

Comparison of The Effect of Ball and Socket Versus Magnetic Attachments on Bone Density at Lateral Apical Region of Implant Supported Maxillary Obturators.

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ABSTRACT:

Aim: To evaluate and compare the effect of ball-and-socket and magnetic attachments on peri- implant bone density at the lateral apical region of interest (ROI) in implant-supported maxillary obturators.

Materials and Methods: Ten completely edentulous hemimaxillectomy patients were rehabilitated with maxillary obturators supported by three implants placed in the intact

premaxillary segment. Patients were randomly allocated into two equal groups according to attachment type: ball-and-socket attachments and magnetic attachments. Bone density at the

lateral apical ROI was assessed using the software Digora system. Data collected after 3, 6, 9, and 12 months. Intergroup comparisons were performed using an independent t-test, while longitudinal changes were analyzed using repeated-measures analysis of variance. Statistical significance was set at $P < 0.05$.

Results: Both groups demonstrated progressive increases in peri-implant bone density throughout the follow-up period. The ball-and-socket attachment group showed significantly greater bone density changes than the magnetic attachment group at all evaluation intervals for the three implants ($P < 0.05$). At 12 months, mean bone density values for Implant 1 were $670 \pm$

30 and 610 ± 35 , for Implant 2 were 660 ± 31 and 600 ± 36 , and for Implant 3 were 670 ± 28 and 605 ± 34 in the ball-and-socket and magnetic groups, respectively.

Conclusion: Within the limitations of the study, ball-and-socket attachments demonstrated significantly greater improvement in peri-implant bone density than magnetic attachments in implant-supported maxillary obturators, suggesting more favorable biomechanical response around supporting implants.

Keywords: Maxillary obturator; implant-supported obturator; magnetic attachment; ball-and-

socket attachment; bone density; cone-beam computed tomography.

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Introduction

Maxillary defects resulting from surgical resection of tumors, trauma, or congenital anomalies may create communication between the oral and nasal or antral cavities, compromising mastication, speech, deglutition, and facial esthetics.¹ Obturator prostheses remain an important rehabilitative option, but retention and stability can be difficult to achieve in completely edentulous patients with extensive unilateral defects.²

Osseointegrated implants can improve prosthesis control and reduce dependence on unfavorable defect anatomy. Nevertheless, the maxillectomy environment differs fundamentally from the conventional edentulous arch: support is asymmetric, the prosthesis may rotate toward the defect, and functional loads are transferred through a reduced residual foundation.³ Dental implants have improved the rehabilitation of maxillary defects by enhancing the retention and stability of obturator prostheses. Implant-assisted maxillary obturators improve load distribution, prosthesis control, and quality of life.⁴ Various attachment systems have been introduced to connect implants to obturator prostheses, including bar attachments, ball-and-socket attachments, and magnetic attachments.⁵

Ball-and-socket attachments provide mechanical interlocking with resilient movement determined by the matrix, whereas magnetic attachments provide self-seating axial attraction with relatively limited resistance to lateral displacement.⁶

Peri-implant bone density is an important radiographic indicator of implant stability and bone remodeling. Radiographic assessment at the lateral apical ROI provides useful longitudinal information about peri-implant bone response when standardized imaging parameters are used.⁷

This study aimed to radiographically compare the effect of ball-and-socket and magnetic attachments on bone density at the lateral apical region of implants supporting maxillary obturators. The null hypothesis was that there would be no significant

difference in peri-implant bone density at the lateral apical region between the two attachment systems.

Materials and Methods

This study was conducted over a 12-month follow-up period in completely edentulous hemimaxillectomy patients rehabilitated with implant-supported maxillary obturators.

The study protocol was approved by the Institutional Ethical Committee, Badr University in Cairo (BUC-IACUC-24743-750), and written informed consent was obtained from all participants.

Sample size was calculated using G*Power software for repeated-measures analysis with two independent groups and four repeated measurements. The calculation was based on an alpha error probability of 0.05, a statistical power of 80%, and an expected large effect size⁷. A minimum of five patients per group was required. Ten patients were randomly allocated into two equal groups ($n = 5$ each).

Patients had healed Aramany Class I maxillectomy defects and were completely edentulous. Inclusion criteria included age between 50 and 65 years, non-smoking status, absence of lesion recurrence. All participants had received total dose of radiotherapy below 50 Gy and last radiation fraction session was since not less than one year to avoid complications of radiotherapy on bone osseointegration (German S3 Guidelines: "Implant Treatment for Oral Rehabilitation in Connection with Head and Neck Radiation"). Patients with previous obturator use was an exclusion criterion. Ten patients were randomly allocated into two equal groups ($n = 5$ each). A computer-generated random sequence was used.

Allocation was performed using a computer-generated random sequence with sealed opaque envelopes. The rehabilitation plan was explained to all patients. Each patient received a detailed explanation of the implant treatment procedures, risks, benefits, follow-up requirements, and

maintenance procedures before signing the informed consent form.

The obturator and mandibular dentures were processed conventionally using heat-cured polymethyl methacrylate. The extension of the obturator into the defect side was hollowed to decrease prosthesis weight. Delivery and adjustment were performed in the conventional manner using pressure-indicating paste and disclosing wax.

Each participant received three endosseous implants placed in the residual alveolar ridge on the non-defect side of the premaxilla under local anesthesia following standard surgical protocols (Titanium root form Advent system with implant extender with 10 mm length, 307 mm diameter. The implants are SBM blasted screen shaped with

apical vent) Titanium root form Advent implant system (Paragon implant company, USA 1158211/ENTTURA Boulevard-RO, SUITE 420, ENCINO.)

. Implants were allowed to be osseointegrated for 6 months. According to the attachment system used, patients were divided into two equal groups. Group I received ball-and-socket attachments (AVBA2, ball attachment for adventure division-venture Boulevard) to retain the implant-supported obturators illustrated in Figure 1. Group II received magnetic attachments (Dyna, prostbus 70, 4600 AB BERGEN Op Zoom, the Netherlands) to retain the obturator prostheses. The keeper of the magnet was attached to the implant, and the magnets were incorporated into the fitting surface of the obturator illustrated in Figure 2.



Figure 1: Group I with ball and socket attachment



Figure 2: Group II with Magnetic attachment

Patients were instructed regarding oral and prosthesis hygiene to preserve the remaining tissues and prevent infection and inflammation. They were taught how to insert and remove the obturators along the planned path of insertion to avoid tissue trauma and frictional wear of the attachments.

The software Digora system was used for evaluating the changes in bone density. The density measurement of the Digora system measures the relative bone density along a line or an area of controlled dimensions (UMax data system Inc, USA, at 4800 DPI (dot per inch) connected to IBM Pentium 11333MHZ Pc, equipped with SCSI card, Adaptic, 961 south mile pitas blvd, California, USA).⁶ Follow-up visits were scheduled for 3, 6, 9, and 12 months. There was no base line data directly after the participants received the obturators to

avoid variation between the participants in developing neuromuscular coordination with their prosthesis which may affect retention and stability and consequently bone density. So, the first Digora system evaluation performed 3 months after implant placement and was used as the reference point for longitudinal analysis. Changes in bone density were subsequently evaluated between 3 and 6 months, 3 and 9 months, and 3 and 12 months.

with standardized exposure parameters. Bone density measurements were performed using a standardized lateral apical ROI for each implant. The radiographic evaluator was blinded to the attachment type. Measurements were repeated by the same examiner on two separate occasions to reduce observer error, and the mean values were recorded

Figure 3.



Figure 3. Digora system evaluation of implant distribution and lateral apical region assessment in a completely edentulous hemimaxillectomy patient rehabilitated with implant-supported maxillary obturator

Quantitative data were expressed as mean $\pm$ standard deviation. Intergroup comparisons were performed using an independent t-test. Repeated-measures analysis was used to evaluate changes over time. The level of significance was set at $P < 0.05$. Statistical analysis was performed using SPSS software (version 26, IBM Corp., Armonk, NY, USA).

Results

All patients completed the 12-month follow-up period without dropouts, adverse events, or implant failure. Both attachment groups showed progressive increases in peri-implant bone density values during the follow-up period. Patients reported acceptable function, retention, and comfort with both attachment designs, although

some patients expressed preference for the ball-and-socket attachment.

For Implant 1, the ball-and-socket group showed higher mean bone density values than the magnetic attachment group at all follow-up intervals. At 12

months, the mean value was 670 ± 30 in the ball-and-socket group compared with 610 ± 35 in the magnetic attachment group ($P = 0.015$). The longitudinal changes in bone density for Implant 1 are illustrated in Figure 4.

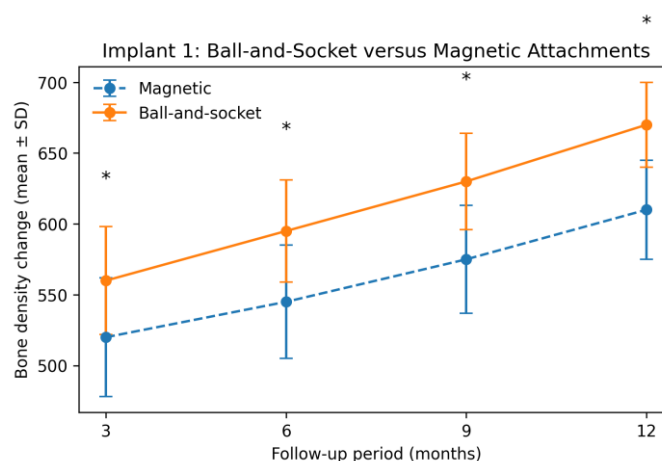


Figure 4: Mean bone density change at the lateral apical region of interest of Implant 1 in magnetic and ball-and-socket attachment groups during the 12-month follow-up. Error bars represent standard deviation. * $P < 0.05$.

For Implant 2, the ball-and-socket group also showed higher mean bone density values at all intervals. At 12 months, the mean value was 660 ± 31 in the ball-and-socket group compared with

600 ± 36 in the magnetic attachment group ($P = 0.018$). The longitudinal changes in bone density for Implant 2 are illustrated in Figure 5.

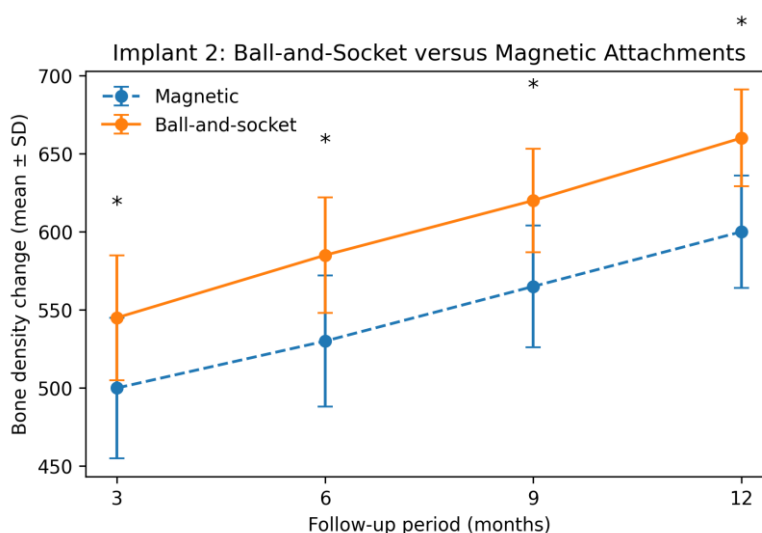


Figure 5: Mean bone density change at the lateral apical region of interest of Implant 2 in magnetic and ball-and-socket attachment groups during the 12-month follow-up. Error bars represent standard deviation. * $P < 0.05$.

For Implant 3, the ball-and-socket group showed higher mean values throughout follow-up. At 12 months, the mean value was 670 ± 28 in the ball-and-socket group compared with 605 ± 34 in the

magnetic attachment group ($P = 0.012$). The longitudinal changes in bone density for Implant 3 are illustrated in Figure 6.

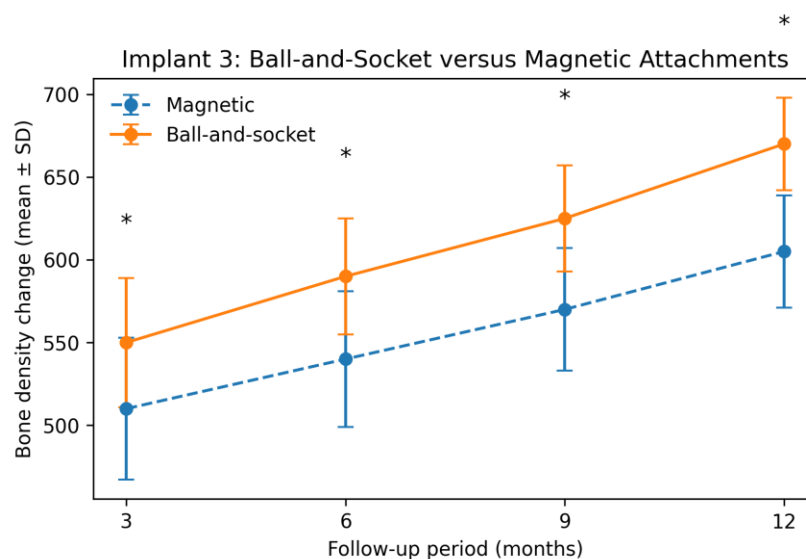


Figure 6: Mean bone density change at the lateral apical region of interest of Implant 3 in magnetic and ball-and-socket attachment groups during the 12-month follow-up. Error bars represent standard deviation. * $P < 0.05$

Discussion

This study evaluated peri-implant bone density changes at the lateral apical ROI in completely edentulous hemimaxillectomy patients rehabilitated with implant-supported obturators using either magnetic or ball-and-socket attachments. Implant-supported obturators can improve retention, stability, and patient satisfaction in maxillectomy patients⁸. Both attachment systems were associated with progressive increases in bone density over the 12-month observation period, suggesting favorable functional adaptation around the implants^{9,10}.

Ball and socket attachment is one of the most popular and affordable stud attachments. The use of a ball shaped abutment on the implant that snaps into a resilient cap (matrix) inside the prosthesis, offering excellent pivot and ease of use¹¹.

The ball-and-socket attachment group demonstrated significantly greater bone density changes than the magnetic attachment group^{12,13}.

This may be related to the biomechanical behavior of ball attachments, which provide mechanical retention and controlled functional loading. Such loading may stimulate bone remodeling around osseointegrated implants¹⁴.

In contrast, magnetic attachments provide mainly vertical retention and may offer less resistance to lateral displacement, potentially resulting in reduced mechanical stimulation of peri-implant bone. Previous biomechanical and clinical investigations have shown that attachment design can influence load transfer and peri-implant response^{15,16}.

The unique biomechanical environment in hemimaxillectomy patients should also be considered. The presence of a unilateral defect leads to altered load distribution and prosthesis instability⁵. In such cases, attachment systems play an important role in compensating for compromised anatomy and supporting prosthesis stability^{17,18}.

When exposure parameters and regions of interest are standardized, the software Digora system will be useful for longitudinal assessment of bone changes⁶. From a clinical perspective, the increased bone density associated with ball-and-socket attachments may contribute to enhanced implant stability and long-term prosthesis success.¹⁹ This is particularly important in maxillary obturator cases, where biomechanical challenges are more pronounced because of compromised anatomy.²⁰

The main limitations of this study include the small sample size and 12-month follow-up period. The study should therefore be a future study with larger sample sizes, longer follow-up periods, and additional clinical outcomes are recommended.

Conclusion

Within the limitations of this exploratory the study, ball-and-socket attachments demonstrated significantly greater improvement in peri-implant bone density than magnetic attachments in implant-supported maxillary obturators. These findings suggest that ball-and-socket attachments may provide a more favorable biomechanical response around implants supporting maxillary obturators.

Ethical Considerations

The study protocol was approved by the Institutional Ethical Committee, Badr University in Cairo (BUC-IACUC-24743-750). Written informed consent was obtained from all participants.

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Conflict of Interest

The author declares no competing interests.

Figure Legends

Figure 1. Ball and socket attachments on implants for group I.

Figure 2. Magnetic attachments on implants for group 2.

Figure 3. Digora system evaluation of implant distribution and lateral apical region assessment in a completely edentulous hemimaxillectomy patient rehabilitated with implant-supported maxillary obturator.

Figure 4. Mean bone density change at the lateral apical region of interest of Implant 1 in magnetic and ball-and-socket attachment groups during the 12-month follow-up. Error bars represent standard deviation. *P < 0.05.

Figure 5. Mean bone density change at the lateral apical region of interest of Implant 2 in magnetic and ball-and-socket attachment groups during the 12-month follow-up. Error bars represent standard deviation. *P < 0.05.

Figure 6. Mean bone density change at the lateral apical region of interest of Implant 3 in magnetic and ball-and-socket attachment groups during the 12-month follow-up. Error bars represent standard deviation. *P < 0.05.

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