Single-Unit Short Implants in the Molar Region: A Retrospective Study with a Minimum 3-Year Follow-up

Eduardo Anitua, MD, DDS, PhD
Javier Flores, DDS
Sofia Fernandez de Retana, PhD
Mohammad Hamdan Alkhraisat, DDS, MSc, PhD, Eu PhD

The high biomechanical loads in molar region wounds challenge the indication for short implants to be used as a single-unit implant. This study reports on the outcomes of single-unit short implants (≤ 8.0 mm) in the maxillary and mandibular molar regions. Forty-nine short implants were placed in 48 patients to replace a missing molar tooth. Two-piece restorations with screw retention were fabricated. During the follow-up, implant survival and marginal bone loss (MBL) were assessed. The known implant length was used as a reference to calibrate the linear measurements on digital periapical radiographs, and descriptive statistical analysis was performed. The implants were followed over a period of 47 ± 12 months. No implant failure was recorded, and no prosthesis failure was observed. The average MBL was 0.15 ± 0.5 mm. The mean crown height space was 13 ± 3 mm. The overall crown-to-implant ratio was 1.7 ± 0.4. Two technical complications occurred due to the loosening of the unit abutment. After screw re-tightening, no more screw loosening was observed. This study supports the use of short implants as a single-unit implant in the maxillary and mandibular molar regions.


Vertical atrophy of the alveolar bone decreases the distance to important anatomical structures (inferior alveolar nerve, maxillary sinus, lingual concavity, and nasal cavity) and may restrict the selection of the implant length. Vertical bone augmentation techniques are needed if the residual height is insufficient to host the implant. These surgical procedures have varied in their degrees of success, cost, waiting time before implant placement, complication rates (intra- and postoperative), and type of bone grafts. It is logical to think that the amount of bone height one needs to gain will vary according to the length of the implant: The shorter the implant, the smaller the amount of bone height needed to gain. Often, using a short implant avoids the need for vertical alveolar bone augmentation altogether.

However, replacing a single missing molar with a screw- or cement-retained restoration is a challenging situation from a biomechanical point of view. Due to the high occlusal forces, the lack of implant splinting, and the absence of a periodontal ligament, short implants will be more vulnerable to eccentric or excessive occlusal loads. This biomechanical risk factor may increase the stress at the bone-implant interface and the risk of technical complications (prosthesis/implant fracture, screw loosening/
fracture, ceramic chipping, etc).  
Moreover, measures should be taken to prevent excessive micromovement of the implants, which may hinder their osseointegration. The stable marginal bone would support the short implants, and it is necessary to adopt several factors to minimize marginal bone loss (MBL).

Several studies have assessed the use of short implants (≤ 8 mm in length) to support single-crown restorations. The outcomes of these studies support the indication of short implants to replace single missing teeth in the posterior region. However, the evidence coming from randomized controlled trials (RCTs) is bi-directional. Two RCTs with a follow-up time of 3 years concluded that 6-mm–long implants functioned as well as standard-length implants regarding MBL and survival rates. Another two RCTs with a follow-up time of 5 years reported more implant loss in the short-implant group than the standard-length–implant group. Brignardello-Petersen indicated that the study by Naenni et al has several limitations, including: more participants with a history of periodontitis and periodontal pocketing were assigned to the short-implant (6.0 mm) group, an uneven proportion of patients lost to follow-up, the bone augmentation hosted 10-mm–long implants, and the sample size calculation was performed to detect marginal bone level differences but not survival differences. In the study by Rossi et al, four 6.0-mm–long implants failed, and one 10.0-mm–long implant failed.

However, one of the 6.0-mm implant failures occurred during healing (not loading), and there was no statistical analysis of the data.

Nevertheless, these outcomes indicate the need for more evidence and long-term follow-ups to support the use of short implants as a single-unit implant.

Thus, the purpose of this retrospective clinical study is to assess the survival and MBL of single-unit short implants (≤ 8 mm long) in the maxillary and mandibular molar regions. The null hypothesis was that the use of short implants to restore a single missing molar will not negatively affect the implant survival nor the MBL.

Materials and Methods

Manuscript preparation was performed following the STROBE (The Strengthening the Reporting of Observational Studies in Epidemiological) guidelines. This a retrospective clinical study on short implants used to replace single missing teeth in the posterior region of the maxilla and mandible. This clinical research was conducted following the Declaration of Helsinki regarding investigations with human subjects. Patient recruitment and treatment were performed in a single clinical center. The cases were selected from a previously published cohort of single-unit implants, and the data were updated in the current research.

Patients who met all the following selection criteria were eligible to participate in the study. The inclusion criteria were as follows: (1) aged ≥ 18 years; (2) were treated at least with a one single-unit short implant (length ≤ 8 mm); (3) having a minimum follow-up time of 3 years since implant insertion; (4) implant restoration with a screw-retained crown; and (5) implant placement in the molar region of either the maxilla or the mandible. Patients were excluded from the study if their implants were unloaded.

Study Variables

Main variable

The survival of the short implants was the main variable of efficacy. Survival was defined by the implant presence in the mouth at the time of evaluation.

Secondary variables of efficacy

The secondary variables included MBL, prosthesis survival, and technical complications.

For MBL, the change in the most coronal position of the alveolar bone with respect to its position at the time of implant loading was evaluated. The first bone-to-implant contact was measured mesially and distally in digital radiographs (1:1) calibrated by the known implant length. The most coronal position of the alveolar bone was measured by calculating the distance between the top of the implant shoulder and the first visible bone-to-implant contact on a digital radiograph (Si-dexis XG, Dentsply Sirona).

Prosthesis survival was defined by the presence of the first definitive prosthesis in the mouth at the time of evaluation.
For technical complications, the occurrence of events related to the prosthesis were recorded, such as crown detachment, chipping, screw loosening/fracture, and prosthesis fracture.

Surgical variables
The surgical variables included implant location, date of implant insertion, insertion torque, date of implant loading, prosthesis type, and the length and diameter of implants.

Implant Placement

The surgical procedure to place the implants was previously reported and was performed by the same surgeon (E.A.). Briefly, implant site ostotomies were performed at a low speed (125 rpm) without irrigation.29 Just before implant insertion, the implant site was irrigated with plasma-rich growth factors (Endoret, BTI Biotechnology Institute).30 The prosthetic rehabilitations are described elsewhere, performed by a different clinician.28 Briefly, a transepithelial abutment (Unit abutment, BTI Biotechnology Institute) was connected to the implant at 30 Ncm. At least 4 months after implant insertion, an impression coping of the abutment was connected for impression-making with the open-tray technique and a polyether impression material (Impregum Penta, 3M ESPE). The crown was cemented to a metallic interface, and the whole assembly was screwed to the abutment at a torque of 20 Ncm. The screw access hole was filled with PTFE (polytetrafluoroethylene) and then closed with composite resin (Tetric EvoCeram, Ivoclar Vivadent). Occlusal adjustment was performed to permit a mutually protected articulation concept.

During the follow-up, the implant-supported prostheses were clinically and radiographically evaluated.

Statistical Analysis
Descriptive statistics were carried out to calculate mean, standard deviation, and range of quantitative variables. Frequency analysis was calculated for qualitative variables. Qualitative variables were compared by chi-square test. Normal distribution was assessed by Shapiro-Wilk test. Quantitative variables were compared by Student t test. SPSS (version 15.0 for Windows, IBM) was used for statistical analysis.

Results
A total of 49 short implants were placed in 48 patients. All implants were inserted to replace a single missing molar tooth in the maxilla or mandible (Fig 1). Eight implants were placed in the second molar position, and 41 were placed in the first molar position. The implant lengths were 6.5 mm (16 implants) and 7.5 mm (33 implants). There were no statistically significant differences in implant length depending on the anatomical position (P = .228). Implant diameters ranged between 3.5 and 6.0 mm (Fig 2), with a mean diameter of 4.7 ± 0.7 mm. The implants were placed with an insertion torque of 43 ± 15 Ncm. With respect to anatomical variables, 17 implants (11 with a length of 6.5 mm) were placed in the maxilla and 32 implants (27 with a length of 7.5 mm) were placed in the mandible. The most frequent bone types were type III in the maxilla and type II in the mandible.

The follow-up period was 47 ± 12 months after implant surgery (Table 1). No implant failure was recorded. The mesial MBL was
0.09 ± 0.52 mm, the distal MBL was 0.21 ± 0.60 mm, and the average MBL was 0.15 ± 0.5 mm (Table 1). In all, 26.3% of implants replaced a terminal tooth. There were no statistical differences regarding MBL between implants at terminal and nonterminal sites (P = .726). Figure 3 shows a case that was treated according to the described method.

Prosthodontically, all implants received delayed loading. The height of the abutment ranged between 2 and 4 mm (mean: 2.8 ± 0.6 mm). No soft tissue augmentation was performed. The crown height space (the distance between the alveolar bone crest and the occlusal plane) was 13 ± 3 mm. The overall crown-to-implant ratio (CIR) was 1.7 ± 0.4. The CIR was 1.6 ± 0.4 and 1.9 ± 0.3 for 7.5-mm and 6.5-mm implants, respectively. No prosthesis failure was observed. Two technical complications occurred due to abutment loosening. After screw re-tightening (at a torque recommended by the manufacturer), no more screw loosening was observed (Table 1).

Table 1 Evolution of Mean Outcome Variables Between Two Follow-ups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Follow-up 1</th>
<th>Follow-up 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implant failures, n</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MBL, mm</td>
<td>0.13 ± 0.5</td>
<td>0.15 ± 0.5</td>
</tr>
<tr>
<td>Prosthesis failures, n</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Technical complications, n</td>
<td>2 (screw loosening)</td>
<td>No new events</td>
</tr>
<tr>
<td>Follow-up time, mo</td>
<td>22 ± 12</td>
<td>47 ± 12</td>
</tr>
</tbody>
</table>

MBL = marginal bone loss.

aData are from a previously published study.28

Discussion

Several studies have assessed short implants (≤ 8 mm) for supporting single-crown restorations.20–23 The outcomes of those studies are in agreement with the findings of the present study, and all support the indication for short implants to replace single missing teeth in the posterior region. However, two randomized clinical trials that observed the 5-year outcomes reported more failures for short implants.25,26 Thus, there is a need for more studies with long-term follow-ups to confirm the use of short implants as a single-tooth implant in the molar region and to discover factors (if any) that may negatively affect their success.

Implant site preparation was performed via low-speed bone drilling without irrigation. This type of osteotomy preparation has been shown not to increase the bone temperature above 40ºC, eliminating the risk of bone necrosis and osseointegration failure.29,31–35 It also allows for harvesting of autogenous material for bone irrigation without the need for filters. Significantly more micro-organisms have been found in the bone harvested with filters (high-speed drilling) compared to bone harvested by low-speed drilling.33 Because this method does not use irrigation, it prevents growth factors and proteins from being washed out of the autogenous material.31 Several studies have shown that the autogenous material harvested by low-speed drilling without irrigation is a valuable source of stem
cells for dentoalveolar bone tissue reconstruction.\textsuperscript{32,34,35}

The current trend in implant dentistry favors screw-retained prostheses, as they are retrievable, do not need intraoral cementation, and require less interocclusal space.\textsuperscript{4,6} It is for this reason that the present study assessed short implants restored with a screw-retained crown. The present outcomes indicate good behavior (implant survival and MBL) of short implants replacing a single molar tooth. These outcomes could be related to several factors that would prevent implant failure and excessive MBL.

From a prosthodontic point of view, the screw-retained restoration in the present study is comprised of two pieces. The two-piece restoration may offer a flexibility to the assembly that may increase its capacity to withstand occlusal loads. Indeed, the estimated failure and technical complication rates have been higher for one-piece restorations than two-piece restorations.\textsuperscript{5} Moreover, the crown height space in the present study was < 15 mm, which may decrease the risk of excessive implant loading and MBL. The crown height space is an anatomical parameter that is defined as the distance that exists between the occlusal plane and the crestal bone. Biomechanically, a crown height space > 15 mm is regarded as unfavorable and results in higher stress concentration at the bone-implant contact.\textsuperscript{12,13} In a previous clinical study, the average crown height space was 17 mm for implants with < 2 mm of bone loss and was 21 mm for implants with ≥ 2 mm of bone loss.\textsuperscript{9}

The CIR in the present study was 1.7 ± 0.4. Recent data from a meta-analysis indicate that the CIR of single-tooth and nonsplinted implants did not increase the occurrence of biologic or technical adverse events.\textsuperscript{11} Guljé et al found that a high CIR (2.14 ± 0.42) for 6-mm single-unit implants was not associated with MBL or technical complications.\textsuperscript{10} These results propose that crown height space has higher importance regarding MBL and technical complications than the CIR.

Surgically, most of the implants in the present study were placed in type II and type III bone, achieving

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig3.png}
\caption{(a) Radiographic view of a short implant that was placed in the maxillary left side to replace a first molar. (b) Periapical radiographic view of an implant and the peri-implant bone at the insertion of the definitive prosthesis and (c) at the 5-year follow-up.}
\end{figure}
a mean insertion torque > 30 Ncm. The high insertion torque, the moderately-rough implant surface, and the threaded implant design prevent excessive implant micromovements that may hinder their osseo-integration.14–16

Several measures were taken to increase the stability of peri-implant marginal bone. The one-abutment one-time concept was implemented to avoid the repeated connection/disconnection of the abutment and to favor marginal bone stability.17 Moreover, the height of the definitive abutment was ≥ 2 mm. One study recently reported that a minimum MBL could be expected when the abutment height is 2 mm.18 The abutment height would indicate the presence of thick gingival tissue and the possibility of establishing the biologic width around the implant without bone loss.

Moreover, quality sealing at the implant-abutment interface would enhance the stability of peri-implant marginal bone. A good seal at this level would reduce the consequences (tissue inflammation and MBL) of microbial infiltration and the chances of excessive stress accumulation at the bone-implant interface.17–19

The main limitations of this study are the sample size and the retrospective design. Further, measuring the MBL in standardized periapical radiographs would result in more accurate data. Prospective controlled clinical studies with long-term follow-ups are needed to confirm the use of short, single-tooth implants in the molar regions and to discover factors (if any) that may negatively affect their success.

Conclusions

Using short implants (≤ 8 mm) to restore a single missing molar in the maxilla or mandible rendered good clinical outcomes. No implant failure was observed, and a stable marginal bone level could be observed. The use of two-piece, screw-retained restorations were not associated with high rates of biologic or technical complications.

Acknowledgments

Dr Anitua is the Scientific Director of BTI Biotechnology Institute (Vitoria, Spain) and is the head of Eduardo Anitua Foundation, Vitoria, Spain. Dr Fernandez de Retana and Dr Alkhraisat are researchers at BTI Biotechnology Institute (Vitoria, Spain). Dr Flores declares no conflicts of interest.

References


27. Brignardello-Petersen R. 6-millimeter implants seem to have lower survival than 10-mm implants with or without bone augmentation after 5 years when single posterior missing teeth are replaced. J Am Dent Assoc 2018;149:e145.


