RESEARCH PAPER

Masticatory Efficiency and Electromyographic Activity During Eating of Implant Supported Maxillary Overdenture Using Two Types of Attachments

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ABSTRACT
Objective: The purpose of this study was to evaluate the effect of ball and socket versus bar attachments in maxillary implant supported complete overdenture opposing Kennedy class I partially edentulous mandible on masticatory force and electromyography during eating. **Subjects and Methods:** Twelve patients with completely edentulous maxilla and opposing partially edentulous arch Kennedy class I were selected from the clinic of Removable Prosthodontic Department Faculty of Dental Medicine, Cairo, Boys, Al-Azhar University. New conventional maxillary complete denture opposing metallic RPD was constructed for each patient, delivered for them, instructed for their use, four implants were implanted in the maxillary canine and premolar areas according to anterior posterior spread concept. the conventional maxillary denture was converted into maxillary over denture. patients were divided into two groups; group I (n=6) patients with maxillary overdenture retained by bar and clip attachment system and group II (n=6) maxillary overdenture retained by ball and socket attachment system. Electromyography during eating and masticatory efficiency were evaluated 6 months and 12 months. **Results:** The results of this study revealed that electromyography during eating and masticatory force with group I (bar-clip) was higher than that with group II (ball and socket) with differences considered statistically significant as indicated by student-t test where P value < 0.05. **Conclusion:** It was concluded that, using of bar with clips attachment system is recommended with implant retained maxillary overdenture opposing Kennedy class I in an attempt to improve masticatory force and electromyography during eating.
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INTRODUCTION

Various treatment modalities have been proposed for patients with an edentulous maxilla and a few remaining anterior mandibular teeth. The selection of treatment ultimately relies on the patient, including the time and financial resources he is prepared to invest, his oral health status, and his preference for fixed or removable prosthetics. Certain patients request implants while others decline them. The advantages of implants over conventional prosthodontics include their ability to stimulate bone and preserve its dimensions akin to natural teeth (1).

In instances of edentulous maxilla and mandible with solely natural anterior teeth, the stress on the anterior maxillary region is significantly intensified; consequently, bone atrophy in this area may become inevitable over time (2).

Anterior maxillary hyperfunction resulting from excessive pressure exerted by the lower natural anterior teeth leads to atrophy of the edentulous area (3). Combination syndrome induces various alterations in the anatomy of alveolar bone, with the modifications in the maxilla differing from those in the mandible primarily due to disparate bone quality. Furthermore, bone resorption occurs more rapidly in the initial stages following tooth extraction (4).

Implant in edentulous patients has been shown to substantially improve chewing performance and patient satisfaction, as well as quality of life (5).

The aging population is driving up the demand for dental implant-supported overdentures among edentulous patients. Less invasive surgery may be possible with implant-supported overdentures if the number of implants required in the mandible is reduced. Patients' quality of life is greatly enhanced with implant-supported overdentures because they have better masticatory function compared to complete dentures (6).

Being one of the most basic stud attachments, ball attachments are widely used because they are inexpensive, easy to manage, require little chairside time, and can be used for both root and implant-supported prostheses (7).

Balls were preferred than bars attachments, as they have a lower cost, less reliant on specific techniques, and be easier to clean. Additionally, the likelihood of mucosal hyperplasia was found to be further reduced with solitary ball attachments. However, bars demonstrated greater retention (8).

The bar attachment composed of a metal bar that connects two or more implants or natural teeth across the edentulous

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ridge. It also includes a sleeve (suprastructure) integrated into the overdenture, which clips over the initial bar to secure the denture in place. Bar attachments come in various forms and can be either prefabricated or custom-made (9).

The literature presents an inconsistent definition of the masticatory function. Terms such as masticatory performance, chewing ability, or chewing efficiency are occasionally employed to describe chewing function. A literature review indicates that certain authors characterize it as the capacity to sever food particles during mastication. Some have described masticatory efficiency when chewed as distribution of food particle size for a given number of strokes (10).

Clinical studies measure masticatory output, an objective function of the jaw muscles, whereas participants or questionnaires assessing oral function evaluate masticatory ability, a self-assessed function of the musculature. (11).

Factors influencing masticatory effectiveness include absence and restoration of the posterior teeth, bite force, age and sex, saliva, food flavor and texture, as well as neuromuscular control (12).

Electromyography (EMG) is primarily used clinically to identify muscle function abnormalities, evaluate muscle activity for recruitment, and study biomechanics of movement, it is useful with TMJ disorders (13).

The non-invasive technique of surface electromyography (sEMG) is still not fully utilized as a therapeutic tool in rehabilitative medicine, despite its usefulness in assessing muscle activity (14).

This study set out to compare the masticatory efficiency and electromyography of four implant-retained maxillary overdentures—one with a bar and clip attachment and one with a ball and socket attachment—as well as an opposing mandibular Kennedy class I metallic removable partial denture—during eating.

The study's null hypothesis states that patients with Kennedy class I partially edentulous mandibles will not experience any change in masticatory efficiency or electromyography when implant-retained single maxillary overdentures with ball-and-sock or bar attachment systems are used during eating as implants provide retention to support for denture regardless type of attachment so that the force will be transmitted to implants and supporting tissues whatever the type of attachments.

PATIENTS AND METHODS:

Study design: Interventional study (an in vivo Randomized clinical study).

Twelve entirely edentulous patients were randomly chosen from the outpatient clinic of the Removable Prosthodontics Department, Faculty of Dental Medicine (Boys), Al-Azhar University, Cairo. According to the research conducted by Emera et al. (15), a sample size of six patients per group was determined utilizing a two-sample two-tailed t-test. The effect size (df=3.024) and the necessary sample size were computed for $\alpha = 0.05$ and a confidence power of 0.03353%, under the assumption of a normal distribution.

The patients were categorized into two groups. Each cohort comprised six patients. Group I (B group): (n=6) patients will receive a maxillary overdenture supported by a bar and clip attachment system (figure 1). Group II (BS group): (n=6) patients will receive a maxillary overdenture supported by a ball and socket attachment system (figure 2). Patients were chosen based on the subsequent criteria: Male patients aged 55 to 70 years. Maxillary Completely edentulous patient with naturally retained lower anterior teeth. Patients possessing sufficient bone height and width, accompanied by healthy, firm mucosa, to facilitate implant placement without necessitating additional procedures.

Patients devoid of any systemic diseases that could influence bone resorption. Patients capable of comprehending instructions. Patients possessing sufficient interarch space. Individuals meeting the subsequent criteria were excluded from the study: Patients with local and systemic conditions that hinder implant placement and osseointegration. Immunocompromised patients. Patients undergoing active chemotherapy or radiotherapy. Individuals exhibiting atypical jaw alignment. Individuals exhibiting parafunctional behaviors. Individuals with temporomandibular joint disorders. Insufficient interarch space.

Cone beam CT imaging was employed to evaluate the type, quality, and height of the alveolar ridge, with measurements taken in cross-sections (16). Fabrication of complete dentures: A new upper complete denture and lower metallic partial denture were fabricated for each patient and subsequently inserted into the patient's mouth following completion and polishing. Esthetics, retention, stability, occlusion, elevated areas, sharp edges, and overextensions were assessed.

A surgical guide was constructed to ensure accurate implant location and angulation by directing the initial implant drill to its designated position. The most straightforward method to fabricate the implant surgical template is an adaptation of Preston's clear splint (17).

An irreversible hydrocolloid impression of the complete arch (Tropicalgin, Zhermack, Italy) was obtained and subsequently cast in dental stone. A vacuum acrylic shell was molded and trimmed (Bioart, Brazil). The occlusal acrylic was excised from the preferred and supplementary areas of the implant, maintaining the facial and facio-occlusal line angle of the surgical template. This ensures optimal flexibility for implant positioning and conveys the preferred implant angulation during the surgical procedure (18).

1- Surgical phase: a) Surgery is performed under local anesthesia; two stages flapless surgical technique will be followed. b) Each patient will receive four dental implants in the maxillary canine and second premolar areas.

2- Prosthodontic phase: a) Maxillary complete denture and mandibular partial denture will be fabricated as usual manner. b) After six months of osseointegration period; implants will be exposed; the cover screw will be removed then ball &socket and bar attachments will be secured in its place for each group respectively. c) maxillary complete dentures will be converted to maxillary overdenture retained by four implants by direct pick up technique using self-cure acrylic resin to retain dentures to attachments.

Figure (1): Casted bar in mouth

Figure (2): Ball abutment in the mouth

Electromyographic activity measurement:
Surface electromyography is the gold standard for detecting and analyzing skeletal muscle electrical activity by means of skin-based electrodes (19). The EMG expert had total control over the entire testing process. The electromyographic activities of masseter muscles were examined by while patients eating on right and left sides, and this was done at different intervals (time of insertion, three months, six months, nine months and twelve months). Patients were set in an upright comfortable position, with the head in balanced, unsupported position and mandibular body at 45 degree with the ground. The measuremrnts were made after six and 12 months for each patient from insertion. Figure (3).

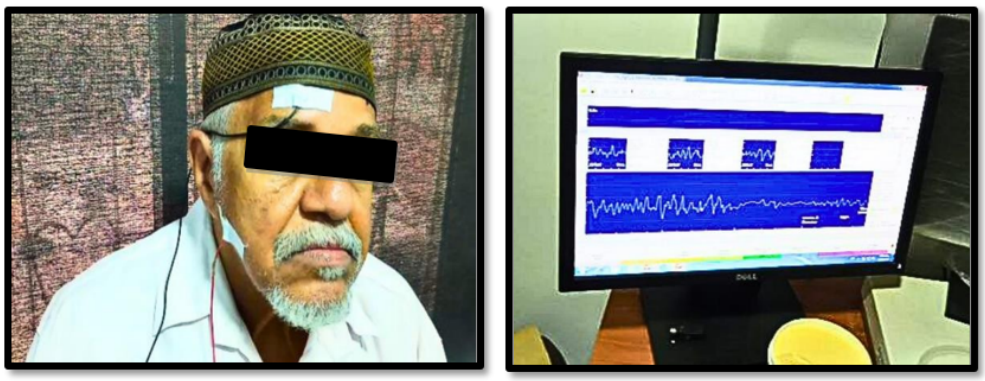

Figure (3): EMG screen and surface electrode on masseter muscle

Masticatory efficiency measurement:
A variety of foods, ranging in hardness from carrots to bananas, were used to gauge the masticatory efficiency. One grain of peanut, one standardized cube of carrot and banana (1 cm x 1 cm), and twenty to twenty-two more of the same were utilized. While wearing their mandibular overdenture, patients were asked to stand up straight and relax into an unrestricted position. We had them eat normally while keeping track of how many chew strokes it took to reach the first swallow, how many chew strokes it took until their mouth was clear of food, how many swallows it took, how much time it took until their mouth was clear of food, and how many seconds it took. One person kept track of the time and the other of the chewing strokes and swallows, which made up the measurements. For every test meal, these metrics were recorded five times, with the average being

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kept. At six and twelve months post-insertion, we tested each patient's masticatory efficiency.

Statistics analysis: Gathering, organizing, and statistically analyzing the data was done using SPSS© Statistics Version 20 for Windows. To verify that our data followed a normal distribution, we employed the Kolmogorov-Smirnov test. The results showed that the data were normally distributed, according to the statistical analysis performed using the student t-test. The significance level was set at $P \leq 0.05$.

RESULTS:

Table (1) shows A statistically significant difference was found between the two groups during all of the follow-up periods.

Table (1): electromyography comparison during eating hard & soft food on right side between group I (B group) and group II (BS group) after 6 months and 12 months.

		Ball (n = 6)	Bar (n = 6)	T	P
Soft R	**6 months**	0.224 ± 0.031	0.283 ± 0.028	3.470*	0.006*
	12 months	0.341 ± 0.044	0.393 ± 0.035	2.251*	0.048*
Hard R	**6 months**	0.328 ± 0.016	0.371 ± 0.025	3.485*	0.006*
	12 months	0.369 ± 0.017	0.460 ± 0.063	3.397*	0.015*

6 replica for each group t: Student t-test Data was expressed using Mean ± SD. p: p value for comparing between the studied groups *: Statistically significant at $p \leq 0.05$

Table (2) shows the mean values of electromyography during eating hard & soft food on right side for the two groups. A statistically significant difference was found between the two groups during all of the follow-up periods.

Table (2): electromyography comparison during eating hard & soft food on left side between group I (B group) and group II (BS group) after 6 months and 12 months.

		Ball (n = 6)	Bar (n = 6)	T	P
Soft L	**6 months**	0.380 ± 0.017	0.554 ± 0.049	8.162*	<0.001*
	12 months	0.458 ± 0.028	0.625 ± 0.092	4.263*	0.006*
Hard L	**6 months**	0.512 ± 0.037	0.576 ± 0.027	3.429*	0.006*
	12 months	0.586 ± 0.020	0.718 ± 0.045	6.561*	<0.001*

6 replica for each group t: Student t-test Data was expressed using Mean ± SD. p: p value for comparing between the studied groups *: Statistically significant at $p \leq 0.05$

Table (3): Masticatory efficiency comparison during eating hard & soft food between group I (B group) and group II (BS group) after 6 months and 12 months.

	6 months				
	No. strokes 1st swallow	**No. strokes mouth free**	**No. swallow mouth free**	**Time till 1st swallow**	**Time till mouth free**
Banana					
Ball group	20.0 ± 2.83	28.67 ± 3.56	2.50 ± 0.55	11.33 ± 1.51	21.50 ± 1.52
Bar group	8.50 ± 2.35	24.83 ± 3.37	2.67 ± 0.52	10.83 ± 0.75	22.0 ± 0.89
t (p)	7.667*(<0.001*)	1.915 (0.084)	0.542 (0.599)	0.728 (0.484)	0.696 (0.503)
Carrot					
Ball group	21.33 ± 3.56	32.67 ± 6.47	4.17 ± 0.75	17.33 ± 1.03	40.50 ± 15.19
Bar group	12.17 ± 2.14	35.17 ± 18.03	3.50 ± 0.84	14.67 ± 2.58	26.33 ± 3.98
t (p)	5.409*(<0.001*)	0.320 (0.760)	1.451 (0.177)	2.349*(0.041*)	2.210 (0.052)
	12 months				
	No. strokes 1st swallow	**No. strokes mouth free**	**No. swallow mouth free**	**Time till 1st swallow**	**Time till mouth free**
Banana					
Ball group	15.33 ± 1.51	23.83 ± 2.14	2.17 ± 0.41	9.83 ± 0.75	17.50 ± 1.05
Bar group	6.33 ± 1.03	17.67 ± 1.37	2.0 ± 0.0	7.67 ± 0.82	13.67 ± 1.21
t (p)	12.075*(<0.001*)	5.955*(<0.001*)	1.00 (0.363)	4.779*(0.001*)	5.861*(<0.001*)
Carrot					
Ball group	16.50 ± 2.66	21.50 ± 3.15	3.33 ± 0.52	14.50 ± 1.05	24.33 ± 11.76
Bar group	8.50 ± 1.38	26.50 ± 14.82	3.17 ± 0.41	9.50 ± 1.05	18.50 ± 3.62
t (p)	6.532*(<0.001*)	0.809 (0.453)	0.620 (0.549)	8.257*(<0.001*)	1.161 (0.272)

*: Statistically significant at $p \leq 0.05$

DISCUSSION:

In this study, every patient in group I was provided with a mandibular overdenture secured by ball and socket attachments. Ball attachments are among the simplest forms of stud attachments, appreciated for their cost-effectiveness, ease of handling, reduced chairside time, and versatility in applications with both root and implant-supported prostheses. (23). The cast bar was utilized in this study due to its ease of fabrication, cost-effectiveness, and adaptability; the pattern was cast in a Co-Cr alloy. The casting was subsequently retrieved, completed, and meticulously polished to prevent any plaque accumulation (24).

The bar was secured in position with fixation screws through the abutments, while the male component of the ball and socket was affixed by being screwed into the fixture (25). Bar and clip attachments are probably the most frequently utilized attachments for implant-supported tissue overdentures. This is due to their enhanced mechanical stability and increased durability relative to individual attachments. Additionally, rigid bars may be employed to establish brief distal extensions, thereby augmenting stabilization and mitigating denture displacement (26).

Masticatory ability refers to one's self-reported and objective level of skill in the process of triturating food. Because it shows the distribution of food chewed across these cycles, the most common and effective way to measure this is by counting masticatory cycles, which is what this study did. As a dependable and non-invasive method, surface electromyography (SEMG) is widely used by researchers to evaluate the bilateral activity of masticatory muscles. The viability of evaluating muscle activity via SEMG is due to the anatomical placement and superficial positioning of the masseter muscles on the facial surface (27).

Bilaterally, records were obtained for the masseter muscle to mitigate discrepancies in muscle activity due to individual preferences in chewing sides (28). The findings of this study indicated that the electromyography during the consumption of hard and soft foods in group II (bar-clip) after six and twelve months of overdenture insertion is superior to that in group I (ball and socket). The disparity between the two groups was statistically significant.

The results aligned with those of SK Abdel-Bary & HE Alameldeen, who investigated the electromyographic evaluation of an implant overdenture secured by two different attachment types, revealing that the locator attachment group exhibited the highest activity values, succeeded by the ball attachment group (29).

It was also found by Teranelly M et al. that implant-supported overdentures had better masticatory efficiency than traditional dentures in an electromyography (EMG) comparison of masticatory muscles using narrow diameter implant-assisted mandibular overdentures. In addition, they found that with severely resorbed mandibular ridges, the amount of implants used affected masticatory efficiency and muscle activity (30).

There was no significant difference in chewing efficiency and electromyographic activity of the masseter muscle between bar and ball prostheses in a study by Moustafa Elsyad et al. (31) who examined three designs of implant-supported mandibular overdentures. Another study by the same authors found the opposite of what was expected when they tested different retentive attachments for implant overdentures in patients with atrophying mandibular ridges. The study had looked at the electromyographic connectivity of the masseter muscle.

Due to their association with improved muscular activity and function, this study found that ball attachments are superior to bar and Locator attachments. Group II (bar-clip) had better masticatory efficiency than group I (ball and socket) six months after overdenture insertion, according to this study. With the exception of the time it took to eat carrots and the number of strokes required to swallow both kinds of food, there was no statistically significant difference between the two groups. The adaptation of patients to implant-supported overdentures using both the ball and socket and bar clip attachment systems could be the cause of this. Mousa A et al. found that masticatory efficiency improved with time (32) when they studied the effects of time and different tooth widths on muscular activity and masticatory efficiency in bilateral free-end saddles. Our results are consistent with theirs. Group II (bar-clip) had better masticatory efficiency than group I (ball and socket) after 12 months of overdenture insertion, according to this study. Except for the following variables: time to first swallow after eating banana and carrot, number of strokes to clear the mouth of food after eating banana, number of strokes to clear the mouth after eating banana, and number of swallows to first swallow after eating banana and carrot, the difference between the two groups was not statistically significant.

The condition of the bar-clip attachment system is satisfactory, but the degradation and loss of retention in the O-ring's rubber component could be to blame.

It was in agreement with the findings of Khalifa K et al., who studied the masticatory efficiency of mandibular bar-supported overdentures under different loading protocols and found that implant-supported overdentures with a bar-clip attachment system were significantly different. Masticatory efficiency improved significantly at the 6-month and 12-month marks, respectively, according to the results. (33)

Consistent with Hussain et al., who used color-changing chewing gum to compare the masticatory efficiency of traditional full dentures with implant-retained overdentures, the current findings support this approach. Participants using ball implant overdentures had much lower efficiency levels than those using bar implant overdentures, according to their findings (34).

Electromyographic activity and chewing efficiency of locator implant-assisted maxillary overdentures vs bars were studied by Radwa M. K. Emera et al. With the exception of the first five strokes, when the bar-assisted overdenture showed better chewing efficiency than the locator-assisted overdenture, a study comparing two implant-retained mandibular overdentures found no statistically significant difference in masticatory efficiency between the two attachment types (35).

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In her study, Flávia Gonçalves looked at how different attachment systems affect the biomechanics and clinical effectiveness of overdentures. She found that the two types of systems, bar-clip and ball and O-ring, performed equally well in terms of masticatory efficiency, with the difference between them being considered non-significant (36).

The results of masticatory efficiency agreed with Atia et al who found that the patients with the thermoplastic overdenture base material supported with bar/clip attachment were more masticatory efficient than the patients with the acrylic resin overdenture base material (37).

The study's findings contradicted the null hypothesis.

CONCLUSION:

Group I (bar-clip) exhibited superior masticatory efficiency and increased electromyographic activity of the masseter muscles compared to group II (ball and socket). The bar-clip attachment system is advised for use with four implants to support maxillary overdentures, as it enhances masticatory efficiency and electromyographic activity of the masseter muscles, yielding superior outcomes compared to the ball and socket attachment system.

Recommendations:

Further clinical studies of implant-retained maxillary overdenture opposing Kennedy class I RPD are recommended to examine further parameters like marginal bone loss, biting force, retention and peri implant strain also, larger sample sizes and longer follow-up periods to test the efficiency and durability of the attachments.

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