Evaluation of Retention force of Two Different Attachments for Mandibular Implant Supported Overdenture (A Comparative Study)

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Method Article

Keywords: Implant retained overdenture, Implant stability, Locator attachment, Retention, ball ring attachment.

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Evaluation of Retention force of Two Different Attachments for Mandibular Implant Supported Overdenture (A Comparative Study)

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I declare that I am respond on behalf of all co-authors.

Abstract:

Objectives: In an in vitro study, comparing the maximum retentive force of ball and socket attachments with locator attachments for mandibular implant-supported overdentures.

Background: Dental implants have revolutionized the field of prosthodontics by offering a reliable and stable solution for patients with missing teeth. Among the various types of implant-supported overdentures, mandibular implant-supported overdentures are commonly used to improve function and esthetics for individuals with total edentulism in the mandible. Retention force is a crucial factor in the success of mandibular implant-supported overdentures, as it directly impacts the stability and comfort of the prosthesis.

Materials and Methods: A comparative study was conducted on two groups of patients who received mandibular implant-supported overdentures with different attachment systems. Group A: received overdentures with Ball and socket attachment system, while Group B: received overdentures with Locator implant attachment system. The retention force of each attachment system was measured using a standardized testing protocol. The measurements were taken at different time points to assess the initial and long-term retention force of the attachments. A gradual increase in tension was observed, and the maximum force required to retain was calculated. The evaluation of retention will occur at baseline (T0) and after 3 months (T1), 6 months (T2), 9 months (T3), and one year (T4) of usage.

Results: The study revealed that Attachment System Ball/Ring exhibited significantly higher retention force compared to Locator implant Attachment System in the initial term assessments. This difference in retention force could be attributed to the design and material properties of the two attachment systems. Locator implant Attachment System demonstrated superior retention force at the end term of assessment.

Conclusion: Both types of attachment systems; Ball/O Ring and Locator attachments are trustworthy modalities for advancement the retention and stability of implant retained mandibular over denture with superior initial stability results for the Locator attachment.

Keywords: Implant retained overdenture, Implant stability, Locator attachment, Retention, ball ring attachment.
Introduction

The complete denture is the top choice among edentulous patients. The patient's psychological response to dentures plays a crucial role in achieving positive treatment outcomes for complete denture wearers. Retention and stability issues compromise oral and masticatory functions with mandibular complete dentures, negatively affecting patient satisfaction and quality of life. Overcoming these problems is possible with the use of Implant-retained over dentures, which are extremely valuable in prosthetic management (1).

Successful treatment of implant-retained over dentures should be planned by 2 implants in the mandibular edentulous ridges which are considered the minimum standard of care for edentulous patient to increase the retention and stability, patient satisfaction, simplicity and cost effectiveness over an extended period of time. Clinicians have selected different attachment systems based on factors such as durability, patient demand, cost effectiveness, technical simplicity, and retention (2).

The types of attachments that could be used with implant overdentures such as magnets, Ball/O-ring, bar(s)/clip(s) and Locator attachments. To extending their longevity, sufficient stability, appearance, and comfort, the over dentures should be cautiously planned. The inter-arch space, stress distribution between implant and mucosa, and the amount of retention and resistance needed are the main factors affecting the selection of attachment systems (3).

“O” Ring or Ball attachment is considered the simplest type of attachment for clinical application with tooth or implant supported overdentures. It considered as an extra-coronal attachment mechanism, that has a screw-retained male abutment in the implant with a spherical shape on its occlusal portion, and a prosthetic anchored female part that can be metallic or covered with nylon having a different retention range. These attachments do not need a great prosthetic space and they allow hinge and rotation dislodgements by using a spring mechanism to absorb the load forces, which allows even distributions of axial tension and tolerate slight rotation of the denture. The advantage of this type of attachment design is minimizing the lateral load on the implant fixture thus facilitate bone health (4).

The Locator attachment is another attachment system, which does not use the splinting of implants. This attachment is self-aligning and has dual retention in different colors with different retention values. Locator attachments are available in different vertical heights, they are resilient, retentive, and durable, and have some built-in angulation compensation. In addition, repair and replacement are fast and easy. Locator attachment will also accommodate divergent implants up to 20 degrees. A variety of abutment heights, angulations correction and different levels of retention are available that help to create the optimum overdenture restoration for each case. Locator attachments are highly recommended to retain mandibular overdentures, as they exhibited high retention values with minimal loss of retention (5,6).

Achievement and maintenance of implant stability are prerequisites for long-term positive outcomes for osseointegrated implants. Thus, implant stability is the key to clinical success. Thus the aim of this study was to Compare between the maximum
retentive force of two different attachments ball and socket versus locator attachments for mandibular implant supported overdenture in-vitro.

**Materials and methods:**

This study was designed as an experimental in-vitro controlled study, that was carried out in the Removable Prosthodontic Department, Faculty of Oral and Dental Medicine, AL-Azhar University (Assiut branch). Because this work was conducted in vitro without using any human or animal tissue, no ethical approved was necessary. Sample size calculation was estimated using G power software version 3.1.9.6.

The aim of the current study was to assess the maximum retentive forces of two distinct implant-supported overdenture therapy techniques. Ball and socket implant retained overdentures were the first type of treatment, and locator attachment was the second.

1. **Construction of the acrylic model:** made with heat polymerized polymethyl methacrylate resin.

2. **Curing of the acrylic resin model**

3. **Implant installation:**

In the canine region, two internal hex implants that were identical were placed bilaterally, perpendicular to the residual ridge area. The two implant sites in the model were drilled using a milling machine. First, a 1.8mm diameter cylindrical drill was used to prepare the sites. Subsequent drills were then used, and finally, a 3.5 diameter drill was used to complete the preparation. The pilot drill was used to check for parallelism at the implant sites. For the purpose of accounting for the abutment shoulder, the drilling depth was 14 mm from the top of the cast. The drilled implant sites were filled with a mixture of chemically activated acrylic resin, and the implants were tightened.

4. **Construction of the prosthesis:** The implant was secured with two straight, contoured abutments.

5. **Preparation of the master cast for duplication:** To create room for the acrylic resin of the overdenture a 1.5 mm thick relief wax was applied around, over, and over the attachments as well as over the anterior and posterior edentulous areas. On the relief wax, two square windows measuring "2X2mm" were carved; one on each side's posterior area and one on the anterior area. In the acrylic model, three triangular-shaped depressions were made: two lateral to the lingual vestibule on either side and one at the lingual frenum region. To create a refractory cast, the model was then copied into an investment material.

6. **Simulation of the mucosa covering the residual ridge:** A number 5 round bur made a series of holes in the residual ridge of the model, each measuring 2 mm deep. A cylindrical carbide cutter bur was used to remove the acrylic resin that was in between the holes. Ridge modification resulted in the creation of mold cavity which was filled with silicon soft liner that had self-cured. As a result, a robust layer with an even thickness that mimicked the mucosa in the edentulous area was created.

7. **Construction of the metal framework**
8. Construction of the overdenture

9. Implant overdenture attachment systems

- Prefabricated ball/o-ring attachment
- Locator attachment

Each attachment system was secured into the implant replicas on the acrylic resin model and the overdentures with the corresponding housing were subsequently placed on it and tightened to 35 Ncm.

9. Retention testing procedure:

- Universal testing machine (UTM) - Instron 5567

With the UTM (Instron 5567 compression tension tensile meter), each of the models were subjected to 100 pulls each to dislodge the overdenture from the acrylic model, and the force values as indicated on the digital indicator were tabulated. The dislodging force was applied in a vertical direction in the center of the acrylic block joining the two metallic clamps holding the overdenture with the UTM. Tensile force was applied to the metal ring during the retention test using a universal testing machine in order to measure the retention forces of each type of retainer. The device, which is made up of a vertical arm and a metal cylinder, was attached to the overdenture's metal ring. Care was taken to make sure the prosthesis was securely gripped in the lower fixed compartment of the computer controlled materials testing machine and that the hook fits passively into the ring. Next, the maximum retentive force was determined and the gradual tensile load was documented.

10. Simulating three years period of use of the attachment: Cycles of insertions and removals were performed to mimic real clinical settings where attachment parts would wear out. Presuming that a patient takes off their prosthesis three times a day. Retention will be evaluated at baseline (T0) and after 3 months usage cycles (T1), 6 months usage cycles (T2), 9 months usage cycles (T3) and one-year usage cycles (T4).

Fig(1): Readymade rubber mould with negative space for largely edentulous mandible with only the two canines left.

Fig(2): Mounting the cast on the milling machine to drill the implant sites
Fig (3) Implant fixtures in canine area

Fig (4): The two implants received straight contoured abutment

Figure 8: Preparation of the master cast for duplication

Fig (6): Modification of the residual ridge for simulation of mucosal coverage
Fig(7): Finished and polished metal framework on the master cast

Fig(8): The finished overdenture

Fig(9): Ball and socket attachment

Fig(10): Locator attachment

Statistical Testing:

Data were collected, tabulated, and statistically analyzed using SPSS ® Statistics Version 20. The Shapiro–Wilk test was used to verify the normality of distribution. Independent t-test was used to compare the nonparametric values between the different groups. F-test (ANOVA) for normally distributed quantitative variables, to compare between more than two groups. The level of significance was set at $P \leq 0.05$.

Results: Comparison between mean values in both, locator attachment and ball and socket attachment group was revealed statistical insignificant values.

1. Comparison of retention values regarding the attachment type: It is assumed that Group1 and group 2 values are normally distributed ($P$-value $>0.05$) regarding. The
ball/socket attachment had a significantly higher mean retentive values (46.78±1.95 N) at the insertion (baseline) when compared with the locator attachment (42.4±1.69 N).

Table (1): Comparison of the retention values in newton (N) regarding the attachment type:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Locator attachment</th>
<th>Ball/socket attachment</th>
<th>t-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Baseline (at insertion)</td>
<td>42.4</td>
<td>1.69</td>
<td>46.78</td>
<td>1.95</td>
</tr>
<tr>
<td>3 months (270 cycles)</td>
<td>37.56</td>
<td>0.77</td>
<td>40.42</td>
<td>0.92</td>
</tr>
<tr>
<td>6 months (540 cycles)</td>
<td>34.26</td>
<td>0.64</td>
<td>37.2</td>
<td>0.57</td>
</tr>
<tr>
<td>9 months (810 cycles)</td>
<td>29.3</td>
<td>0.98</td>
<td>31.46</td>
<td>0.60</td>
</tr>
<tr>
<td>12 months (1080 cycles)</td>
<td>27.72</td>
<td>1.13</td>
<td>29.44</td>
<td>0.91</td>
</tr>
</tbody>
</table>

Figure(11): Bar chart of mean retention values of locator and ball/socket attachments

Table (2): Comparison of the retention values in newton (N) of locator attachment regarding the time (the number of the insertion cycle (time):
Table (3): Comparison of the percentage of decrease in retention values regarding the attachment type: The ball/socket attachment had a insignificantly higher change in the mean retentive values (13.48±3.79 N) when compared with the locator attachment (11.32±0.77 N) after 270 cycles.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Locator attachment</th>
<th>Ball/socket attachment</th>
<th>t-value</th>
<th>P -value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>0-270 cycles</td>
<td>11.32</td>
<td>3.53</td>
<td>13.48</td>
<td>3.79</td>
</tr>
<tr>
<td>0-540 cycles</td>
<td>19.10</td>
<td>3.14</td>
<td>20.33</td>
<td>4.28</td>
</tr>
<tr>
<td>0-810 cycles</td>
<td>30.83</td>
<td>2.93</td>
<td>32.69</td>
<td>1.71</td>
</tr>
<tr>
<td>0-1080 cycles</td>
<td>34.54</td>
<td>3.52</td>
<td>37.02</td>
<td>1.97</td>
</tr>
</tbody>
</table>

*; significant at P≤0.05. Ns: Non-significant.

Figure (12): Bar chart of the percentage change in the mean retention values of locator and ball/socket attachment.

Discussion:
Impact of higher retention force values of overdenture in mandibular arch attributed in enhancing the mechanical properties, stability and improve the overall success and patient satisfaction with the prosthesis. Dentists and prosthodontists should consider the biomechanical properties of attachment systems when choosing the right system for their patients. Maintenance of the abutment supporting structures is considered a key factor to the success of overdenture treatment. Occasionally overdenture wearers may experience severe breakdown of the abutment supporting structures, which are of critical importance of the maintenance and success of this treatment. The principle in applying the retentive implant-overdenture systems in the treatment of edentulous patients is to increase denture retention and stability, thereby enhancement of the chewing function and patient comfort. Implant stability is curricular element for dental implants success and it is provided initially by mechanical engaging in the implant bed bony walls. Secondary stability occurs during healing by deposition of bone on the implant surface (osseointegration)\(^7,8\).

This study highlight the importance of selecting an appropriate attachment system for mandibular implant-supported overdentures. Group A: received overdentures with Ball and socket attachment system, while Group B: received overdentures with Locator implant attachment system. The results revealed that the retention values showed no statistically significant difference between group I and group II before overdenture insertion (T0) while it was there at the time of loading (T1) and after 3 months (T3) with higher mean values for group I when compared to group II (P<0.05). Comparing the results of both groups: 1. Locator attachment showed comparable retentive force with ball/socket attachment at insertion. 2. Locator attachment loss its initial high retentive force earlier than the ball/O-ring attachment. 3. The ball/socket attachment showed a higher mean retention force at the end of removal cycle \(^9\).

The results of the current study revealed that the ball/socket attachment resulted in significantly higher retentive forces than the locator attachment at the insertion. This could be related to the rubber nitrile which used to make O-rings in the ball/socket attachments, which have elastic qualities, resistance to steel, compressive strength, and wear resistance \(^10\). Cakarer et al \(^11\) reported no difference between ball attachment and Locator systems regarding implant failure, replacement of attachments, and fracture of overdentures. However, they found that overall, the Locator system had more advantages than the ball or bar-clip systems.

According to the findings of Nawaid et al. (2020) \(^12\) the ball/O-ring connection acquired a larger retentive force than the locator attachment. Furthermore, following an early peak, the locator attachment showed a decline in retentive capacity. This is because however, the rubber matrix in O-ring showed higher wear and deformation than the metal parts of the matrix but titanium nitride coatings improved the matrix surface’s wear resistance and stiffness \(^13\). The most frequent issue with implant overdentures is loss of attachment retention over time \(^14\). The finding of this current in vitro study revealed that the retention values of ball/socket as well as locator attachments tend to gradually decrease with repeated loading and insertion/withdrawal cycles. This could be related to the wear of their matrix and matrix component due to frictional movement during the repetitive removal and insertion cycle \(^15,16\).

**Conclusion:** The implant survival and success rate of mandibular implant overdentures is our main target. The prosthetic maintenance and complications may be influenced by...
attachment systems. However patient satisfaction may be independent depending upon attachment system. The ball/o-ring and bar–clip attachments maintain their retentive capacity longer than the Locator attachment. A decrease in the retention force was observed in both the two groups of attachment systems after subjecting them to thermal cycles and this decrease was found to be statistically significant.

**Recommendation:** Further research is required to understand the loss in retention force of various overdenture attachment systems.

**Competing interests:** The authors declare that they have no competing interests in this section.

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**Availability:** public available

### References


