

## The Effect of Ball and Socket and Bar/Clip Attachments in Implant-Retained Complete Mandibular Thermoplastic Overdenture on Masticatory Performance: A Crossover Study

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### Abstract

#### Objective

To evaluate the effect of ball and socket and bar/clip attachments in implant-retained complete mandibular thermoplastic overdenture on masticatory performance.

## Subjects and Methods

Ten completely edentulous patients divided into two groups : Group I (n=5) was treated with two implant retained thermoplastic overdenture with ball and socket attachment system then after 3 months replaced by custom made bar. Group II (n=5) was treated with two implant retained thermoplastic overdenture with custom made bar attachment system then after 3 months replaced by ball and socket. The masticatory performance test measurements were recorded for each patient: at insertion, after 1 month and after 3 months for each attachment.

## Results

Bar-Clip retained thermoplastic mandibular overdenture had significantly better masticatory performance compared to Ball and Socket attachments.

## Conclusion

Bar- clip attachment is considered a promising treatment regarding to masticatory performance as compared to ball and socket attachment.

## Introduction

Complete-denture wearers usually suffers from the problems of retention and stability of the mandibular prosthesis which causes complaints of oral function. For this group of patients mandibular implant-retained overdenture is a successful treatment modality [1]. Improvement of masticatory function, satisfaction level and quality of life are the results of receiving implant-retained prostheses [2]. The mandibular implant-retained overdentures acceptance has become so overwhelming on Overdentures [3,4]. A two-implant retained overdenture for completely edentulous mandible should become the standard of care. Ball and bar/clip are attachment types for clinical application with tooth- or implant-retained overdentures [5].

The combination of maxillary conventional complete denture and a mandibular implant- retained overdenture provides significant improvement in masticatory performance compared to conventional complete dentures in both arches for a limited population having persistent functional problems with an existing mandibular complete denture due to severely resorbed mandible [6].

Many attachment types can be used with implant overdentures to guarantee sufficient retention, stability, appearance, form, finest shape, and comfort, the overdentures should be planned cautiously [7].

The main factors affecting attachment systems selection are the inter-arch space, stress distribution between mucosa and implant , and the required amount of resistance and retention [8].

Ball and bar-clip attachments are the most common systems used to retain overdentures. Ball attachments have the advantages of being less expensive and technique-sensitive and more adequate to tapered arches,

but they have the disadvantages of being less retentive than bar-clip attachments and need more maintenance, especially in the first year after insertion [9,10].

Polymethyl methacrylate (PMMA) resin has a long, clinically established history for being utilized as denture base material, due to its adequate physical properties, excellent aesthetic, reasonable cost and easy processing technique [11-13]. Thermoplastic resins as alternative polymeric materials of new processing techniques have resulted due to continuous research focusing on PMMA properties improvement. High creep and solvent resistance, high fatigue endurance and excellent wear characteristics are the physical properties of these new materials [14]. It was claimed that in compression molding technique, the combination of polymerization shrinkage and distortion of denture bases owing to thermal stresses which affects the adaptation accuracy of denture base to the underlying tissues creating a micro gap. Injection molding technique is an alternative technique which may overcome the problems and increase denture base adaptation due to continuous injection which compensates polymerization shrinkage [14,15].

Masticatory performance has been most frequently determined using solid hard food, such as carrots, coconut and peanuts, After these materials being chewed for a number of chewing cycles or for a period of time, the resulting ground products is collected and usually separated in size ranges using sieves with different, calibrated openings. The separated portions, referred to as fractions, of the ground materials weighed and the rates determined are recorded for analysis [16].

Nakasima *et al* introduced a test material in the form of rubber capsules containing pigment coated granules.

The colorimetric and spectrophotometric methods have also been used to assess masticatory performance [17,18].

The objective masticatory performance significantly improved after implant treatment. The number of chewing cycles required to halve the initial size of a test food decreased, on average, from 47 cycles to 25 cycles after implant treatment. Thus, after implant treatment, subjects need only about half the number of chewing cycles as before treatment to comminute their food [10]. The effect of different attachments in implant-retained mandibular complete overdenture on masticatory performance requires investigation.

### **Aim of the Study**

The aim of the present study is to evaluate the effect of ball and socket and bar/clip attachments in implant-retained complete mandibular thermoplastic overdenture on masticatory performance.

### **Subjects and Methods**

Ten completely edentulous male patients were selected from the clinic of the removable prosthodontics, Faculty of Dental Medicine, Al Azhar University. All the selected patients were motivated to the treatment, and they agreed to cooperate and follow the recommendations and instructions of the clinician. The research protocol were applied for ethical committee, faculty of dental medicine, Al-Azhar University and the patients were signed a written consent form before taking part in the study.

### The Patients Were Selected According to the Following Criteria

Completely edentulous patients at least 6 months before beginning of the study, Free from any systemic diseases (cardiac disease, uncontrolled diabetes mellitus, and debilitating diseases) which may affect the prognosis of implant- overdenture, Healthy firm mucosa covering the edentulous ridge which is free from any remaining roots, cysts, residual infection or impacted teeth, Each patient should have a minimum inter-arch distance of 20mm and a fairly equally divided inter-maxillary spacing (This was necessary to ensure room for the attachment within the mandibular overdenture.), Co-operative patients, Patient could be motivated for good oral hygiene.

### The Following Patients Were Excluded From the Study

Patients with history of previous radiation or osteoporosis. Patients with history of bruxism or clenching, Patients with bone width less than 7mm at prospective implant site. Cases with severe bony undercuts (especially lingual bony undercut), sharp bony edges and wiry ridges, Heavy smokers. (more than twenty cigarettes per day), High frenal or muscle attachments that may require surgical correction, Presence of any attached or keratinized mucosa at the prospective implant site, Cases of either extremely large or small jaws, Patients with TMJ disorders or limited mouth opening.

### Grouping

- Group I: 5 patients received two implant retained thermoplastic overdenture with ball and socket attachment system was replaced by custom made bar after 3 months.
- Group II: 5 patients received two implant retained thermoplastic overdenture with bar / clip was replaced by ball and socket attachment system after 3 months.
- Evaluation of masticatory performance

Masticatory performance was assessed using the sieve method [15] with carrot as a test food material [16]. Patients were asked to chew the equal sized cubes of the test food material which was 10g weight per each cube for:

a)15 strokes; b) 30 strokes and expectorate the bolus into a plastic cup and the mouth were rinsed thoroughly until all particles were eliminated into the cup. Passing the collected fragments through paper filters to eliminate excess water , then placing in an oven for 48 hours at 37°C. Weighing of the dried particles and placing on a series of 6 stacked sieves with progressively smaller mesh sizes, ranging from 5.6 to 0.71mm. Constant vibration of the sieves for 5 minutes. The contents of each sieve were then weighed on an analytic scale with a 0.001g precision. Since the specific mass of the test-food is known, weight were converted into volume. The values were evaluated using the formula [15].

$$MP (\%) = \left. \frac{\text{Initial weight} - \text{residue} \times 100}{\text{Initial weight}} \right\} \times 100$$

- Cone beam CT was done for each patient as a pre-operative radiograph.

### **Surgical Procedures**

The surgical procedures were done in two stages; the flap was reflected buccally and lingually.

Drilling started using (IP drill, Dentis surgical kit, Korea) till 3.5mm as a final drill to be suitable for the 3.7mm implant diameter and 10mm length; the flap was secured by interrupted suture. The 2<sup>nd</sup> stage surgery was done using punch with low speed contra angle hand piece to uncover the implants for attachment application.

### **Construction of Complete Denture**

The implants were exposed, and the healing abutments were placed after 4 months. Preliminary impressions were made with irreversible hydrocolloid material (Tropicalgin, Italy). The impressions were casted to get diagnostic casts. Mandibular special trays were fabricated with holes over the implant regions using self cure acrylic resin (Acrostone, Egypt). Peripheral tracing of the borders of the maxillary and mandibular trays were molded using a green sticky compound (Hiflex, India), and the final impressions were completed using rubber base (BMS DENTAL, Italy). The mandibular impression tray was retrieved from the mouth of the patient, and excising the excess impression material from the holes with a scalpel #15.

The transfer impression copings were screwed into the implants using the fixation screws. The tray was carefully replaced in the mouth, and a light-bodied rubber base material (BMS DENTAL, Italy) was injected around the impression transfers while posterior portions of the tray were held under finger pressure. The impression copings were picked up to the tray with self-cure acrylic resin which also covers the light-body rubber base material. The implant analogues were attached to the transfer copings, and casting the impression was done using type IV extra-hard stone (Supercal, USA).

The bar abutments were screwed to the implant analogues on the master cast. The plastic pattern of a resilient bar (OT bar multiuse, Italy) was luted to the plastic portions of bar abutments leaving 2mm space between the bar and the ridge for maintenance of oral hygiene. The bar assembly investment and casting were done with cobalt-chromium alloy, then finished and polished. The bar was tested for verification of its passive fit. Upper and lower record blocks were constructed and used for jaw relation registration, Facebow transfer (BIO\_ART, Italy). Mounting the casts on the articulator (BIO\_ART, Italy) were done in centric relation. Functional and esthetic setting up of teeth were completed.

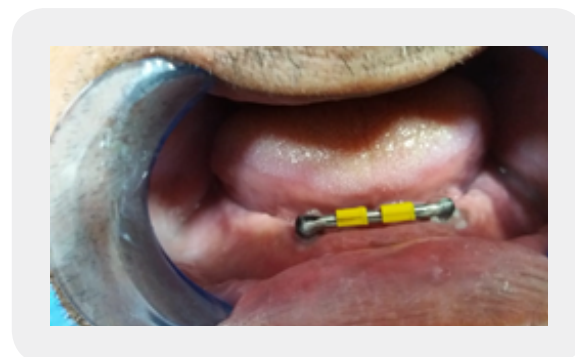
Aluminum foil sheets of a thickness of two-millimeter were applied over and around the bar to provide a dequate room for the soft liner, and denture processing was completed according to the usual injection molding technique. Thermoplastic materials was brought in granular form, with low molecular weight, wrapped in cartridges, thermal plasticization was done in special devices at (200°c- 250°c). After heating, the metallic cartridges containing thermoplastic grains were set in place into the injecting unit and the plasticized resin was forced into the mold at pressure of (6-8) bars. Pressure, temperature and injecting time are programmed in the injecting unit (Deflex -Germany).

The bar assembly was tightened to the bar abutments intraorally using a 20-Ncm torque. The space between the bar and the ridge was blocked out with wax intraorally. Two plastic clips (OT bar multiuse, Italy) was placed on the bar. The plastic clips were picked up to the mandibular denture with self cure acrylic resin (Acrostone, Egypt) to engage a prepared undercut in the fitting surface of the poly amide denture base material (Bredent -Germany) while the patient occlude in centric relation. The mandibular denture was removed, and trimming of the excess acrylic resin around the clips was done.

Painting of the fitting surface of the mandibular denture around the bar with soft liner adhesive was done. The self cured silicone soft liner (Softliner, Promedica GmbH, Germany) was mixed and loaded in the space created by the aluminum foil sheets. A closed mouth technique was used for relining of the mandibular denture with the soft liner around the bar. The mandibular overdenture was removed, and trimming of the excess soft lining material was done with a sharp scalpel. Mixing of the base and the catalyst of the glaze, and painting the mixture to the soft liner were done for the surface roughness seal. Denture insertion with emphasis on adequate oral hygiene procedures was the most important for the patient.



*Figure 1: Ball and socket attachment*



*Figure 2: Bar-clip attachment*

## Measurements

The masticatory performance test measurements were recorded three times for each patient ; after each attachment insertion, one month and 3 months post insertion.



## Data Management and Analysis

Data were collected and statistically analyzed by SPSS program. Paired t test were used to compare between the two attachments.

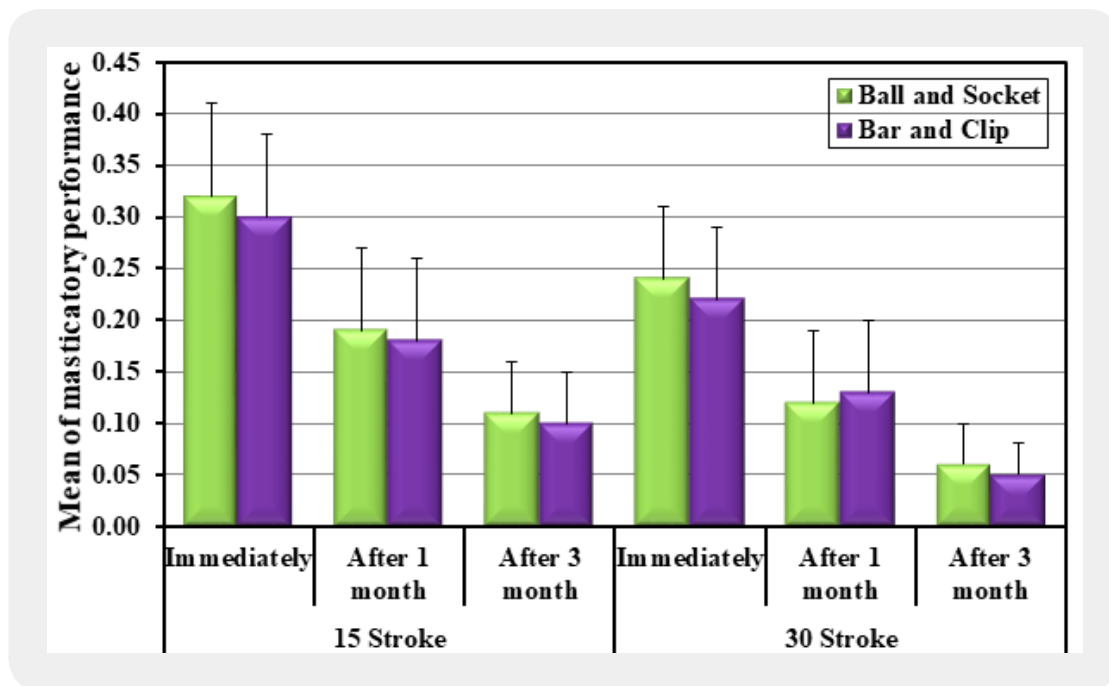
## Results

Table (1) summarizes comparison between the two studied techniques. Regarding masticatory performance, after 15 Stroke, At insertion, there was a statistically non-significant difference between treatment modalities. After 1 and 3 month, there was a statistically significant difference between treatment modalities. Bar and Clip showed a lower particle size than Ball and Socket ( $p=0.023^*$  and  $0.008^*$  respectively). After 30 Stroke, At insertion and After 1 month there was a statistically non-significant difference between the treatment modalities. After 3 month, there was a statistically significant difference between the treatment modalities. Bar and Clip showed a lower particle size than Ball and Socket ( $p=0.046^*$ ).

**Table 1:** Comparison between the two studied attachments according to masticatory performance

	Ball and Socket (n=10)	Bar and Clip (n = 10)	T	P
<b>Masticatory performance</b>				
<b>15 Stroke</b>				
At insertion	$0.32 \pm 0.09$	$0.30 \pm 0.08$	2.087	0.067
After 1 month	$0.19 \pm 0.08$	$0.18 \pm 0.08$	2.744*	0.023*
After 3 month	$0.11 \pm 0.05$	$0.10 \pm 0.05$	3.407*	0.008*
<b>30 Stroke</b>				
At insertion	$0.24 \pm 0.07$	$0.22 \pm 0.07$	2.227	0.053
After 1 month	$0.12 \pm 0.07$	$0.13 \pm 0.07$	0.310	0.764
After 3 month	$0.06 \pm 0.04$	$0.05 \pm 0.03$	2.313*	0.046*

\*: Statistically significant at  $p \leq 0.05$



*Chart 1: Comparison between the two studied techniques according to masticatory performance*

## Discussion

The conventional complete mandibular denture as a treatment modality for patients with severely resorbed ridges often exhibits poor retention, support and stability. This results in marked difficulty in basic functions such as eating, speaking and leads to satisfaction levels deterioration, and deterioration in quality of life. Stabilizing the complete denture prosthesis by using Osseointegrated dental implants offers the possibility to overcome some of the limitations of conventional complete dentures. Nowadays, a multitude of implant and attachment systems are available. Several studies have been reported the evaluation of the ball and bar and other attachment systems [15]. Retention is of great importance for the satisfaction of the patient [10].

Several studies evaluated the retention force and prosthetic complications for ball and bar attachments. Cakarer *et al.*, [15] proved the less cost and less sensitivity of the technique in the solitary ball attachments. However, the bar designs seem to be more retentive than ball attachments. Naert *et al.*, [19] reported that single attachments provide less retention than bars for overdenture attachments.

Retention and stability problems of the mandibular dentures are the main complaints of oral function in complete-denture wearers. Masticatory function is quite poor for these subjects if compared with that of healthy dentate subjects. Their maximum bite force is only 20-40% of that of dentate subjects [5]. Furthermore, complete-denture wearers require up to seven times more chewing strokes than healthy dentate subjects to halve the original particle size of the test food [15].



In this study , the cross over study design reduces the variability between patients regarding masticatory performance (eg. Age, gender, anatomical factors, ..... etc.) because all tests are done for the same patients. So, a small sample size can be used with the cross over studies compared to parallel group studies.

In this study , male patients were selected to avoid the sexual variations specially in the power of biting force due to high muscle activity in males than females and to avoid post-menopausal factors because all patients are more than 50 years old.

All patients included in this study ranged from 54 - 71 years old , and they were completely edentulous at least 6 months before beginning of the study to insure perfect tissue healing and less bone irregularities.

All cases were class I ridge relationship to avoid abnormal forces directed to the implants.

Poor oral hygiene Patients were excluded to avoid the risk of peri-implantitis and hence implant failure. Patients with history of para-functional habits such as bruxism and clenching were excluded to avoid over load and undue concentrated forces on the implants. The use of natural test food was said to cause more variations due to their physical properties such as fracture strength, shape and sizes [20]. Inhomogeneous and different food preparation were the main shortcomings of natural test food might lead to diverse effects in terms of force generation and jaw movement [21]. Carrots were found to be the most suitable natural test food for complete denture wearer [22,23].

In this study , carrot were used as a test food because it is natural, simple, cheap, favourable and rapid. Yurkstas & Manly [24] measures the volume of particles that passed through each sieve, this can be done only when the test food size was known [25]. A number of authors had determined masticatory performances using single sieve, namely Manly and Braley (1950), Kapur and Soman (1964) and Demers *et al* (1996). In this study we used multiple sieves according to Yurkstas & Manly for detailed information on masticatory performance.

Mandibular implant supported overdenture treatment is a successful treatment plan in these patients [26]. After the implant treatment, the patients reported high satisfaction levels regarding various aspects of their denture functions and they were more satisfied than patients with similar problems who received a conventional denture without implant support [19-22].

Implant treatment Improved the oral function as demonstrated by objective methods [7]. The masticatory performance significantly improved after implant treatment [7,20,27-29].

The number of chewing cycles needed to comminute the test food to the half its initial size on average decreased from 47 to 25 cycles after implant treatment [19]. Thus, subjects needed only about half the number of chewing cycles after implant treatment than before treatment to comminute their food to a certain size [30].

Bar-clip retained mandibular overdenture had significantly better masticatory performance compared to ball and socket attachment which may be attributed to high retention and stability and less posterior bone resorption in bar-clip [31].

## Conclusion

With the limitations of this study regarding the sample size and short study periods, the following conclusions can be provided: Despite that both types of attachments provided sufficient values in terms of Masticatory performance, Bar- retained thermoplastic overdenture is considered a promising treatment protocol regarding masticatory performance compared to ball and socket attachments. Further studies is recommended with additional more subjects and more investigation methods for evaluating this type of treatment modality and comparing it with others.

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