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Influence of Rigid and Flexible Occlusal Stents on Electromyographic Patterns in Individuals Exhibiting Different Degrees of Occlusal Wear

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Abstract **Aim:** This study was designed to assess the impact of Rigid and Flexible Occlusal Stents on electromyographic (EMG) endeavor in patients suffering from different degrees of occlusal wear at various time intervals. **Methods:** Individuals aged 20–50 complaining from different degrees of Occlusal wear were assigned to either group I (RS) getting rigid stent, or group II(FS), getting flexible stents. The Electromyographic endeavor of masticatory muscles was noted during rest and clenching positions for both study and monitor groups, with and without the use of occlusal stents at different time intervals. intergroup and intra-group comparisons were done using the Nonparametric tests. **Results:** Nonsignificant difference was exhibited in between t study and monitor groups in spite that the Standard Electromyographic endeavors were greater in the study groups than the monitor groups. After one day, the patients in both rigid and flexible occlusal stents showed significantly lower ($p < 0.05$) electromyographic endeavor than those without stents. After one month, and two months, the electromyographic endeavor decreased in the rigid stent group, but better in the flexible stent group in comparison with the monitor group. This difference was significant only during clenching of the anterior temporalis in group I(RS) and nonsignificant for other study groups. **Conclusion:** The stent materials and duration of use improve the masseter and anterior temporalis masticatory muscles activities. After two months, both types of occlusal stents facilitated the muscle adaptation to the increased occlusal vertical dimension, The anterior temporalis muscle showed more noticeable muscle activity compared to the masseter muscle.

Keywords: *occlusal vertical dimension, electromyography, occlusal stent, occlusal teeth loss*

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1. Introduction

Occlusal Tooth loss is a multifaceted incident characterized by a range of factors and widespread prevalence. Physiological tooth wear is often associated with aging and can result in various outcomes, such as dentine sensitivity, decreased occlusal height, and a general imbalance within the TMJ and masticatory muscles. When occlusal tooth loss advances, leading to decreased vertical occlusal dimension, ultimately limiting space for accommodating Prosthodontic treatment [1,2]

Progressive occlusal stents play a crucial role in muscle deprogramming, restoring TMJ stability in a flexible behavior to the new increase in occlusal vertical dimension. Additionally, these stents offer valuable indicative and predictive insights during the steadying or pre restorative period [3,4]. Therefore, it is imperative to investigate the impacts of stents on muscular endeavor, determine the effective period of tooth loss for achieving the required effects, therefore understand the differential actions of stents fabricated from various materials.

One extensively explored method in the literature for studying these effects is electromyographic (EMG) endeavor of some muscles of mastication namely the anterior temporalis and masseter muscles. EMG is an effective proven display for assessing the condition of the oral cavity, TMJ and Masticatory muscles, and understanding the efficient mechanisms of stents [5].

Previous investigations [5-7] have documented a decrease in electromyographic endeavor in the masseter and anterior temporalis muscles when using rigid stents, during which the impact of flexible stents on electromyographic endeavor activity has shown variability. previous reports were primarily done on normal persons or those suffering from temporomandibular joint disease (TMD) or bruxism. A noteworthy finding was that wearing rigid stents for three months contributed to restoring normal resting condition of the muscles following adjusting the occlusal vertical dimensions [8]. The fabrication of rigid stents is slow, complex technique, and necessitates further visits to adjust occlusion. Moreover, the rigidity of rigid stents poses a risk of poor patient compliance, potentially undermining their effectiveness in breaking the muscle engram. Conversely, flexible stents have gained popularity among clinicians due to their quick fabrication and better tolerance [9]. Several searches have suggested that using flexible stents may lead to change in the pattern of occlusion and parafunctional habits, although others indicated that selective grinding of the occlusal surface during stent insertion could prevent such changes over time [10].

One study. [11] concluded that there was improved response inpatient suffering from parafunctional habits, with no significant difference in electromyographic endeavor between rigid and flexible stents groups. Investigations into the effect of rigid versus flexible stents on relieving pain, clenching force, muscle spasm, or brain functional activity have predominantly focused on normal individuals or those exhibiting bruxism directly following stent therapy, with results reported up to 6 weeks [12-14]. Another study [15] noticed that there was no significant difference between rigid and flexible stent therapy up to 15 weeks, while another study suggested greater pain relief with flexible stents during a similar timeframe [12,15]. A recent clinical trial indicated that a rigid stent provided a greater improvement in TMD symptoms contrasted to flexible stent, though the interpretability of the scoring criterion used in the assessment remains uncertain [16].

To date, there is limited literature reporting the effects of rigid and flexible stents on the electromyographic (EMG) endeavor in patients suffering from occlusal tooth loss and need gradual increase in the vertical dimension of occlusion. Given the pivotal role of patient compliance in achieving desired results, understanding the patient's tolerance of stents is equally crucial, and this aspect wasn’t adequately addressed in existing literature.

Hence, the research was designed to examine and assess the impact of rigid and flexible stents on the electromyographic (EMG) endeavor of the masseter and anterior temporalis muscles in individuals suffering from different degrees of occlusal tooth loss. This assessment was conducted at two different muscle functions, during rest (PRP) and during clenching (MVC), directly after one day, and over two months period, with and without the stent therapy.

2. Materials and Methods

The study commenced following the principles and ethics of Research Unit and the University Dental Hospital of at the Faculty of Dentistry, Taif University regulation rules . A total no. of sixteen patients were assigned into two study groups: eight patients each. The first Group I RS (Rigid stent made from heat cure acrylic resin) and second group IIFS (Flexible stent made from thermo-vacuum formed flexible polyvinyl stent). Additionally, another eight patients with the same inclusion and exclusion criteria were assigned as a monitor control group. However, this control group did not undergo any stent therapy.

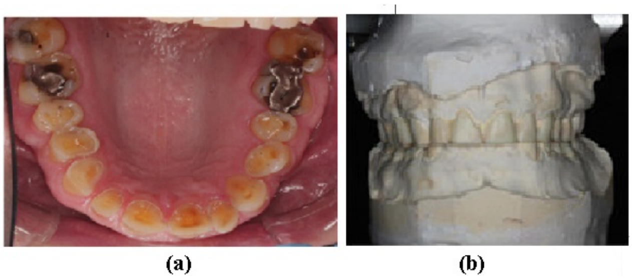

Figure 1. (a) signs of occlusal wear (b) study cast mounted on articulator.

Inclusion and Exclusion Criteria: [17-19] Patients aged 20–50 years, exhibiting features of occlusal tooth attrition, (Figure 1) were assigned to the Prosthetic specialty clinics from the Department of Oral Medicine and Allied Dental sciences of Dentistry in the University Dental Hospital at the Faculty of Dentistry, Taif University for additional consultation and enrolment in this research. All patients showed different degrees of tooth attrition ranging from 0-3 (no-mild-moderate-sever). This careful selection process ensured the inclusion of participants with relevant occlusal wear while excluding those who might introduce confounding variables or compromise the effectiveness of the stent therapy. While exclusion criteria were implemented to ensure that the study participants had a specific dental and health profile, excluding individuals with conditions or treatments that might confound the investigation into the impacts of stents on the activity of the muscles such as: bruxism, Presence of neuromuscular disorders., TMJ disorder/TMD (Temporomandibular Joint Disorder)., Systemic problems such as rheumatoid arthritis., any other past dental treatment that might potentially influence activity of the muscles, and Individuals outside the specified age range. and Individuals with contraindications to stent therapy. eligible participants were given a comprehensive explanation of the study plan, emphasizing the importance of compliance with wearing splints, participation in electromyographic (EMG) studies, and attendance at follow-up visits. Prior to their participation, patient consent form was signed by the patient and obtained in adherence to the Helsinki Declaration principles [20], ensuring that participants were fully informed about the study procedures and voluntarily agreed to participate. The fabrication of occlusal splints involved a systematic process. Face-bow records were used to mount Upper and lower study models on a semi-adjustable articulator then 1and 3 mm separation is created in the posterior and anterior region respectively. Rigid stents were crafted on the upper model from heat polymerized methyl methacrylate. Move the anterior guidance of the articulator to ensure that there is1 mm separation in the posterior region during eccentric movements [21] (Figure 2). A 3 mm thickness flexible polyvinyl sheet*[1] were adapted on the upper model using heat and pressure [22]. The stent was modified to prove standardized and slight occlusion in the posterior and anterior regions respectively during centric occluding position (Figure 3). For Quality

[1] Bioplast; Scheu-dental GmbH, Iserlohn, Germany

Control, all stents were constructed by a single technician to ensure consistency in appliance construction. An experienced supervisor confirmed the sitting and precision of each stent. All Contributors were trained to insert the stent continuously, all day and remove it during meals. They were asked to inform us directly in case of any complaint of pain, tenderness, headache during using the stent. Agreement checks were performed repeatedly to monitor individual adherence to the prescribed regimen.

Figure 2. Rigid Occlusal Stent

Figure 3. Flexible Occlusal Stent

Figure. 4. Electromyography for the anterior temporalis

Electromyography (EMG): The electromyography (EMG) procedure was conducted with precision and consistency through a specific well-trained expert. The EMG equipment used was an eight-channel system [2] installed with corrected constant measurement [23] Participants were explained the EMG procedure and seated comfortably with unsupported heads. The anterior temporalis and masseter muscles were examined to ensure accurate electrode placement. wired rods were applied and fastened to the muscles with suitable gel or taps (Figure 4). Signals were logged using a section where activities in all channels remained stable over 5 seconds [11,23] Measurable quantities of magnified motorized part abilities in microvolts (μV) were evaluated beginning from the bottom to peak of the detailed diagram. Computer-assisted programming was employed for measurement of EMG values. for each participant we take 3 interpretations and calculate their mean value. EMG activity was recorded at four time points: pretreatment/reference, one day after stent insertion, after one month, and after two months. Measurements were taken for two positions on each visit: (PRP) and (MVC). This standardized, comprehensive approach ensured reliable and comparable EMG data across all participants and time points, contributing to the accuracy and validity of the study findings. Electromyographic endeavor was documented both with and without the stent for the study group. Regarding the monitor group, Electromyographic endeavor was documented only at the time of their enrolment in the research, encompassing both PRP and MVC positions. A dental nurse, blinded to the aim of the study and the stent type, played a crucial role in gathering subjective feedback from participants regarding any complain such as pain, tenderness, headache, difficulty in speech, muscular or temporomandibular joint pain on Likert scale ranging from 0-3 (where:0 = None,1 = Mild**,**2 = Moderate**,** and 3 = Severe)**.** Participants provided subjective feedback after the application of stents and throughout the study time intervals. This dual assessment strategy, combining objective EMG recordings and subjective reporting, provides a comprehensive understanding of the impact of splint usage on both muscle activity and participants' subjective experiences. The blinded reporting by the dental nurse adds an additional layer of objectivity to the study, reducing potential biases in participant feedback. The statistical analysis of the study data was conducted using the Statistical Package for the Social Sciences (SPSS) software, Version 19 by IBM Corp. The following methods and criteria were employed: the activity of the muscles was showed as average in μV. The Shapiro–Wilk test was used to assess the data normality. The Kruskal Wallis test was employed for intergroup assessments. The Mann Whitney U test was employed for pair wise assessments between groups. A p-value of <0.05 is deemed statistically significant. These statistical methods were chosen to assess changes over time within groups, make comparisons between groups, and ensure the reliability and significance of the study findings. The application of Bonferroni corrections in the Wilcoxon signed-rank test and the consideration of a 95% confidence interval add rigor to the statistical analysis.

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3. Results

Table (1) presents demographic details, including the number of participants, mean age, gender distribution, and degree of occlusal wear for each group. The wear score reflects the severity of tooth wear on a scale from 0 to 3. In Group I RS: Regarding speech difficulties there were four individuals registered minor and another four expressed moderate. Three contributors complained about biting his check one day after stent insertion. While three members in Group II FS described mild speech difficulty and one described minor cheek biting. More contributors in group I RS had phonetic problems compared to group II FS. After one day, the same number of participants complained from biting his/her checks in two groups. No one of the applicants described TMJ problems, muscular fatigue, or headache. Following modifications and correctness of occlusal discrepancies, no more complaints were stated at succeeding time interval appointments as shown in Table 2. These results provide insights into the subjective experiences of participants after stent insertion, highlighting differences in speech difficulty between the rigid and flexible stent groups and addressing and resolving reported issues through adjustments and counseling during follow-up visits.

Electromyography (EMG) recording at different muscle functions were presented in figures 5 and 6 respectively revealing that the difference between the left and right muscles was statistically insignificant ($p > 0.05$). Significant differences in muscular function were observed in the two groups after one day of stent insertion ($p < 0.01$). insignificant differences were noted at other different time intervals. Also, insignificant differences ($p > 0.05$). were noted in the initial electromyographic endeavor of masseter and anterior temporalis muscles during Rest and Clenching for the two study and monitor control groups, even though initial muscular function remained advanced in study groups than in monitor control group. The Rigid Stent group exposed an insignificant reduction ($p > 0.05$) in electromyographic endeavor after one and two months in comparison with the initial one of the monitor groups excluding the anterior temporalis during MVC, that displayed significantly lesser electromyographic values after one month with and without splint ($p = 0.006$, $p = 0.007$) and after two months with and without splint ($p = 0.027$, $p = 0.03$). Group II FS established a nonsignificant ($p > 0.05$) improved PRP and MVC functions after one and two months in comparison with the initial values of the monitor group. After one day, nonsignificant reduction ($p > 0.05$) was observed between experimental groups in the function of masticatory muscles, with and without a stent. At one and two months, nonsignificant differences were observed in masseter muscle functions (PRP&MVC) and in the anterior temporalis muscle PRP with and without stent therapy. While there was a significant improvement of anterior temporalis muscle during MVC function in the Flexible Stent group than the Rigid Stent group after one month ($p = 0.04$) and two months ($p = 0.03$). These results provide a detailed analysis of EMG activity in masticatory muscles under various conditions, highlighting significant changes and trends over the study period. The differences between the experimental groups and the impact of stent usage on muscle function activity are explored comprehensively.

Table 1. occlusal wear scores in the control and different study groups

individual	Control	Rigi Stent	Soft Stent	P value
Age (mean ± SD)	35.66 ± 3.34	36.5 ± 5.32	35.62 ± 7.55	0.363
Gender Male	6 (75%)	6 (75%)	6 (75%)	1.000
n (%) Female	2 (25%)	2 (25%)	2 (25%)	
Degree of Occlusal wear 0 (%) 1 2 3	5 (62.5%)	0	0	Group IHS vs control: 0.0157
	3 (37.5%)	0	0	Group IISS vs control: 0.022
	0	6 (75%)	5 (62.5%)	
	0	2 (25%)	3 (37.5%)	Group I vs II: 1.000

Table 2. Symptoms of both Rigid and Flexible stents at different time intervals

		Speech difficulty			*TMJ problems*			*Muscular pain*			*Cheek biting*			*Headache*		
		One day	*One month*	*two month*	*One day*	*One month*	*two month*	*One day*	*One month*	*two month*	*One day*	*One month*	*two month*	*One day*	*One month*	*two month*
Group I Rigid Stent	non	0	4	6	8	7	7	5	7	6	5	7	7	7	4	4
	mild	1	2	5	0	0	0	4	0	0	3	4	5	8	6	0
	Mod.	4	1	1	0	0	0	1	0	0	0	2	3	7	5	0
	sever	2	1	0	0	0	0	2	0	0	4	3	0	5	1	0
Group II Flexible Stent	non	2	1	0	7	6	6	2	0	0	7	7	6	8	5	5
	mild	4	0	0	0	0	0	2	0	0	5	6	6	6	0	0
	Mod.	3	0	0	0	0	0	1	0	0	4	2	3	7	6	2
	sever	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table3. Electromyographic endeavor of masticatory Muscles at different positions

Muscle	Position	RS	FS	Monitor control	p-value
Masseter muscle.	Postural rest position	10.05 (3.66–19.56)	10.84 (4.55–18.23)	9.77 (4.35–10.15)	0.723
	Maximum voluntary clenching	239.14 (86.1–497)	453.89(87.05–510.7)	269.99 (89–540.02)	0.125
Anterior temporalis muscle	Postural rest position	14.45 (8.19–29.49)	16.7 (9.82–398)	13.77 (8–19.5)	0.353
	Maximum voluntary clenching	349.88 (95.2–573.2)	846.42(239.9–953.2)	558.22(199.04-879.52)	0.298

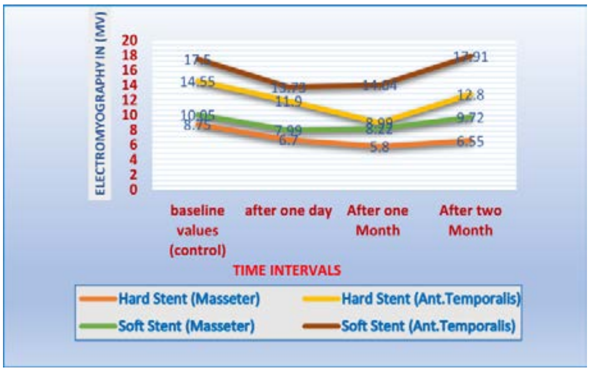

Figure. 5. Electromyography (EMG) recording at postural rest position (PRP)for both groups (Rigid and Flexible Stents) at different time intervals.

Figure. 6. Electromyography (EMG) recording at maximum voluntary clenching (MVC), for both groups (Rigid and Flexible Stents) at different time intervals.

4. Discussion

The study suggestion was somewhat believed that there is insignificant variances in the electromyographic muscle function between both groups apart from for Maximum Voluntary Clenching function of the anterior temporalis muscle after one and two months of stent delivery which was statistically significant. Initial standard electromyographic muscle function remained greater in the study groups than in monitor control group showing minimum or zero-degree occlusal tooth loss or attrition. Enduring occlusal tooth loss or attrition initiated to alter the electromyographic muscle function of contributors, with considering the degree of occlusal tooth loss as the main significant factor. The variation in baseline muscle activity between study and monitor control groups was insignificant due to uniformity in their distribution. This suggests that, despite differences in baseline activity, muscle activity remained within physiological limits. Some contributors initially complained from biting their check and speech difficulty, particularly with maxillary stents. Making the required modifications, these complaints were alleviated, emphasizing the importance of patient adaptation. Maxillary stents may cause farther speech difficulty; however, this was improved after one day wear, ensuring equal intensity contacts. Narita et al.'s study [12] reported increased muscle tiredness with soft splints compared to hard splints, which might change with psychological and muscular adaptation over time. Insignificant variations were monitored among left and right-side muscles after stent insertion, indicating a balanced correlation among joints and muscles. Previous study [5] concluded that there was diminished anterior temporalis muscle function activity and increased masseter activity with a rigid stent in normal individuals, suggesting effectiveness of stents for reasons beyond redistributing unfavorable joint loading. The discussion highlights the complex interplay between stent use, muscle adaptation, and patient comfort. It also emphasizes the importance of considering individual factors such as tooth wear severity in understanding the influences of various stents on muscular function activity. Variability in muscle response to stents, as observed in previous studies, underscores the complexity of these interactions. Hugger S et al. [6] observed inconsistent changes in muscular function activity with clenching on rigid stents. Factors such as anxiety of fracture of teeth, sudden increase in vertical dimension, may indicate variable outcomes. Results from this research indicated advanced EMG activity with the flexible stent in comparison with the rigid stent along the follow-up period. The improved muscle function with the flexible stent may be attributed to its soft nature and significant occlusal contact. Contributors may possibly also have prevented applying maximum biting force on rigid stent, fearing splint or tooth breakage. The flexible stent's ability to be deformed by occlusion biting forces may contribute to dissipation of biting force, particularly under maximum voluntary clenching. Most studies focus on the two masticatory muscles, namely the anterior temporalis and masseter muscles owing to their accessibility for electrode placement. Regarding our research, EMG function activity of the anterior temporalis muscle was greater than the masseter muscle, with the difference more noticeable during MVC after one and two months, with or without stent. This suggests that anterior temporalis is more affected by changes in vertical dimension. Achieving therapeutic harmony between various jaw muscles is considered crucial for treatment success.

Both study groups explained reduced muscular function activity one day after stent application. This may be because of the stent effect on the peripheral sensory receptors in the periodontium, muscle fibers, and Temporomandibular joint. Immediate changes may be related to altered reflex patterns or tissue healing influenced by gradual tooth surface loss.

In summary, the discussion highlights the intricate dynamics of muscle response to different stents, considering factors such as material properties, occlusal contacts, and changes in vertical dimension. Understanding these factors contributes to the broader understanding of occlusal therapies and their impact on muscle adaptation.

The study results underscore the significance of the stent material in patients with tooth wear, aiding the adaptation of the individuals to a new raised VD. It is emphasized that the effects of stents are reversible, making it crucial to determine the appropriate duration for achieving a harmony among CR and CO prior to continuing for final treatment. While it has been advised to use rigid stent for 3 months in certain cases, the study aimed to evaluate the effects after one day, after one and two months considering the challenges associated with a prolonged stabilization phase.

Both rigid and flexible stents demonstrated noticeable changes in muscle activity after one month. Muscle activity increased from day one to one month in a flexible stent in PRP and MVC, while it reduced using a rigid stent during the same period. Subsequently, there was a meaningful improvement in muscle function activity in the two groups at one to two months. After two months of stent usage the masticatory muscles may become adjusted to the raised vertical dimension and gain a fixed situation, approximating the initial monitoring values which explains the insignificant difference with or without stent. The resiliency of flexible stents consistently displayed advanced muscular functions throughout follow-up periods related to rigid stents. Study limitations include the use of convenience sampling, the absence of radiographic attributed to assessment of condylar position before and after stent therapy, and the inability to confirm subjective patient preference. Additionally, exploring patients' perspectives and preferences would contribute valuable insights to the overall findings.

5. Conclusion

Stents help in getting a balanced influence on the muscular function activity of contributors with tooth surface loss. They aided the adaptation to a raised occlusal relationship. The anterior temporalis muscle showed higher muscular function activity than the masseter muscle following stent usage. This highlights the importance of considering specific muscles in the evaluation. Objective evaluation of muscle activity is recommended for patients undergoing permissive stent therapy. This evaluation can contribute to reliable improvement of the stomatognathic system. The study suggests that an ideal period of stent usage is 2 months after which proceed for final treatment. This timeframe may help ensure optimal adaptation and effectiveness of the stent therapy.

These conclusions emphasize the clinical relevance of stents in managing tooth wear, providing insights into the specific effects on muscle activity and supporting the establishment of guidelines for the duration of splint wear in patient care.

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