Clinical and Radiographic Evaluation of Bar, Telescopic, and Locator Attachments for Implant-Stabilized Overdentures in Patients with Mandibular Atrophied Ridges: A Randomized Controlled Clinical Trial

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Purpose: The aim of this study was to evaluate the clinical and radiographic peri-implant tissues of bar, Locator, and resilient telescopic attachments for two-implant stabilized overdentures in subjects with mandibular atrophied ridges. Materials and Methods: Ninety edentulous individuals with mandibular ridge atrophy were randomly assigned into three equal groups and received two implants in the canine areas. Mandibular overdentures were constructed and attached to implants with Dolder bar attachments (BOD), resilient telescopes (TOD), and Locators (LOD). Plaque scores, gingival scores, pocket depths, implant stability, width of keratinized mucosa, vertical bone loss, and horizontal bone loss were evaluated at the time of prosthesis delivery and 6 months and 12 months after delivery. Results: With the exception of pocket depth and implant stability, all parameters showed a significant increase from prosthesis delivery to 6 months. BOD recorded the highest plaque scores, gingival scores, and pocket depths followed by LOD, and TOD recorded the lowest values. No significant difference in implant stability and keratinized mucosa was observed between groups. TOD and BOD recorded the highest vertical and horizontal bone losses, respectively. LOD recorded the lowest vertical and horizontal bone losses. There was no difference in implant survival rate between groups. Conclusion: Bar, resilient telescopic, and Locator attachments can be used successfully for two-implant stabilized overdentures in subjects with mandibular atrophied ridges after a 1-year follow-up period. Telescopic attachments were associated with improved clinical peri-implant soft tissues compared with other attachments. However, Locator attachments may be advantageous in terms of peri-implant bone preservation. Int J Oral Maxillofac Implants 2018;33:1103–1111. doi: 10.11607/jomi.6363

Keywords: attachment, bar, implant, Locator, overdentures, telescopic

Alveolar ridge resorption hinders the stability and the retention of complete dentures. First, knife-edged ridge occurs and, when resorption continues, the residual ridges become atrophied, resulting in flat surfaces with prominent genial tubercles and sharp mylohyoid crests in the mandible. Den- ture-related problems in patients with mandibular alveolar ridge atrophy can be solved by osseointegrated implants stabilizing overdentures to avoid complications of vestibuloplasty and ridge augmentation.

According to the McGill consensus statement, a two-implant overdenture should become the standard of care of the edentulous mandible. Such a prosthesis can be attached to a variety of anchors, such as bars, ball attachments, magnets, Locators, and telescopic crowns. Bar attachments contribute to load sharing between the implants, and have a lower incidence of prosthetic complications. Telescopic attachments are self-aligning and facilitate overdenture insertion for old patients with serious systemic diseases. The Locator attachments have dual retention and have
different retention values. Moreover, they are resilient, can be used with limited interarch distance, and have some built-in angulation compensation.

The attachment choice should take into consideration the ridge anatomy. Bar and telescopic attachments are indicated with advanced mandibular ridge atrophy to resist horizontal displacement and provide prosthesis stability. Locator attachments also improve prosthesis stabilization, as they have dual retention that comes from internal and external frictional flanges, which provide limited lateral prosthesis movements.

Reviewing the literature, several studies compared clinical outcomes of different attachments for implant overdentures. Other studies evaluated clinical and radiographic outcomes of Locator attachments compared with ball, bar, and magnetic attachments. Additional reports compared peri-implant tissues of telescopic attachments with ball and bar attachments. Zou et al. reported improved peri-implant hygiene parameters with rigid telescopic, bar, and Locator attachments of maxillary overdentures. However, most of these studies have several shortcomings, such as inadequate sample size, unequal group sizes, and short observation period. Moreover, the effect of attachment type on clinical and radiographic outcomes of implants stabilizing mandibular overdentures in patients with atrophied mandibular ridges was not investigated. Accordingly, the aim of this randomized controlled trial was to evaluate the clinical and radiographic peri-implant tissues of bar, Locator, and resilient telescopic attachments for two-implant stabilized mandibular overdentures in subjects with atrophied ridges.

**MATERIALS AND METHODS**

**Participant Selection**

Ninety completely edentulous participants (aged between 45 and 70 years) with retention and stability problems of conventional mandibular dentures were selected. Inclusion criteria were: sufficient bone quantity (classes IV to VI, Cawood and Howell) and good bone quality (classes I to III, Lekholm and Zarb) in the canine areas of the mandible to receive implants of a minimum length of 11 mm and a minimum diameter of 3.7 mm. Exclusion criteria included: diabetes mellitus, osteoporosis, chemotherapy, and smoking habits. Based on the results of a previous study on marginal bone level around three types of attachments for implant-supported overdentures, a sample size of 30 participants/group (anticipated 15% dropouts) was calculated to provide 90% power with alpha level of .05, and an effect size of 0.4 mm (SD = 0.2 mm) in marginal bone loss between groups.

The participants were stratified according to age, sex, number of old dentures, height of mandibular bone, and years of edentulism. Allocation of the participants was performed using a balanced randomization procedure to ensure comparability of baseline criteria (Table 1) between groups before conducting the trial. The participants were assigned into three equal groups: BOD, which included 30 participants who received bar-retained overdentures (Fig 1); TOD, which included 30 participants who received resilient telescopic-retained overdentures (Fig 2); and LOD, which included 30 participants who received Locator-retained overdentures (Fig 3). The guidelines of the Helsinki Declaration for ethics in clinical trials were followed.

**Surgical and Prosthetic Procedures**

For each participant, a tissue-borne stereolithographic surgical template was fabricated using cone beam computed tomography (CBCT) and used for placement of implants. Two implants (TioLogic, Dentaurum) were inserted in canine regions of the mandible by the same oral and maxillofacial surgeon using the non-submerged flapless surgical technique. A minimum 35-Ncm torque was obtained at implant insertion. The healing abutments were screwed to the implants, and the participants’ existing mandibular denture was relieved and relined using a soft liner (Ufigel, Voco). Participants were instructed to eat a soft diet and perform oral hygiene procedures.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Baseline Characteristics of All Groups</th>
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<tbody>
<tr>
<td></td>
<td>BOD</td>
</tr>
<tr>
<td>Age (y) Mean ± SD</td>
<td>59.38 ± 6.89</td>
</tr>
<tr>
<td>Sex (male/female) Frequency</td>
<td>4/2</td>
</tr>
<tr>
<td>Height of mandibular bone (mm) Mean ± SD</td>
<td>26.38 ± 2.00</td>
</tr>
<tr>
<td>Period of mandibular edentulism (y) Mean ± SD</td>
<td>5.13 ± 1.13</td>
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<tr>
<td>No. of previous mandibular dentures Mean ± SD</td>
<td>1.75 ± 0.71</td>
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</table>

BOD = bar overdentures, TOD = telescopic overdentures, LOD = Locator overdentures.
The healing abutments were removed 3 months after implant placement, and the open-tray impression procedure was started. Primary maxillary and mandibular impressions were made, and custom trays were fabricated. The mandibular tray was constructed with two openings above the implants. The trays were border molded, and final impressions were completed using zinc oxide paste. Long transfer copings were screwed to the implants, and light viscosity polyvinyl siloxane impression material was injected around the transfers. The impression copings were secured to the tray using self-cure acrylic resin. The implant analogs were threaded into the transfer copings, and the impression was poured with hard stone dental stone (type IV, Zhermack, Rovigo).

For BOD, a cobalt chromium Dolder bar joint (Resilient bar rematitan, macro, TioLogic, Dentaurum) with titanium clips was used (Fig 1). For TOD, resilient telescopic crowns were fabricated. The precious metal abutments were built up with wax to form inner crowns (6 mm height and 4 mm width), cast with gold alloy, and refined using a milling machine (AMANNGIHRBACH, af 350) (Fig 2). The outer crowns were waxed over the inner crowns and cast with cobalt chromium alloy. A tiny amount of circumferential space (0.3 to 0.5 mm) as well as an occlusal space (0.5 mm) between the primary and secondary crowns was made to provide resiliency and minimize the moments of the implant during load application. Frictional type TC snap (Sitecte, Gevelsberg) was used for retention between the primary and secondary crowns. For LOD, blue nylon male inserts (extra-light retention) were used. For all groups, maxillary and mandibular occlusion rims were constructed and used to register jaw relations. Semi-anatomical acrylic teeth (Vitapan, Vita Zahnfabrik) were arranged into balanced occlusion, and dentures were processed in the usual manner. All participants were instructed in proper oral hygiene.

**Peri-implant Tissue Outcomes**

Clinical and radiographic evaluations of peri-implant tissues were performed after prosthesis delivery (T0), six (T6), and 12 (T12) months after delivery. Plaque scores and gingival scores were evaluated using the Mombelli indices. A graduated plastic probe was used to measure the pocket depth in millimeters. The width of peri-implant keratinized mucosa was measured in millimeters using a graduated plastic probe as the distance between the gingival margin and the mucogingival junction. Implant stability was assessed using resonance frequency analysis. The Osstell device (Integration Diagnostics) expresses the
stability as implant stability quotient. Plaque scores, gingival scores, and pocket depth were measured at the midfacial, midlingual, midmesial, and middistal aspects of each implant.

Digital periapical radiographs were made using a direct digital imaging system (Digora Optime, Orion Corp./Soredex). Standardization of film position was done by fixing the film positioner to the implants using the placement aid of the implants.19,22 The digital images were traced using the accompanying software, and vertical and horizontal bone losses were measured as recommended by Elsyad et al.18,19,21,22 The distance between implant shoulder (A) and bone-to-implant contact (B) was considered vertical bone height (VBH) (Fig 4). The distance between the marginal bone level (C point) (which represents the intersection point of a tangent to the horizontal bone crest [CD line] and another tangent to the crater-shaped defect [CB line]) and the implant perpendicularly indicated horizontal bone height (HBH) in millimeters. VBH and HBH were measured at the mesial and distal aspects of each implant. Vertical and horizontal marginal bone losses were estimated by subtracting VBH and HBH at T6 and T12 from their values at T0.

Clinical and radiographic evaluations were performed by three examiners. Two examiners (E.M.A. and E.E.A.) were trained in the software tool used in this study, familiar with these measurements, and calibrated previously.19 An additional examiner (D.B.A) was added after instructions and calibrations by one examiner (E.M.A.) using the same methodology. Examiner data were collected interpersonally and intrapersonally (three times on the same day).

Statistical Analysis
SPSS software version 18 (SPSS Inc) was used to analyze the data. The α (Cronbach) test was used to test the reliability of data. To detect differences in plaque and gingival scores between observation times, the Friedman test and Wilcoxon signed-rank test were used. Between-group comparisons of these scores were performed using the Kruskal-Wallis test followed by the Mann-Whitney test for pairwise comparisons. Two-way mixed analysis of variance (ANOVA) was used to compare pocket depth, implant stability, width of keratinized mucosa, and vertical and horizontal bone losses between groups and between observation times followed by the Bonferroni test for pairwise comparisons. P values < .05 were considered to be significant.

RESULTS
There was no significant difference in baseline criteria between groups (P > .05, Table 1). The study was conducted according to the “intention to treat principle.” Contact was lost with one patient in the LOD group, and the evaluation could not be completed for him. Another patient in TOD could not attend the follow-up visits because of severe illness. Two implants failed in two patients who belonged to BOD after 3 months of implant loading, and the patients were excluded from the study. Thus, 86 patients (95.5%) completed the study, and four patients (4.5%) dropped out. Kaplan-Meier survival analysis for groups is presented in Fig 5. The flow diagram of participants is presented in Fig 6. The survival rates of the implants were 96.6%, 100%, and 100% for BOD, TOD, and LOD, respectively. No significant difference in implant survival between groups was noted (logrank test, P = .134). Intraclass correlation coefficients for all parameters were > .80.

Clinical Outcomes
Frequency distribution of plaque and gingival scores for groups and time intervals are shown in Figs 7 and 8, respectively. Comparisons of plaque and gingival scores between groups and time intervals are shown in Table 2. Plaque scores significantly increased with time for BOD (P < .001) and LOD (P = .025). For TOD, plaque scores did not significantly change with time (P = .125). There was a significant difference in plaque scores between groups at T6 (P < .001) and T12 (P < .001). BOD was associated with the highest plaque scores, followed by LOD, and TOD showed the lowest plaque scores at T6 and T12 (P < .05, Fig 7). Gingival scores significantly increased with the advance of time for BOD (P < .001), LOD (P = .144), and TOD (P = .002). There was a significant difference in gingival scores between groups at T0 (P < .001) and T6 (P < .001). BOD was associated with the highest gingival scores, followed by LOD, and TOD showed the lowest gingival scores at T0 and T6 (P < .05, Fig 8).
Table 2  Comparison of Plaque Index and Gingival Index Between Observation Times and Groups

<table>
<thead>
<tr>
<th></th>
<th>T0 M(min–max)</th>
<th>T6 M(min–max)</th>
<th>T12 M(min–max)</th>
<th>Freidman</th>
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<tbody>
<tr>
<td><strong>Plaque Index</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>BOD</td>
<td>1.00a (0.00–2.00)</td>
<td>1.00b (0.00–2.00)</td>
<td>1.50c (0.00–3.00)</td>
<td>&lt; .001*</td>
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<tr>
<td>TOD</td>
<td>0.00a (0.00–2.00)</td>
<td>0.00a (0.00–1.00)</td>
<td>1.00a (0.00–2.00)</td>
<td>.125</td>
</tr>
<tr>
<td>LOD</td>
<td>1.00a,b (0.00–2.00)</td>
<td>1.00a,b (0.00–2.00)</td>
<td>1.00b (0.00–2.00)</td>
<td>.025*</td>
</tr>
<tr>
<td>Kruskal-Wallis</td>
<td>.078</td>
<td>&lt; .001*</td>
<td>&lt; .001*</td>
<td></td>
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<tr>
<td><strong>Gingival Index</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOD</td>
<td>1.00a (0.00–2.00)</td>
<td>2.00b (1.00–2.00)</td>
<td>1.00a (0.00–2.00)</td>
<td>&lt; .001*</td>
</tr>
<tr>
<td>TOD</td>
<td>0.00a (0.00–1.00)</td>
<td>0.00a (0.00–1.00)</td>
<td>1.00b (0.00–2.00)</td>
<td>.014</td>
</tr>
<tr>
<td>LOD</td>
<td>0.00a (0.00–1.00)</td>
<td>1.00b (0.00–1.00)</td>
<td>1.00b (0.00–2.00)</td>
<td>.002*</td>
</tr>
<tr>
<td>Kruskal-Wallis</td>
<td>&lt; .001*</td>
<td>&lt; .001*</td>
<td>&lt; .43</td>
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M = median, min = minimum, max = maximum. *P is significant at 5% level. Different letters in the same row indicate a significant difference between each two observation times (P < .05).
Comparisons of pocket depth, implant stability, and width of keratinized mucosa between time intervals and groups are shown in Table 3. The statistical model showed a significant difference in overall pocket depth between observation times ($F(1,45) = 25.07, P < .001$), groups ($F(1,45) = 19.29, P < .001$), and the interaction observation times*groups was also significant ($F(2,45) = 4.75, P = .013$). Pocket depth increased significantly at T6, then decreased again at T12 for all groups ($P < .001$).

There was a significant difference in pocket depth between groups at T6 ($P = .001$) and T12 ($P = .006$). BOD showed the highest pocket depth, followed by LOD, and TOD was associated with the lowest pocket depth at T6 and T12 ($P < .05$). The overall implant stability did not differ significantly between time intervals ($F(1.45) = 1.61, P = .20$), groups ($F(1,45) = 1.78, P = .17$), or the interaction observation times*groups ($F(3,86.1) = 1.15, P = .33$). The model revealed a significant difference in overall width of keratinized mucosa between observation times ($F(1.54,69.61) = 47.36, P < .001$). However, the between-group difference ($F(2,45) = 1.10, P = .34$) and the interaction observation times*groups ($F(2,45) = 1.32, P = .27$) were not significant. Width of keratinized mucosa decreased significantly with time ($P = .005$ and .001 at T6 and T12, respectively).

**Radiographic Outcomes**

Comparisons of vertical and horizontal bone losses between time intervals and groups are shown in Table 3. The model revealed a significant difference in vertical bone loss between observation times ($F(1,45) = 9.10, P = .004$), and groups ($F(2,45) = 21.80, P < .001$). However, the interaction observation times*groups was...
not significant \( (F(2,45) = .72, P = .48) \). Vertical bone loss increased significantly from T6 to T12 for all groups \( (P = .019 \text{ for } \text{BOD}, .016 \text{ for } \text{TOD}, \text{ and } .044 \text{ for } \text{LOD}) \). There was a significant difference in vertical bone loss between groups at T6 and T12 \( (P < .001) \). TOD was associated with the highest vertical bone loss, followed by BOD, and TOD showed the lowest vertical bone loss at T6 and T12 \( (P < .05) \). The model revealed a significant difference in horizontal bone loss between groups \( (F(1,45) = 14.9, P < .001) \). However, no statistically significant difference in horizontal bone loss was noted between time intervals \( (F(1,45) = .31, P = .57) \), and the interaction group*observation time \( (F(2,45) = 1.66, P = .20) \) was also not significant. There was a significant difference in horizontal bone loss between groups at T6 \( (P = .018) \) and T12 \( (P = .008) \). BOD showed the highest horizontal bone loss, followed by TOD, and LOD was associated with the lowest horizontal bone loss at T6 and T12 \( (P < .05) \).

**DISCUSSION**

BOD recorded significantly higher plaque and gingival scores than LOD and TOD. A similar finding was observed in other studies.\(^{25,35}\) However, Zou et al.\(^{28}\) found that plaque and gingival scores did not differ significantly between bar, Locator, and telescopic attachments of maxillary overdentures. The increased plaque and gingival scores with BOD were in agreement with Elsyad et al.\(^{36}\) who attributed the increased plaque to the gaps around the Dolder bar/abutments in the fitting surface of the denture, which provide a hidden area for microflora and plaque to aggregate. The higher plaque accumulation may be attributed to the difficulty of cleaning of the bars and abutments by the patients due to limited access and decreased manual dexterity of old participants. Moreover, the larger surface of the bar morphology compared with Locator and telescopic attachments enhances plaque accumulation.\(^{35}\) The decreased plaque accumulation with Locator and telescopic attachments may be due to the unsplit nature and smooth surface of both attachments, which decrease plaque accumulation and facilitate oral hygiene practice.\(^{26}\) The decreased gingival scores for TOD are in agreement with the findings of Eitner et al.\(^{27}\) who reported that the double crown attachment for implant overdentures provided a tendency for healthier gingival tissues compared with the bar attachments.

In this study, pocket depth increased significantly at T6, then decreased again at T12 for all groups. A similar observation was noted in other investigations\(^{19,22}\) in which the authors attributed the increased pocket depth to the increased peri-implant bone resorption and peri-implant soft tissue enlargement after 6 months, while the decreased pocket depth after 1 year was attributed to gingival recession. The increased pocket depth with BOD may be attributed to the hyperplasia of the gingival tissues in the denture spaces around the bar and abutments. These spaces are necessary to allow rotational freedom of the denture without transmitting forces to the implant during function. The decreased probing depth for TOD was in agreement with Heckmann et al.\(^{11}\) and may be explained by the greater volume of the crown neck.\(^{26}\) However, Krennmaier et al.\(^{35}\) found that pocket depth did not differ between telescopic and milled bar groups after 3 years.

At the beginning of the study, the width of keratinized mucosa for all groups did not exceed 1.5 mm. There are several patients who had no width of keratinized mucosa due to the presence of severely atrophied ridges with thin mobile non-keratinized mucosa in the anterior segment of the mandible. Similarly, Heckmann et al.\(^{11}\) found that 31.9% of the sites investigated did not exhibit keratinized mucosa, and the remaining sites revealed keratinized mucosa with a width of 1 mm or more. Width of keratinized mucosa decreased with time in all groups. This could be explained by the increased marginal bone loss, pocket depth, and gingival recession with the advance of time. At buccal peri-implant sites, the gingival recession is more likely to occur as a result of a stripping pressure from the labial flange of the mandibular denture during insertion and removal. Lin et al.\(^{34}\) stated that a lack of adequate width of keratinized mucosa around implants is associated with more plaque accumulation, tissue inflammation, marginal recession, and attachment loss. The insignificant decrease in implant stability quotient with time for all groups was in agreement with Elsyad et al.\(^{19,22}\) and may represent the reduction in bone-to-implant anchorage due to the remodeling process. The insignificant difference in implant stability between groups could be attributed to the high density of basal in the interforaminal area of the mandible.

The range of vertical and horizontal bone losses for all groups \((0.22 \text{ to } 0.49 \text{ mm})\) after 1 year is lower than the normal range of marginal bone loss reported in the literature, which is 1 mm during the first year.\(^{37}\) The reduced vertical and horizontal bone losses in this study may be attributed to the fact that the implants were inserted in an atrophied mandible with dominance of basal compact bone, which has a reduced liability to bone resorption.\(^{8}\) Also, the implants used in the present study have a platform-switching design, which reduces stresses in the crestal bone region.\(^{8}\) Another explanation may be attributed to the one-stage surgery with early loading protocol employed in this study. This protocol reduces the possibility of bone...
loss that may occur following implant uncovering and abutment connection. However, it should be noted that the vertical bone loss that occurred between implant placement and overdenture insertion was not calculated. For all groups, vertical bone loss was significantly higher at T12 compared with T6. A similar observation was also noted in other studies for canine implants immediately loaded by Locator and magnetic-retained overdentures. The authors attributed the increased vertical bone loss to the prosthesis loading and bone reorganization combined with function stresses.

The increased vertical bone loss with TOD may be attributed to the prominent height of the TOD attachment, which increases the vertical cantilever and micromotions transmitted to the implants. In agreement with this explanation, Heckmann et al found that TOD are subjected to horizontal forces due to forward movement of the mandibular denture under mastication. These forces may be exaggerated in patients with atrophied ridges causing increased moment loads on the implants. Another explanation may be attributed to the apical tight fit between the primary and secondary copings, which increases retention, stability, and maximum occlusal forces of TOD. In contrast, Eitner et al found less vertical bone loss with TOD compared with BOD. The decreased vertical bone loss with LOD compared with other attachments may be explained by resiliency and reduced vertical height of the Locator attachment. The resiliency comes from the nylon inserts, which provide a limit of 1.2 mm movement in the vertical direction and 8 degrees in all directions during function. The reduced vertical height minimizes the stresses produced by the vertical cantilever of the attachment and may be responsible for reducing vertical bone loss. In agreement with this observation, Akça et al found that the mean marginal bone loss in the Locator group was significantly lower than in the ball attachment for early-loaded, one-stage implants retaining mandibular overdentures after 5 years. Also, Elysyad et al found that vertical bone loss did not significantly differ between Locator and magnetic attachments despite varying degrees of lateral freedom provided by each attachment. This finding suggests that LOD may be advantageous in terms of peri-implant bone preservation compared with BOD and TOD. BOD recorded the highest horizontal bone loss, and LOD recorded the lowest. A similar observation was also noted in a previous study in which the author noted an increased horizontal bone loss for bar attachments, especially at the mesial peri-implant site.

The findings of this study are preliminary. Therefore, future clinical trials with a larger number of patients and longer observation period are recommended to evaluate the patient-based outcomes, prosthetic aspects, and masticatory functions with different attachments used to stabilize implant overdentures in patients with mandibular ridge atrophy.

CONCLUSIONS

Within the limitations of this preliminary study, regarding the small sample size and the short follow-up period, it could be concluded that bar, resilient telescopic, and Locator attachments can be used successfully to stabilize implant overdentures in subjects with mandibular ridge atrophy after a 1-year follow-up period. However, resilient telescopic may be advantageous in terms of clinical peri-implant tissue health, and Locator attachments may be advantageous in terms of peri-implant bone preservation.

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The authors reported no conflicts of interest related to this study.

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