these types of RPD are made from both an aesthetic and a mechanical perspective.

PEEK materials were injected at 400 °C for 20 minutes under a pressure of 950 megapascals and a velocity of 6 bars over 240 seconds, whereas Bre-Flex materials required 222 °C for 15 minutes during injection in the Thermoflex 400 molding unit. Each denture was thoroughly finished and polished, inserted into the patient's mouth, and meticulously verified to ensure the correct vertical dimension of occlusion and a harmonious occlusal relationship.

MUSCLE ACTIVITY EVALUATION

Clinical measurement was performed for one month in three visits utilizing a digital electromyogram (EMG) to assess muscular activity, quantified by the root mean square (RMS) value.

The position of the surface electrodes were identified on the masseter muscles of the patient by selecting two points bilaterally; the first point marked 1cm above the inferior border of the mandible over the main palpable portion of the masseter muscle while the second point marked approximately 20 mm apart.

The electromyographic activity of the masseter was recorded by the Cadwel Excel high power EMG/EP instrument. The EMG is equipped with a high resolution, 14 inch full-color monitor. The EMG boasts an eight-channel amplifier that electronically montages 20 inputs, an analog electromyograph, and a laser printer.

During the electromyography recording sessions, the participants were positioned upright in a relaxed manner, with their heads aligned with their bodies. The patient's skin was disinfected with alcohol in the specified areas before electrode placement. Furthermore the palm of the The patient's hand was sanitized at the site of the ground electrode placement. The inner surfaces of the electrodes were filled with Ten20 conductive EEG paste and secured to the patient's skin using adhesive tape.[18] (Figure 1)

Fig. (1): The electrodes were adhered to the patient's skin with an adhesive tape.

We recorded each participant's muscle activity during maximum clenching and chewing of equal-sized pieces of carrot (hard food), and banana (soft food) as the properties of food may affect

masticatory behavior. These properties include the size, shape and flavor of the food as well as material characteristics including texture, elasticity and rheological properties.[19]

Muscle activity was measured for each participant three times after denture insertion (immediately after insertion, after three weeks and after one month). Data were collected, calculated, tabulated and subjected to statistical analysis.

RESULTS

SPSS (Statistical package for the social sciences) version 20 from IBM Corp., U.S.A., was used to conduct the statistical analysis. The data were displayed as minimum, maximum, mean ± standard deviation. The data distribution's normality was investigated using the Kolmogorov-Smirnov test (K-S). Within each of the groups under study, variables were compared using the repeated-measures analysis of variance test (ANOVA). A Hoc test was done if ANOVA was significant for determination of the source of variation. Variables between the two groups under study were compared using an independent sample t-test. Results considered statistically significant if the p-value was less than 0.05.

As shown in table 1 and figure 2. The motor unit action potential (MUAP) was the highest for both groups when they ate hard foods like carrots, especially for patients wearing Bre-flex (21.51±1.94) right after putting in their dentures. However, the lowest was for soft food (eating banana) with patients wearing Bre-flex (10.53±1.25) at 3 weeks record.

As shown in table 2 and figure 3. The mean area of MUAP between both groups was the highest for hard food (eating carrots) with patients wearing Bre-flex (1691.83±434.52) immediately after denture insertion. However, the lowest was for soft food (eating banana) with patients wearing Bre-flex (711.69 ± 135.97) at 3 weeks record.

TABLE (1) Comparison between Duration of MUAP of Groups I & II during the follow-up period: (T- test)

		Group I Bre-flex		Group II PEEK		
Duration		M	SD	M	SD	P value
Immediately	Clenching	20.26	3.73	16.74	1.52	0.012*
	Hard food	21.51	1.94	17.25	2.32	0.002*
	Soft food	20.90	2.51	17.18	2.71	0.004*
After 3 weeks	Clenching	11.37	1.20	14.06	1.23	0.0001*
	Hard food	11.66	2.00	13.78	1.61	0.018*
	Soft food	10.53	1.25	13.94	1.42	0.001*
After 4 weeks	Clenching	11.84	1.17	15.33	1.74	0.001*
	Hard food	11.59	1.38	16.53	1.76	0.001*
	Soft food	12.03	0.86	16.36	1.37	0.001*

M ; mean SD ; standard deviation P value; probability level *significant difference

TABLE (2) Comparison between area of MUAP of group I & II during follow-up period: (T-test)

Duration		Group I Bre-flex		Group II PEEK		P value
		M	SD	M	SD	
Immediately	Clenching	1364.33	248.64	1200.29	234.05	0.19
	Hard food	1691.83	434.52	1260.96	332.57	0.02*
	Soft food	1657.02	304.72	1226.23	296.67	0.004*
After 3 weeks	Clenching	786.85	166.96	1048.71	133.67	0.001*
	Hard food	788.73	132.83	1039.75	208.74	0.005*
	Soft food	711.69	135.97	1013.54	144.85	0.0008*
After 4 weeks	Clenching	808.95	175.94	1161.83	161.54	0.002*
	Hard food	813.55	186.82	1452.96	307.50	0.0001*
	Soft food	918.31	123.40	1486.27	217.14	0.0001*

M ; mean ***SD ; standard deviation*** ***P value; probability level*** ****significant difference***

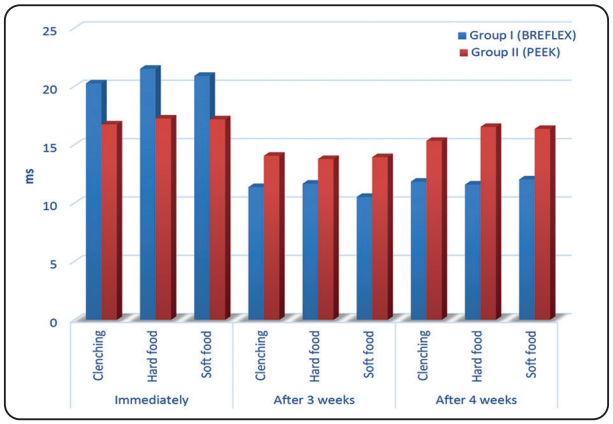

Fig. (2) Duration of MUAP of group I& II

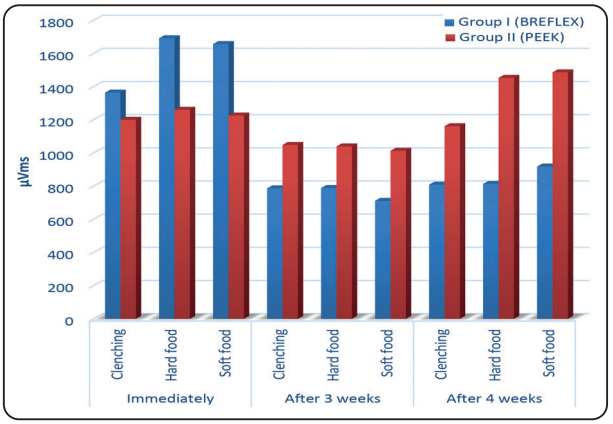

Fig. (3) Area of MUAP of group I & II.

DISCUSSION

When comparing the initial and final measurements of clenching in this study, both groups showed a pattern of muscular activity reduction. This result is comparable to Ferreira et al.'s findings for all prostheses users.[20]

Immediately in both groups, the mean duration and area values were highest during hard food consumption, followed by those during soft food consumption, while they were lowest during clenching. This could be because clenching food causes the muscles to contract more, which moves the jaw and applies the forces needed to cut and grind the food.[21]

Four weeks following the dental prosthesis' installation, mean duration values during clenching, hard and soft food decreased in both groups. This finding could be explained by the patient's improved adaptation to the prosthesis and acceptance, as well as the improved neuromuscular control they have naturally acquired over time.[22]

Consequently, mastication required less effort over time, which could lead to improved masticatory function and the preservation of the masticatory system. Another study concurred with this finding, suggesting that the prosthesis adaptation could be responsible for the reduction in masticatory muscle activity.[23]

While mean area values during clenching, hard and soft food were decreased in group I (bre-flex), but increased in group II (PEEK). This may be related to the shock-absorbing ability of PEEK material.[13]

The actual reduction in muscle activity suggested that the masticatory system was functioning better.

CONCLUSION

1. Bre-flex RPD shows better adaptability of the neuromuscular system during follow up periods.
2. This was a short-term study, and more research is needed to assess the long-term effects of Bre-flex and PEEK RPDs on masticatory muscle activity.

Conflict of Interest:

No conflicts of interest are disclosed by the authors.

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