**Original Research**

**A Comparison of the Retentive Force of Ball and Socket Attachment versus Magnet Attachment in Mandibular Overdentures: A Randomized Control Trial**

Ahmed I. El Bakry1, Mohamed Farouk Abdall2,3, Mohamed Y. Sharaf4

1Department of Prosthodontics, Faculty of Dentistry, University of Ahram Candian, Cairo, Egypt; 2Department of Prosthodontics, Faculty of Dentistry, University of Cairo, Cairo, Egypt; 3Department of Prosthodontics, Faculty of Dentistry, Future University, Cairo, Egypt; 4Department of Prosthodontics, Faculty of Dentistry, University of Beni-Suef, Beni-Suef, Egypt

**Abstract**

**Aims and Objectives:** The aim of this study was to compare the retention and patient satisfaction of implant-supported mandibular overdentures with ball and socket attachment versus magnet attachment. **Materials and Methods:** Twenty-four participants (10 males and 14 females) were divided into two equal groups (n = 12). Both groups received implant-supported mandibular overdentures retained by ball and magnet attachment. Two implants were installed in the canine region bilaterally. Evaluation of retention was made at overdenture insertion, 3, 6, and 12 months. Patient satisfaction evaluation with Oral Health Impact Profile Questionnaire-14 (OHIP-14) was made at overdenture insertion 3, and 12 months subsequently. **Results:** The ball group showed a statistically significantly higher retention force \( P < 0.05 \) than the magnet group at insertion, 3 and 6 months. The ball group had a statistically significantly lower mean of physical disability and physical pain \( P < 0.05 \) than the magnet group through all follow-up. One-way analysis of variance (ANOVA) test was used to compare between groups as well as to study the changes by time within each group. **Conclusion:** Both implant-supported mandibular overdenture retained with magnet or ball and socket attachments consider a successful treatment option with superior improvement in the ball and socket group.

Keywords: Attachment, Overdenture, Patient Satisfaction, Quality of Life, Retention

Received: 20-1-2020, Revised: 05-02-2020, Accepted: 04-04-2020, Published: XX-XX-XXXX.

**INTRODUCTION**

Dental implants have completely changed the world of edentulism; despite the enormous efforts exerted, there are still many controversies regarding the retention of implant attachments, which will affect patient satisfaction and preference. There is insufficient evidence to determine the relative effectiveness of different attachment systems on prosthetic success, maintenance, patient satisfaction, or patient preference.\(^{[1-5]}\) Implant-retained overdentures offer a line of treatment that improve denture retention, patient’s satisfaction, and patient quality of life.\(^{[6-8]}\) Implant-retained overdentures with different types of attachments represent approximately 60% of installed implants.\(^{[9,10]}\) Mandibular overdentures supported by two implants is a cost-effective, predictable line of treatment that improve retention, stability, and patient satisfaction, so it is considered as the standard treatment for the edentulous mandible.\(^{[11]}\)

Several types of attachments have been developed that are mainly classified into splinted anchorage systems, such as the bar type and unsplinted anchorage systems, as the unsplinted anchorage attachments have been used in many overdentures cases such as the ball and socket. The ball attachment requires less space within the prosthesis.

**Address for correspondence:** Dr. Mohamed Yahia Sharaf, Department of Prosthodontics, Faculty of Dentistry, University of Beni-Suef, Beni-Suef 62511, Egypt E-mail: dent_1983@yahoo.com

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: El Bakry AI, Abdall MF, Sharaf MY. A comparison of the retentive force of ball and socket attachment versus magnet attachment in mandibular overdentures: A randomized control trial. J Int Oral Health 2020;XX-XX-XX.
is easier to clean and more economical, as well as less
technique sensitive. The ball attachment distributes and
reduces the transmitted load to the implant by allowing
slight multidirectional movement.\cite{12-15} However, magnets
showed many advantages as low profile, minimal lateral
stress transmission to the implants, minimal stress
generated in the periimplant bone, and also not interfere
with surrounding gingival tissues during overdenture
dislodgement; magnets are less prominent, smoother, and
comfortable to the patients when the prostheses are absent
from the mouth.\cite{16-20} The attachments used with implants
mainly require frequent adjustment and repairs, as well as
the attachment components liable to fracture, distortion,
and disengagement with gradual loss of retention and
stability. These problems are a common cause of patient
dissatisfaction.\cite{21-23} Thus, there are still many controversies
regarding the retention of implant attachments that are used
in implant-supported overdentures, where the success of
an implant-retained overdentures primarily depends on the
retentive capacity of attachment as well as better esthetics,
which will be reflected toward the patient satisfaction and
quality of life for long-term functionality.\cite{1-5}

The purpose of this clinical trial was to compare the
retention and patient satisfaction of implant-supported
mandibular overdentures with ball and socket versus with
magnet attachment. The research hypothesis was that the
ball and socket would provide better retentive force as well
as better patient satisfaction.

**Materials and Methods**

**Setting and design**

Participants were enrolled from the outpatient clinic,
Cairo University, Faculty of dentistry from March 2018
till May 2018 in a parallel randomized control trial for
1 year. The Faculty of Oral and Dental Medicine Research
Ethics Committee approved the protocol.

**Sampling criteria**

Based upon the results of Cune et al.,\cite{24} the study will
include a minimum of 12 subjects per group for a total of
24 subjects. Sample size calculation was performed using
IBM Statistical Package for the Social Sciences (SPSS)
Sample Power Release.

The participants were enrolled according to the
following criteria: completely edentulous, Angle’s
class I maxillomandibular relationship, and all participants
were free from neuromuscular disorders, temporomandibular
joint disorders, and systemic diseases that could interfere with
implant placement or implant osseointegration with age range
from 50 to 70 years. Twenty-four selected participants were
randomly divided by the team leader with a sealed envelope
 technique into two equal groups (n = 12) (seven females
and five males in each group). The allocation concealment
key was retained by the chairman of the department. The
ball group received an implant-supported mandibular
overdenture retained by ball attachment. The magnet group
received an implant-supported mandibular overdenture
retained by magnet attachment where all patients were
blind regarding the type of final prosthesis. Fabrication of
maxillary and mandibular complete denture as conventional
manner with teeth arranged according to the linguized
occlusal concept,\cite{25} then the dentures were evaluated
intraorally for extension, retention, stability, esthetics,
phonetics, occlusal plane orientation, centric occluding
relation, and vertical dimension. Then the participants
were instructed for denture and oral hygiene measures. The
mandibular denture was duplicated into a radiographic stent
using a mixture of acrylic resin and barium sulfate with a
ratio of 4:1. The stent was then evaluated intraorally.\cite{26} Cone
beam computed tomography (CBCT) images were made
with the radiographic stent in place to determine the optimal
place for implant placement, then the radiographic stent
was converted into a surgical guide by making holes in the
proposed implant site.

**Surgical procedures**

The surgical guide was disinfected by immersing it in a 2%
glutaraldehyde solution for 15 min. Infiltration anesthesia
was given in the proposed implant site. The surgical
guide was placed; and an explorer was used to mark the
proposed sites for implant placement. A crestal incision
was made using a Bard Parker blade no. 15, extending
5-mm mesial and distal to the marked implant site.
A full-thickness mucoperiosteal flap was reflected using
a sharp mucoperiosteal elevator. In some situations, with
a sharp knife-edge ridge or irregular ridge, a low-speed
fissure bur and bone file was used for smoothing the ridge
and creating a bony plateau. Then, the surgical guide
was again placed into the patient’s mouth, and a large
round bur was used to mark the implant placement site
under copious saline irrigation. The implant osteotomy
(diameter 3.6 mm and length 12 mm) was made by
sequential drilling. The same procedures were repeated
for the other implant, and then parallelism was evaluated
between both implants using a paralleling tool. The
implant was installed in the osteotomy site and rotated
gradually till flushing with the bone then the cover screw
was placed. The flap was repositioned and sutured. After
3 months, digital periapical radiographs were carried out
to ensure implant osseointegration. Infiltration anesthesia
was given around the implant site. The surgical-guide
was reinserted to determine the implant position, then
the implant cover screw was exposed and replaced with
suitable healing abutment according to mucoperiosteum
thickness covering the implant [Figure 1]. The denture
was modified to allow the patients to wear the denture,
then the healing abutment was replaced by final abutment
after the formation of a gingival collar [Figures 2 and 3]. Pickup of the metal housings and magnet assay was
carried out using self-cure acrylic resin.
Retention measurement (primary outcome)
There is no dropout; all patients completed the follow-up period. The retention was measured at the time of insertion 3, 6, and 12 months after prosthesis insertion for all participants. The procedure was started by identification of the geometric center of the mandibular arch to allow placement of the metallic loop. The digital force-meter machine was attached to the metallic loop to measure the retentive force of mandibular overdentures by applying a gradual pulling up force of the denture until it disengaged. The record appeared at the screen of the force meter (Extech 475040 digital force gauge), which is a single-blind measurement as the examiner knows the two different designs.

Questionnaire method (secondary outcome)
Patient satisfaction measured by Oral Health Impact Profile-14 (OHIP-14) was used where the five responses for each item are as follows: never, hardly never, occasionally, fairly often, and very often. Items were scored on a 5-point scale ranging from 0 (never) to 4 (very often) [Table 1]. Lower scores represent a higher patient satisfaction and better quality of life. The questionnaires

Table 1: Comparison between retention forces (G) in the two groups

<table>
<thead>
<tr>
<th>Time</th>
<th>Conventional (Mean (SD))</th>
<th>Magnet (Mean (SD))</th>
<th>P Value</th>
<th>Effect size (ηp²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>At insertion</td>
<td>425.86 (15.27) a</td>
<td>254.33 (17.6) a</td>
<td>&lt;0.001*</td>
<td>0.988</td>
</tr>
<tr>
<td>95% CI</td>
<td>401.6–449.2</td>
<td>270–247.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 months</td>
<td>398.96 (12.74) b</td>
<td>248.06 (8.5)</td>
<td>&lt;0.001*</td>
<td>0.940</td>
</tr>
<tr>
<td>95% CI</td>
<td>410–387.2</td>
<td>235.4–255.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 months</td>
<td>311.16 (10.20) c</td>
<td>238.6 (8.5)</td>
<td>&lt;0.001*</td>
<td>0.642</td>
</tr>
<tr>
<td>95% CI</td>
<td>299.5–328.5</td>
<td>188.3–265.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 months</td>
<td>208.8 (21.46) d</td>
<td>222.08 (7.37) b</td>
<td>&lt;0.0976</td>
<td>0.920</td>
</tr>
<tr>
<td>95% CI</td>
<td>197.3–241.9</td>
<td>195.2–234.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P Value</td>
<td>&lt;0.001*</td>
<td>&lt;0.001*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effect size (ηp²)</td>
<td>0.997</td>
<td>0.999</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SD = standard deviation, CI = confidence interval
*Significant at P ≤ 0.05
Different superscripts in the same column are statistically significantly different
were recorded at baseline (2 weeks), 3 months, and 12 months after prosthesis insertion for patients of all groups. All questionnaires were taken by the same research interviewer (assisted interviewer) as he was blind about the type of prosthesis as he is from another department. All questionnaires were in English form and translated during the interview.

**Statistical analysis**

Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov–Smirnov and Shapiro–Wilk tests). All data showed normal (parametric) distribution. Data were presented as mean, standard deviation (SD), and 95% confidence interval for the mean (95% CI) values. Repeated measures one-way analysis of variance (ANOVA) test was used to compare between the groups as well as to study the changes by time within each group. Bonferroni’s post hoc test was used for pairwise comparisons. The significance level was set at $P < 0.05$. Statistical analysis was performed with IBM SPSS Statistics for Windows, version 23.0 (IBM Corp., Armonk, NY, USA).

**Results**

The data were collected for all patients without dropout. There was a decrease of retention throughout the follow-up period in both groups; the ball and socket group showed statistically significantly ($P < 0.05$) better retention force compared to that of magnet group at 0, 3, 6 and 12 months [Table 1]. Within all groups, there was a decrease in mean retentive force, but within the ball and socket group, there was a statistically significant decrease in mean retentive force from baseline to 12 months [Table 1]. There was an increase of patient satisfaction throughout the follow-up period in both groups; the ball and socket group showed statistically significantly ($P < 0.05$) higher mean of overall satisfaction compared to that of magnet group along all follow-up period [Table 2].

**Discussion**

Ball and socket group showed a statistically significantly lower median score than the magnet group along all follow-up periods regarding both physical disability and physical pain, whereas for other five aspects “Handicap, Social disability, Psychological disability, Psychological discomfort, and Functional limitation” no significant difference was found between both groups [Table 2].

<table>
<thead>
<tr>
<th>OHIP-14</th>
<th>Time</th>
<th>Conventional</th>
<th>Magnet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
<td>Min</td>
</tr>
<tr>
<td>Functional limitation</td>
<td>0 month</td>
<td>0.208</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3 month</td>
<td>0.166</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>12 month</td>
<td>0.166</td>
<td>0</td>
</tr>
<tr>
<td>Physical pain</td>
<td>0 month</td>
<td>0.125</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3 month</td>
<td>0.166</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>12 month</td>
<td>0.291</td>
<td>0</td>
</tr>
<tr>
<td>Psychological discomfort</td>
<td>0 month</td>
<td>0.125</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3 month</td>
<td>0.125</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>12 month</td>
<td>0.125</td>
<td>0</td>
</tr>
<tr>
<td>Physical disability</td>
<td>0 month</td>
<td>0.208</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3 month</td>
<td>0.166</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>12 month</td>
<td>0.166</td>
<td>0</td>
</tr>
<tr>
<td>Psychological disability</td>
<td>0 month</td>
<td>0.208</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3 month</td>
<td>0.166</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>12 month</td>
<td>0.166</td>
<td>0</td>
</tr>
<tr>
<td>Social disability</td>
<td>0 month</td>
<td>0.083</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3 month</td>
<td>0.083</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>12 month</td>
<td>0.083</td>
<td>0</td>
</tr>
<tr>
<td>Handicap social disability</td>
<td>0 month</td>
<td>0.083</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>3 month</td>
<td>0.083</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>12 month</td>
<td>0.083</td>
<td>0</td>
</tr>
</tbody>
</table>

OHIP-14 = Oral Health Impact Profile-14, SD = standard deviation
system. It was not possible to determine any preferred attachment system for mandibular overdentures.[2,28] Using implants in completely edentulous patients has proven for many times their success in providing the denture wearer satisfaction and confidence regarding implant-supported overdenture.[29,30] As the study denotes a decrease of retention along with the follow-up period that coincides with many investigations, explaining loss of retentive force over time is inevitable. This loss of retention has been attributed to wear of attachment components, which may be related to deformation that occurs during insertion and removal of the prosthesis.[4,17] With advancement and modification of magnet such as the development of encapsulated and rare earth magnets that allow its use with implant systems. These magnets showed greater retentive forces and reduced susceptibility to wear and corrosion, as well as a low maintenance requirement and high success rate.[31,32] Retention of overdenture is crucial for clinical success as the attachments that provide more retention against displacement will give more acceptable results of better oral function and patient satisfaction.[33] The ball and socket group showed superior retentive force through all follow-up period,[34] which may be attributed to the nature of mechanical interlocking between male and female parts, whereas the magnets are deprived of mechanical retention as well as no lateral stability. The magnets group showed a minimal reduction in retentive force, which might be due to microscopic corrosion that might occur within the stainless steel but of low value due to recent technology of magnet production, and the ball showed more wear during insertion and removal.[7] The satisfaction score for ball and socket is superior regarding physical pain and physical disability, which may be attributed to the mild difficulty in eating or uncomfortable eating of some kind of sticky food as the magnet does not provide resistance to lateral forces. Several studies concluded that the ball yields stable implant outcome and improved Oral Health-Related Quality of Life (OHRQoL).[35] Data need to be confirmed by further randomized trials with a larger sample size as well as studying magnet attachment regarding other parameters.

**Conclusion**

Within the limitation of this comparative study, the following conclusions were made:

Both implant-supported mandibular overdentures retained with magnet or ball and socket attachments
consider a successful treatment option. The ball attachment provided more retention than the magnet attachment and led to improved patient satisfaction. This trial may form a base regarding the selection of best attachment regarding improving quality of life as well as the patients’ satisfaction.

Data availability statement
The data set used in this study is available on request.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

Declaration of patient consent
The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

REFERENCES


Author Query???
AQ1: Kindly check and approve the change made to reference 34 as provided.
THE PATIENT SATISFACTION QUESTIONNAIRE (OHIP-14)

Patient name
Chart number

Functional limitation:
1. Have you had trouble pronouncing any words because of problems with lower partial denture?
2. Have you felt that your sense of taste has worsened because of problems with lower partial denture?

Physical pain:
3. Have you had painful aching in your mouth?
4. Have you found it uncomfortable to eat any foods because of problems with your lower partial denture?

Psychological discomfort:
5. Have you been self-conscious because of your lower partial denture?
6. Have you felt tense because of problems with your lower partial denture?

Physical disability:
7. Has your diet been unsatisfactory because of problems of lower partial denture?

8. Have you had to interrupt meals because of problems of lower partial denture?

Psychological disability:
9. Have you found it difficult to relax because of problems of lower partial denture?
10. Have you been a bit embarrassed because of problems of lower partial denture?

Social disability:
11. Have you a bit irritable with other people because of problems of lower partial denture?
12. Have you had difficulty doing your usual jobs because of problems of lower partial denture?

Handicap:
13. Have you felt that life in general was less satisfying because problems of lower partial denture?
14. Have you been totally unable to function because of problems of lower partial denture?

CODE: 0, 1, 2, 3, 4
0 = Never, 1 = hardly never, 2 = occasionally 3 = fairly often, 4 = very often