



## THE EFFECT OF TWO DIFFERENT TYPES OF ATTACHMENTS IN IMPLANT-RETAINED COMPLETE MANDIBULAR THERMOPLASTIC OVERDENTURE ON BITING FORCE: A CROSSOVER STUDY

Hamam FA<sup>(1)</sup>, Farahat MY<sup>(2)</sup>, Baraka OA<sup>(3)</sup>

### ABSTRACT

**Objective:** To evaluate the effect of ball and socket and bar-clip attachments in implant-retained complete mandibular thermoplastic overdenture on biting force. **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 the ball attachment was 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 the bar was replaced by ball and socket. The maximum bite force measurements were recorded for each patient using occlusal force meter device: at insertion, after 1 month and after 3 months for each attachment. **Results:** The maximum bite force measures were higher for bar-clip attachments than ball and socket attachments but still statistically of non-significant difference between the treatment modalities. **Conclusion:** The thermoplastic mandibular implant retained overdenture with the bar-clip might be selected over the ball and socket attachment in cases of two implant retained mandibular overdenture, because it has more sufficient biting force values.

**KEYWORDS:** Ball and socket, bar-clip, overdenture, biting force, thermoplastic overdenture.

### INTRODUCTION

Implant-retained overdentures have expanded rapidly as a successful treatment modality for rehabilitation of completely edentulous patients. Retention, stability, esthetics and function was improved as well as residual bone preservation, especially in the mandible. However it is difficult to use a fixed prostheses in patients with a severely resorbed alveolar ridge or edentulous alveolus. As a result, the use of implant-retained overdentures has become a standard option for patients who are edentulous and have undergone mandibular resection<sup>(1)</sup>.

Bite force decreases drastically over time with the use of conventional dentures, but it was stated that the placement of implant supported overdentures could increase the bite force of edentulous patients from 60% to 120% and reduce the number of masticatory cycles till swallowing<sup>(2-5)</sup>. It was reported that after stabilization of the mandibular denture with two osseointegrated implants the maximum bite force doubled, whereas the number of chewing cycles needed to comminute food particles to a certain size became half of that before implant treatment<sup>(6)</sup>. Furthermore, mandibular implant-supported overdenture treatment reduced various denture complaints<sup>(7)</sup>.

1. Associate lecturer, Department of Removable Prosthodontics, Faculty of Dental Medicine, Al-Azhar University
2. Lecturer of Removable Prosthodontics, Faculty of Dental Medicine (Boys – Cairo), Al-Azhar University.
3. Professor of Removable Prosthodontics, Faculty of Dental Medicine (Boys – Cairo), Al-Azhar University.

• **Corresponding author:** faridhamam.209@azhar.edu.eg

DOI: 10.21608/ajdsm.2021.69408.1193

Many attachments types can be used with implant overdentures to guarantee sufficient retention, stability, form, finest shape, comfort and appearance, the overdentures should be continuously planned<sup>(8)</sup>.

The inter-arch space, stress distribution between mucosa and implant, and the amount of resistance and retention needed are the main factors affecting selection of the attachment systems<sup>(9)</sup>. Ball and bar-clip attachments are the most common systems used to retain overdentures. Ball attachments may be less expensive and technique-sensitive and more suitable for tapered arches, but they seem to be less retentive than bar-clip attachments and need more maintenance, especially in the first year<sup>(10,11)</sup>.

Polymethyl methacrylate (PMMA) resin has a long, clinically established history for being utilized as denture base material, due to its adequate physical properties, reasonable cost, excellent aesthetic and easy processing technique<sup>(11-13)</sup>. Thermoplastic resins as alternative polymeric materials of new techniques of processing have resulted due to continuous research focusing on improvement of PMMA properties. High creep and solvent resistance, high fatigue endurance and excellent wear characteristics are the physical properties of these new materials<sup>(14)</sup>.

It was claimed that the combination of polymerization shrinkage and distortion of denture bases due to thermal stresses which occur in compression molding technique affects the adaptation accuracy of denture base to the underlying tissues creating a microgap. Injection molding technique is an alternative technique which may overcome the problems and increase denture base adaptation<sup>(13,14)</sup>.

Biting force is an important parameter to evaluate efficiency of the dental prosthesis and it also reflects an idea about the temporomandibular disorders and neuromuscular changes. It was reported that the masticatory bite force with the patients using complete denture is smaller than those produced by natural dentition which is about 200N, while

the maximum bite force have been reported for complete dentures are 60 – 80N and 150 – 170N for the implant supported overdenture<sup>(15)</sup>.

The effect of different attachments in implant-retained mandibular complete overdenture on biting force requires investigation. The aim of the present study was to evaluate the effect of ball and socket and bar-clip attachments in implant-retained complete mandibular thermoplastic overdenture on biting force.

## 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 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) that 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); cooperative patients and patients could be motivated for good oral hygiene.

### **The following patients were excluded from the study:**

Patients with history of previous radiation or osteoporosis, history of bruxism or clenching.

Patients with bone width less than 7 mm at prospective implant site and 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 and 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 which was replaced by custom made bar after 3 months.

Group II: 5 patients received two implant retained thermoplastic overdenture with bar-clip which was replaced by ball and socket attachment system after 3 months.

### Construction of complete denture :

Preliminary impression was registered using impression compound (Hi flex, India), this impression was casted, while individual trays were made of auto polymerizing acrylic resin; Peripheral tracing with green sticky compound (Hi flex, India) was performed for both arches, then final impression was registered using Zinc oxide and eugenol impression material (Cavex, Holland), Jaw relation registration, Face bow transfer, Mounting, Setting up of teeth and Waxing up were carried out.

Acrylic teeth were used and balanced on semi-adjustable articulator for centric and eccentric positions following the bilateral balanced concept of occlusion. Maxillary and mandibular complete thermoplastic dentures were constructed for all patients following 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 plasticized resin is forced into the mold at pressure of (6-8) bars.

Pressure, temperature and injecting time were automatically controlled by the injecting unit.

### Surgical procedures:

Cone beam CT was done for each patient as a pre-operative radiograph to assess the bone height and width at the implant sites.

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 3.5 mm as a final drill to be suitable for the 3.7 mm implant diameter and 10 mm length (Cleanant dental implant system, Model: DSFM3710S, Type: s-Clean, Tapered-RBM, Dentis co., Korea); The flap was secured by interrupted suture.



FIG (1) Occlusal force meter

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.

Loading of the thermoplastic overdenture making a large space in the fitting surface of the denture with slight excess and with undercuts for making mechanical interlock with auto polymerizing acrylic resin (Acrostone, Egypt).

### Evaluation of maximum bite force

For each patient the maximum bite force was measured using occlusal force meter device (Fig.1). Bite force was measured for each type of attachments at insertion, after 1 month and after 3 months of insertion. The recorded force during maximum clenching was obtained with one bite force meter placed between pairs of the opposing teeth. The meter was located at pre molar/molar with a strong determinant of muscle action and subsequent great bite force.

During testing the patient was seated in an upright position. The patient was asked to bite slowly on the tip of the disposable cap that covered the arm of the meter device. When the force has exceeded the set-point, the buzzer was sounded. For each patient, the mean of 10 records of the right and left side were collected for statistical analysis. According to Dahlberg's equation, the error of the measurement for the maximum bite force less than 10% within the acceptable range were excluded.

**Measurements** biting force 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 Ball and Socket Bite Force, was  $97.70 \pm 17.96$  Immediately,  $125.90 \pm 23.44$  After 1 month, and  $143.60 \pm 21.73$ .

After 3 month. Regarding Bar and Clip Bite Force, was  $114.0 \pm 18.53$  Immediately,  $129.50 \pm 23.51$ , After 1 month, and  $147.0 \pm 21.50$ , After 3 month. Immediately, after 1 and 3 month, there was a statistically non-significant difference between treatment modalities.

**TABLE (1)** Comparison between the two studied techniques according to Bite Force.

	Ball and Socket (n = 10)	Bar and Clip (n = 10)	T	P
<b>Bite Force</b>				
Immediately	97.70±17.96	114.0±18.53	0.710	0.431
After 1 month	125.90±23.44	129.50±23.51	0.730	0.484
After 3 month	143.60±21.73	147.0 ± 21.50	0.728	0.485

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

## DISCUSSION

The conventional complete mandibular denture often exhibits poor retention, stability, and support in the patients with severely resorbed ridges. This result in marked difficulty in patients carrying out basic functions such as eating, speaking and leads to deterioration in satisfaction levels, and overall quality of life. Osseointegrated dental implants offer the possibility of stabilizing the complete denture prosthesis in such cases, thereby overcoming some of the limitations of conventional complete dentures. Today, a multitude of implant and attachment systems are available. Several studies have been reported the evaluation of the ball and bar attachment systems<sup>(15)</sup>. There is strong evidence that retention is of great importance for the patient's satisfaction<sup>(16)</sup>.

In this study the cross over study design reduces the variability between patients regarding maximum bite force (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.

Patients with poor oral hygiene 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 excessive load and undue concentrated forces on the implants.

Thermoplastic mandibular over denture retained with bar-clip attachment compared to overdentures retained with ball and socket had improved bite force; which may be due to more surface area for retention and less posterior bone resorption in bar-clip.

Several studies evaluated the ball and bar attachments regarding the retention force and prosthetic complications. Cakarer et al.<sup>(17)</sup> reported that solitary ball attachments appear to be less costly and less technique sensitive. However, ball attachments seem to be less retentive than the bar design. Naert et al.<sup>(18)</sup> reported that single attachments provide lower retention than bars for the fixation of overdentures.

Retention and stability problems of the mandibular prosthesis often cause complaints of oral function in complete-denture wearers.. Their maximum bite force is only 20–40% of that of dentate subjects<sup>(19)</sup>.

Mandibular implant overdenture treatment is a successful treatment modality in this group of

patients<sup>(20)</sup>. After the implant treatment, the patients reported high levels of satisfaction regarding various aspects of their denture function and they were more satisfied than patients with similar problems who received a conventional denture without implant support<sup>(18-21)</sup>.

Improvement of the oral function after implant treatment was also demonstrated by objective methods. The maximum bite force of subjects with a mandibular denture supported by implants was 60–200% higher than that of subjects with a conventional denture<sup>(22)</sup>.

Maximum bite force more than doubled after the mandibular denture was attached to the implants. The average number of chewing strokes needed to halve the initial size significantly decreased after implant treatment. The patients needed only half the number of chewing cycles to obtain the same chewing result<sup>(23)</sup>.

It was reported that directly after implant treatment, significant increases in maximum bite force and chewing performance. A 3- and 10-year longitudinal study with fixed implant-supported dentures showed that the maximal occlusal force increased over the years until a mean force of approximately 250 N, while masticatory performance slightly improved<sup>(24)</sup>.

In vitro mechanical cycling resulted in a higher loss of initial retention with the bar and clip system<sup>(25)</sup> in up to 100 cycles of insertion and removal of the overdenture prosthesis because of clip loosening. However, considering over 14 600 movements, both systems tend to present similar results<sup>(26)</sup>, indicating that the elastomeric O-ring is worn out when used more. Therefore, better retention is obtained with the ball and O-ring system initially but is lost over time.

In the selected studies, the efficacy of patient mastication was measured from different aspects, including maximum occlusal force, muscular activity, masticatory function (size of particles

obtained), and masticatory efficiency (masticatory cycles needed)<sup>(27)</sup>. Three randomized clinical trials compared or more of these masticatory aspects in patients with mandibular or maxillary overdentures supported by bar and clip or ball and O-ring attachments, and no differences were observed between the attachment systems with regard to the mastication or maximum occlusal force of the participants<sup>(28-30)</sup>.

This study showed that regardless of the overdenture type, patients' maximum bite force increased after implant overdenture treatment.

## CONCLUSION

With the limitations of this study regarding the sample size and short study periods, it was concluded that the thermoplastic mandibular implant retained over denture with the bar-clip might be selected over ball and socket attachment in cases of two implant retained mandibular over denture, because it has more sufficient biting force values.

## REFERENCES

- Salinas TJ. Implant prosthodontics. In: Miloro M, Ghali GE, Larsen PE, Waite PD, editors. *Peterson's Principles of Oral and Maxillofacial Surgery*. London: BC Decker, Inc Hamilton; 2004. p. 263.
- van Kampen FM, Cune MS, van der Bilt A, Bosman F. Retention and post-insertion maintenance of bar-clip, ball, and magnet attachments in mandibular implant overdenture treatment; an in vivo comparison after three months of function. *Clin Oral Implants Res* 2003;14:720-6.
- Pocztaruk RL, Frasca LCF, Rivaldo EG, Fernandes EL, Gavião MB. Protocol for production of a chewable material for masticatory function tests (Optocal – Brazilian version). *Braz Oral Res* 2008;22:305-10.
- Caloss, R., Al-Arab, M., Finn, R.A. & Throckmorton, G.S. The effect of denture stability on bite force and muscular effort. *Journal of Oral Rehabilitation* 2011; 38: 434–439.
- Cakarar S, Can T, Yaltirik M, Keskin C. Complications associated with the ball, bar and locator attachments for implant-supported overdentures. *Med Oral Patol Oral Cir Bucal* 2011;16:e953-9.
- van Aken AA, van Waas MA, Kalk W, van Rossum GM. Differences in oral stereognosis between complete denture wearers. *Int J Prosthodont* 1991;4:75-9.
- Boerrigter EM, Geertman ME, van Oort RP, Bouma J, Raghoobar GM, van Waas MA et al. Patient satisfaction with implant-retained mandibular overdentures. A comparison with new complete dentures not retained by implants – a multicentre randomized clinical trial. *Br J Oral Maxillofac Surg* 1995;33:282-8.
- Pocztaruk RL, Frasca LCF, Rivaldo EG, Mattia PR, Vidal RA, Fernandes EG, Duarte MB. Satisfaction level and masticatory capacity in edentulous patients with conventional dentures and implant-retained overdentures. *Braz J Oral Sci* 2006;5:1232-38.
- Cune M, van Kampen FM, van der Bilt A, Bosman F. Patient satisfaction and preference with magnet, bar-clip, and ball-socket retained mandibular implant overdentures: a cross-over clinical trial. *Int J Prosthodont* 2005;18:99-105.
- MacEntee MI, Walton JN, Glick N. A clinical trial of patient satisfaction and prosthodontic needs with ball and bar attachments for implant-retained complete overdentures: three-year results. *J Prosthet Dent* 2005;93:28-37.
- Sadowsky SJ. Mandibular implant-retained overdentures: A literature review. *J Prosthet Dent* 2001;86:468-73.
- van Kampen FM, van der Bilt A, Cune MS, Fontijn-Tekamp FA, Bosman F. Masticatory function with implant-supported overdentures. *J Dent Res* 2004;83:708-11.
- van Waas MAJ. The influence of psychological factors on patient satisfaction with complete dentures. *J Prosthet Dent* 1990;90:545-8.
- Slagter AP, Bosman F, Van der Bilt A. Comminution of two artificial test foods by dentate and edentulous subjects. *J Oral Rehabil* 1993;20:159-76.
- Fontijn-Tekamp FA, Slagter AP, Van der Bilt A, Van 't Hof MA, Witter DJ, Kalk W et al. Biting and chewing in overdentures, full dentures, and natural dentitions. *J Dent Res* 2000;79:1519-24.
- van Kampen F, Cune M, van der Bilt A, Bosman F. Retention and postinsertion maintenance of bar-clip, ball and magnet attachments in mandibular implant overdenture treatment: An in vivo comparison after 3 months of function. *Clin Oral Implants Res* 2003;14:720-6.
- Chung KH, Chung CY, Cagna DR, Cronin RJ Jr. Retention characteristics of attachment systems for implant overdentures. *J Prosthodont* 2004;13:221-6.

18. Naert, I., Alsaadi, G. & Quirynen, M. (2004) Prosthetic aspects and patient satisfaction with twoimplant-retained mandibular overdentures: a 10- year randomized clinical study. *International Journal of Prosthodontics* 17: 401–410.
19. Fontijn-Tekamp, F.A., Slagter, A.P., van der Bilt, A., van't Hof, M.A., Witter, D.J., Kalk, W. & Jansen, J.A. (2000) Biting and chewing in overdentures, full dentures, and natural dentitions. *Journal of Dental Research* 79: 1519–1524.
20. Fueki, K., Kimoto, K., Ogawa, T. & Garrett, N.R. (2007) Effect of implant-supported or retained dentures on masticatory performance: a systematic review. *Journal of Prosthetic Dentistry* 98: 470–477.
21. Cune, M.S., van Kampen, F.M.C., van der Bilt, A. & Bosman, F. (2005) Patient satisfaction and preference with magnet, bar-clip, and ball-socket retained mandibular implant overdentures: a cross-over clinical trial. *International Journal of Prosthodontics* 18: 99–105.
22. van Kampen, F.M.C., van der Bilt, A., Cune, M.S. & Bosman, F. (2002) The influence of various attachment types in mandibular implant-retained overdentures on maximum bite force and EMG. *Journal of Dental Research* 81: 170–173.
23. van der Bilt A, Burgers M, van Kampen FM, Cune MS. Mandibular implant-supported overdentures and oral function. *Clin Oral Implants Res.* 2010 Nov;21(11):1209-13.
24. Carlsson, G.E. & Lindquist, L.W. (1994) Ten-year longitudinal study of masticatory function in edentulous patients treated with fixed complete dentures on osseointegrated implants. *International Journal of Prosthodontics* 7: 448–453.
25. Tabatabaian F, Alaie F, Seyedan K. Comparison of three attachments in implant-tissue supported overdentures: an in vitro study. *J Dent (Tehran)* 2010;7:113-8.
26. Kobayashi M, Srinivasan M, Ammann P, Perriard J, Ohkubo C, Muller F, et al. Effects of in vitro cyclic dislodging on retentive force and removal torque of three overdenture attachment systems. *Clin Oral Implants Res* 2014;25: 426-34.
27. Awad MA, Rashid F, Feine JS; Overdenture Effectiveness Study Team Consortium. The effect of mandibular 2-implant overdentures on oral health related quality of life: an international multicentre study. *Clin Oral Implants Res* 2014;25:46-51.
28. Elsyad MA, Hegazy SA, Hammouda NI, Al-Tonbary GY, Habib AA. Chewing efficiency and electromyographic activity of masseter muscle with three designs of implant-supported mandibular overdentures. A cross-over study. *Clin Oral Implants Res* 2014;25:742-8.
29. van der Bilt A, van Kampen FM, Cune MS. Masticatory function with mandibular implant-supported overdentures fitted with different attachment types. *Eur J Oral Sci* 2006;114:191-6.
30. van Kampen FM, van der Bilt A, Cune MS, Fontijn-Tekamp FA, Bosman F. Masticatory function with implant-supported overdentures. *J Dent Res* 2004;83:708-11.