



Evaluation of Maximum Biting Force in Two Different Attachment Systems (Bollard vs. Ball and Socket) Retaining Mandibular Overdenture: A Split-mouth Design

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Abstract

AIM: The study was conducted to evaluate maximum biting force (MBF) in two different attachment systems (bollard a vs. ball and socket attachment) retaining mandibular overdenture using a split-mouth design.

SUBJECTS AND METHODS: Twelve completely edentulous patients received complete dentures and after adaption of the patient with the new denture, 24 implants were inserted in the canine region using two-stage surgical technique and conventional loading protocol. Six patients received the Bollard attachment at the right side and the Ball and Socket at the left side. Moreover, the other six patients received the bollard attachment at the left side and the ball and socket attachment at the right side. Each patient was treated according to split-mouth design. Insertion of each of the attachment type was assigned randomly. Using occlusal force meter instrument, MBF was measured immediately after loading (0), after 6 months (6), and after 12 months (12).

RESULTS: Significant statistical differences ($p < 0.05$) were obvious in in MBF between Attachment (1) and Attachment (2) immediately after loading (0 months), after 6 months (6) and after 12 months (12) follow-up visits.

CONCLUSION: Mandibular implant retained overdenture received Bollard abutment that retained with the denture by the help of resilient liner "Retention.sil"* without housing have higher biting forces than mandibular implant retained overdenture with ball abutment where the plastic house was picked up by monomer free self-cured acrylic resin.

Edited by: Aleksandar Iliev

Citation: Elbeheiry RTK, Mohamed GF, Badr AMI. Evaluation of Maximum Biting Force in two different attachment systems (Bollard vs. Ball and Socket) Retaining Mandibular Overdenture: A Split-mouth Design. Open Access Maced J Med Sci. 2021 Mar 08; 9(D):47-53. <https://doi.org/10.3889/oamjms.2021.5829>

Key words: Bollard; Ball and socket; Maximum biting force

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Received: 01-Feb-2021

Revised: 16-Feb-2021

Accepted: 26-Feb-2021

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Funding: This research did not receive any financial support

Conflict of Interest: The authors declared that they have no conflict of interest.

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Introduction

Edentulism is defined as "the state of being without any natural permanent teeth. It is an irreversible condition that is evident in age groups of 65 years and older and was previously considered part of the normal aging process [1].

The glossary of implant dentistry, define implant-retained prosthesis as any prosthesis that is completely or partially supported by implant or implants [2].

The clinical outcome of implant retained overdenture is significantly better than that achieved with conventional dentures, especially when patients are experiencing technical problems because of compromised prosthesis retention or stability. Mostly, efficient retention and stability are easily achieved by a fixed restoration or using overdenture's attachments instead of depending on the physical means of retention with conventional dentures [3], [4], [5].

The design of implant-supported overdentures varies according to the method of attachment and amount of support to be desired from implant and ridge

mucosa. Various attachments have been advocated for retaining overdentures to implants. The commonly used types are bars, ball and sockets, locators, magnets, OT equators, and telescopic crowns [6].

The advantages of ball and socket attachment are simplicity in design, ease of use and maintenance, low cost, varying degrees of retention, wide range of movement, great patient satisfaction, and used to increase retention of implant overdenture prostheses with regard to optimizing stress and minimizing denture movement [7]. The Bollard (Poller) is a new resilient telescopic attachment employed in implant supported removable denture cases [8].

The use of long-term soft denture lining (LTSDLs) is characterized by markedly improved speech and ability to chew, significantly reduced feelings of pain and oral soreness under the dentures, better retention and stability of the dentures, an increase in psychological comfort and longer denture wearing times [9], [10], [11].

Retention.Sil was introduced according to its chemical composition that is based on Polyvinylsiloxane (PVS) that has three options according to the detachment force desired (200, 400, and 600 gf) [12].

The maximum biting force (MBF) is considered to be the force that generated by the greatest effort of the mandibular teeth against the maxillary teeth when the jaw is closed under the effect of the jaw muscles as a result of the coordination between the components of the masticatory system. Masticatory muscles such as Masseter, Temporalis, and Medial Pterygoid play an important role in the closure of the jaw and hence the biting forces [13], [14].

The masticatory force is an important indicator of the functional state of all the masticatory system. The biting forces are used to understand the biomechanical principles of masticatory system and feedback of prosthetic treatment. Furthermore, the MBF measurement is very important for the treatment of dysfunction of the stomatognathic system [15]. Their measurement indicates, quantitatively, the muscular efficiency of the dental tightening, thereby enabling effective detection of possible masticatory alterations [16], [17]. Their values are influenced by many factors. Individual characteristics, the recording device, bruxist individuals, and the posture of the individual's head are some of these factors [14], [18]. This variable is directly related to individuals' quality of life since the greater the masticatory capacity and efficacy, the better the food fragmentation will be and the better the digestion [19]. Furthermore, the maximum occlusal force can significantly increase with the use of LTSDLs [20], [21].

The aim of the study was to evaluate MBF in two different attachment systems (Bollard a vs. Ball and Socket attachment) retaining mandibular overdenture using a split-mouth design.

Subjects and Methods

Patient selection and pre-surgical procedures

All treatment procedures, complications, and treatment outcomes were explained for patients. Informed consent that lay down by research ethics committee at Faculty of Dentistry-Minya University was submitted by the patients to participate in the study before data collection.

Twelve completely edentulous patients (six males and six females) were selected from those attending the outpatient clinic of Removable Prosthodontics Department-Faculty of Dentistry-Minya University with the following inclusion criteria: Cooperative patient, patient free from any systemic diseases that may affect osseointegration, firm healthy mucosal coverage of the edentulous ridge, sufficient bone dimensions at the anterior mandibular segment should

be 16 mm height and 5 mm width at least, inter-arch space not <22 mm, Angle's Class I maxillomandibular relationship, and no temporomandibular joint disorders. Moreover, the following exclusion criteria: Patients with bad habits (i.e., Bruxism), heavy smokers, alcohol consumption patient, patients on long-term steroids or immunosuppressive drugs or bisphosphonates, and patients who received radiotherapy to the head or neck region.

Twelve complete dentures were constructed following the conventional denture fabrication procedures. Primary impressions were taken with irreversible hydrocolloid material (Cavex CA37, Normal Set, Holland) to obtain study casts. Final impressions using a border molded autopolymerizing acrylic special trays (Palapress Vario Heraeus Kulzer, Hanau, Germany) and non-eugenol Zinc-oxide and eugenol (Cavex impression paste, Holland) to obtain the master casts.

Waxing-up of the metal framework making into consideration not to cover the site of the canine in both sides. Investing and casting with base-metal alloy were made according to the manufacturer's instructions. Intraoral metal framework try-in and jaw relation were done. The master casts were mounted on a semi-adjustable articulators (HANAU, Wide; Whip Mix Corporation, Farmington Ave, Louisville, KY, USA). For mounting the maxillary casts, face bow records were used. For mounting the mandibular casts, centric relation records with (check-bite technique) at the proper vertical dimension. Protrusive and lateral records were taken to adjust the condylar and lateral guidance of the articulator. Artificial acrylic teeth (Vitapan; Vita Zahnfabrik, Badackingen, Germany) were set in bilateral occlusal balance. Overcontoured waxing up was made at the canine area in both sides. Intraoral waxed try-in was done.

Flasking and wax elimination were accomplished. Packing of the overdenture was done using heat-cured acrylic resin (Acrostone, WHW, England). After that, the processing was accomplished with the conventional method. The dentures were delivered to the patients after finishing and polishing.

Patients were given instructions for denture hygiene. After 1 week, denture inspection and occlusal adjustments were made and clinical remounting during the follow-up session. The patients were recalled for at least 3 months before implant insertion.

Surgical procedures

The mandibular complete dentures were duplicated into clear acrylic resin to be used as surgical stents. Using cone beam computerized tomography machine (Scanora3D, Sorredex-Finland, 15 mA, 85 KV) a pre-operative radiograph was taken before implant placement with and without the stent to assess the residual alveolar bone quality and quantity.

The patients were given a pre-operative oral antibiotic 48 h before surgery then continued for another 72 h after surgery. Bilateral infiltration anesthesia to the labial and lingual vestibules at intra-foraminal area was given to the patients.

After reflection of the flap, the stent was applied over the mandibular ridge and used to slightly retract the soft tissue. The standard technique of implant insertion was followed (low speed drilling with high torque motor, successive drilling, and double coolant under strict aseptic condition). Each patient received two implants of 3.5 mm diameter and 14 mm length (Sky implant system, REF: nsky3514, Bredent medical GmbH & Co.KG Weissenhorner Str. 2 | 89250 Senden | Germany) at the canine region bilaterally. The implants were inserted using two-stage surgical technique and conventional loading protocol. Implants were manually inserted with the torque wrench until flushing with bone level. External coolant was applied during tightening the implant to avoid overheating the bone. Implants remained submerged for 3 months. Post-surgical instructions and antibiotics were prescribed for each patient.

All patients were randomly divided into two equal groups according to the site of implant attachment position either right or left. Six patients received the Bollard attachment at the right side and ball and socket attachment at the left side. Moreover, the other six patients received the Bollard attachment at the left side and the ball and socket attachment at the right side. Each patient was treated according to split-mouth design.

Attachment 1 (bollard attachment)

Received Bollard abutment (TiSi.snap 5/3 REF:TISIOY53, SKY implant system, Bredent medical GmbH & Co.KG Weissenhorner Str. 2 | 89250 Senden | Germany) and retained with the denture by the help of resilient liner "Retention.Sil 600" (65 SH, 600 g/6 Newton, REF:580 RTS 65, SKY implant system, Bredent medical GmbH & Co.KG Weissenhorner Str. 2 | 89250 Senden | Germany) without housing.

Attachment 2 (ball and socket attachment)

Received Ball abutment (2,2 abutment, 4 mm, DH2mm, REF 46000042, SKY implant system, Bredent medical GmbH & Co.KG Weissenhorner Str. 2 | 89250 Senden | Germany), where the plastic house was picked up by monomer free self-cured acrylic resin (Figure 1).

Prosthetic procedures

After 3 months, the implants were exposed using a tissue punch. Then, the bollard abutments

and the ball abutments were fastened to the implants intraorally using the torque wrench.



Figure 1: Bollard abutment versus ball abutment

The denture's fitting surface opposite the abutments position was prepared to allow for complete seating without interference. For the ball abutments (Group 2), the plastic house was picked up by monomer free self-cured acrylic resin (Acrostone Cold Cure Acrylic Resin, Acrostone Co., England) at dough stage. A small window was created at the lingual flange opposite to the abutment to allow for the escape of excess pick-up material. Whereas for the bollard abutments (Group 1), the created recesses were then painted with primer liquid (Multisil-Primer 5 ml, REF 520 0100 4, SKY implant system, Bredent medical GmbH & Co.KG Weissenhorner Str. 2 | 89250 Senden | Germany) provided with Retention.Sil kit (Figure 2). After drying of the primer, Retention.Sil 600 paste was then filled up to the top by injection from its auto-injected cartilage, the denture was inserted into the patient mouth and asked the patient to close into centric occlusion 3 min to ensure that it was fitted into its place over the bollard abutment (Figure 3). After that, the denture was removed and the excess was removed then finished with the special silicone trimmer (4.1 mm, REF SKY-DR 41, SKY implant system, Bredent medical GmbH & Co.KG Weissenhorner Str. 2 | 89250 Senden | Germany).



Figure 2: Retention.Sil 600 kit

The overdenture was delivered to the patient and accurate fitting on the abutments was insured (Figure 4).



Figure 3: Loading of Retention.Sil 600 paste by its auto-injected cartilage into the overdenture

Assessment of MBF

The MBFs were measured with an occlusal force meter instrument (model GM, NaGONO Keiki Seisakusho, LTd., J. Morita Corporation,



Figure 4: Fitting surface of mandibular overdenture with the plastic housing of the ball abutment and retention.sil around the bollard abutment

33-18-3-Chome-Torumi-Cho Suita City, Osaka 564-8650, Japan). The instrument consisted of a hydraulic pressure gauge and a biting element (17 mm in width and 5.4 mm in height) made of a vinyl material encased in a disposable plastic tube, as shown in Figure 5.



Figure 5: Occlusal force-meter

Before the actual data collection, all patients were allowed to be familiar with the measurement procedure and the instruments. During measurements, the patient was seated in an upright position, looking

forward and head in unsupported position. The plastic tube that covered the arm of the occlusal force meter sensor device was inserted into the patient mouth and he asked to bite on it slowly. The recorded force during maximal clenching was obtained with one bite force meter placed between pairs of opposing teeth at one side at the area of 2nd premolar/first molar where there is more number of occlusal contacts with strong determinant of muscle action and subsequent great bite force with 45 s intervals between successive bites then changing to the contralateral side to check the occlusal force. None of the patients experienced any discomfort or pain during biting on the occlusal force meter instrument. The MBF was displayed digitally on the screen of a computerized interface in Newton (Figure 6).



Figure 6: Measurement of maximum biting force

During performance, the patient maintained the desired level of biting force during all the test period and a buzzer sound will be heard if the biting force has exceeded the set-point. For each patient at each follow up visit, ten records of the right and left sides were collected.

Measurements of MBF were done for both Attachment (1) and Attachment (2) immediately after loading (0), after 6 months (6), and after 12 months (12) for each patient, using the instrument.

Statistical analysis

The data were collected, tabulated, and statistically analyzed by SPSS (SPSS Inc., Chicago, IL, USA). Mann-Whitney test was used to compare between groups, Friedman test was used to compare follow-up readings in single group.

Results

The mean values and standard deviations of the MBF in Attachment (1) (Bollard attachment) were 75.7 ± 1.4 , 97.8 ± 2.08 , and 168.6 ± 22.1 immediately

Table 1: Descriptive statistics and comparison between Attachment (1) (Bollard attachment) and Attachment (2) (Ball attachment) regarding maximum biting force in (Newton)

| Maximum biting force | Attachment (1) | Attachment (2) | p-value |
|---------------------------|----------------|----------------|---------|
| Immediately after loading | | | |
| Range | 74–78.5 | 60.7–74.6 | 0.001* |
| Mean ± SD | 75.7 ± 1.4 | 66.09 ± 4.7 | |
| After 6 months | | | |
| Range | 94.8–99.86 | 82.03–86.78 | 0.001* |
| Mean ± SD | 97.8 ± 2.08 | 84.1 ± 2.01 | |
| After 12 months | | | |
| Range | 128.8–188.9 | 82.1–117.4 | 0.001* |
| Mean ± SD | 168.6 ± 22.1 | 94.5 ± 10.8 | |
| p | 0.001* | 0.001* | |

Significant difference if (p>0.05), values marked with () are significant.

after loading (0 months), after 6 months (6), and after 12 months (12) follow-up visits respectively. The mean values and standard deviations of the MBF in Attachment (2) (Ball attachment) were 66.09±4.7, 84.1±2.01, and 94.5±10.8 immediately after loading (0 months), after 6 months (6), and after 12 months (12) follow-up, respectively, as shown in Table 1. The MBF showed an obvious increase in each single group. There was statistically significant difference (p < 0.05) in MBF between Attachment (1) and Attachment (2) immediately after loading (0 months), after 6 months (6), and after 12 months (12) follow-up visits. The MBF showed an obvious increase throughout the whole study period, as shown in Figure 7.

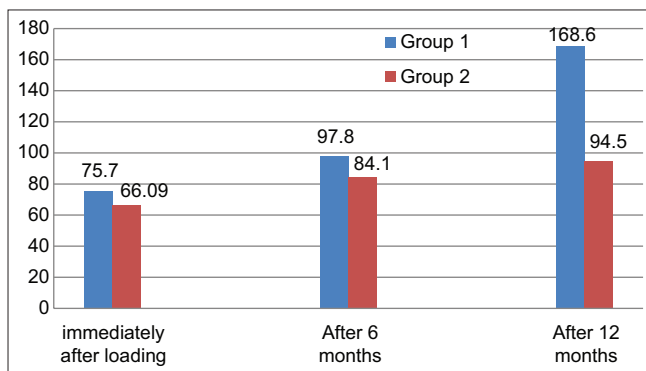


Figure 7: Maximum biting force of Attachment (1) (bollard attachment) and Attachment (2) (ball attachment) immediately after loading (0 months), after 6 months (6), and after 12 months (12) follow-up visits

Discussion

The main goals of any dental prosthesis are to restore function and esthetics of the patient regardless of any atrophy or resorption. In the cases with resorbed mandibular ridge, it becomes difficult to achieve these goals with the conventional denture. The use of dental implants nowadays for supporting and retaining mandibular dentures has helped to fulfill the functional requirements of the patient with any challenging cases [22].

Placing from two to four implants with attachments can improve the retention and stability of mandibular implant overdentures and can achieve greater support by projecting axial loads into the bone [23].

Interforaminal implant placement has been the choice in most cases to avoid surgical preparation for the ridge and escape from the inferior alveolar injury with satisfaction to the patient needs for a retentive restoration [24].

Randomization in this study in choosing the position of abutment placement either to the right side or the left side is mandatory to diminish the effect of preferable chewing side of the patient.

A split-mouth design was used to evaluate the MBF of the same patient to ignore any other interfering variable that may affect the results.

The use of metal framework in this study was to decrease the possibility of denture fracture especially at the area opposing the abutment and its attachment systems.

Overcontoured waxing up was made at the canine area in both sides to provide sufficient thickness of acrylic base that allowing relief of the fitting surface opposing the abutment without perforation of the denture base.

Ball and socket abutment was used in this study due to its simplicity, ease of handling, minimal chair side time, and relatively low-cost [22].

The Bollard (Poller) is a new resilient telescopic attachment system that is employed in implant supported removable denture cases. It offers better wide force distribution, mechanical durability, reduced denture movement, and increased retention thus improving the masticatory function of the patients [8].

Retention.Sil systems are similar to the elastic impression materials that allow for the ease of insertion and removal of the denture. They also allow for even stress distribution to the supporting structures being a traumatic that increasing the chewing and masticatory function because of the material flexibility [25]. The reduced ability of advanced age patients to adapt to new complete dentures because of their reduced or diminished neuromuscular control can be easily treated with this system. The easy of chair-side pick-up of such system is also one of the main advantages and therefore, patient's comfort, and satisfaction with dentures [26].

Clinical observations promote retention.sil as a suitable matrix product for implant overdenture cases, due to its positive biological, physical, and retention properties. Retention.Sil was introduced based on its chemical composition on PVS that has three options according to the detachment force desired (200, 400, and 600 gf). Retention.sil 600 was used in this study because it best suited in the later phases after osseointegration and offers a better retention with the abutment which remains almost constant over time with different attachment systems (ball or Locator attachment system) [12], [27].

Resilient liner housing completely obturates the space found around the abutment, and so it

minimizes the plaque accumulation and the microbial adhesion that cause peri-implant tissue inflammation, bone loss, and pocket formation. Recent studies considered that resilient denture liner materials can be useful for tissue-supported implant-retained overdenture. The use of resilient silicone lining material for retention resulted in a considerable decrease in the stresses transmitted to the implant and peri-implant bone compared to metal housing [28]. Shock-absorbing ability of soft liner reduces the stress applied to the implants which, in turn, reduces peri-implant bone loss [27].

Denture wearers were found to undergo an adaptation process to the new prosthesis, during which the MBF was found to increase considerably after 1 month of use [29].

MBF in mandibular implant-supported overdenture patients is almost twice as much as that of conventional (complete denture) prosthetic patients [30].

The MBF in this study showed significant increase throughout the whole study follow-up period (0, 6, and 12 months) in both groups and inside every single group which is an indication of better patient adaptation and neuromuscular coordination with the mandibular implant retained overdenture. The results of the current study confirm that mandibular implant retained overdenture with bollard abutment that was retained with the denture by the help of resilient liner "Retention.Sil 600" without housing showed higher MBF and masticatory performance than mandibular implant retained overdenture with ball abutment where the plastic house was picked up by monomer free self-cured acrylic resin.

And our results favoring the bollard attachment over the ball and socket and this can be attributed to the wider flat top surface of the bollard abutments relatively to the ball abutment and this wider flat table help in exerting a higher biting force. Moreover the use of retention.sil soft relining materials may be a factor permitting the patient to perform a higher biting force.

Conclusion

Within the limitations of this study, it can be concluded that mandibular implant retained overdenture with Bollard abutment that retained with the denture by the help of resilient liner "Retention.Sil 600" without housing have higher biting forces compared to mandibular implant retained overdenture with ball abutment where the plastic house was picked up by monomer free self-cured acrylic resin.

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