Assessment of Short Dental Implants Restored With Single-Unit Nonsplinted Restorations

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Although dental implants have been shown to be a beneficial and predictable treatment modality for the long-term restoration of missing teeth, anatomic restrictions can often complicate implant placement. Procedures such as sinus augmentation, guided bone regeneration, distraction osteogenesis, inferior alveolar nerve repositioning, and alveolar osteotomies have been used to address anatomic limitations that would otherwise limit or prevent implant placement. These procedures, however, increase treatment time, carry risks of surgical morbidity, and have varying degrees of success.

In selected cases, short dental implants (<10 mm in length) have been suggested as an alternative to bone regeneration because of their ability to osseointegrate in a limited volume of residual bone without the need for additional grafting procedures, but early studies showed that shorter implants had statistically lower survival rates than longer implants, particularly when placed in the maxillary jaw. However, with modern, rough-surfaced implants, survival rates of short implants are comparable with those of longer ones. Furthermore, it has been shown that improvements on existing rough surface technologies can increase implant stability and Implant Stability Quotient values and decrease the marginal bone loss. Nonetheless, reports on the success of short dental implants restored with a single unit are limited to 1 implant system (Straumann SLA implants, Basel, Switzerland) in the posterior maxillary and mandibular regions and only 1 study reported on the survival of 40 short implants over a 2-year period. Moreover, it was not clear whether these studies used bone grafting or used nonsplinted restorative protocols.

The main objective of this study was to report on the survival of short (<9 mm) dental implants restored with single-unit, nonsplinted restorations in the maxillary and mandibular regions. The secondary objective was to assess the effect of bone augmentation on the survival of short implants.

Null Hypotheses
This study had 2 null hypotheses. (1) H01: Bone augmentation has no

Objectives: To investigate the survival rate of short (≤9 mm) implants restored with single-unit, nonsplinted crowns after an average follow-up of 37 months (21–94 months).

Materials and Methods: Two hundred and twenty-one implants were placed in 168 patients (74 men, 94 women, aged 34–87 years, mean = 61 years). Implant lengths were 6 (n = 16), 8 (n = 166), 8.5 (n = 2), or 9 mm (n = 34). The implant diameters ranged from 3.7 to 5.6 mm. Implants were placed in the maxillary (n = 44) and mandibular arches (n = 176).

Results: Survival rate was 94.1% (maxilla [88.6%] and mandible [96.0%]) and 12 early failures (first 4 months) and 1 late failure (4.5 years in the maxillary molar region) observed. Of the 12 early failures, 4 were in the maxilla (2 premolars and 2 molars) and 8 in the mandible (2 premolars and 6 molars). The early failures were 11 implants of 8 mm long and a 9-mm implant. Smoking cigarettes, diabetes mellitus, and bone augmentation procedures were not associated with implant failure significantly (P > 0.05).

Conclusions: Survival rate of short implants restored with single-unit, nonsplinted restorations over an average period of 37 months was favorable and comparable with longer implants. (Implant Dent 2013;22:499–502)

Key Words: short implants, implant survival, implant failures
Table 1. Distribution of Short Implants Used in This Study

<table>
<thead>
<tr>
<th>Implants Used</th>
<th>Straumann</th>
<th>Astra</th>
<th>Zimmer</th>
<th>3i</th>
<th>BioHorizons</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>163</td>
<td>41</td>
<td>14</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Materials and Methods

This retrospective study investigated the long-term survival of short dental implants (≤9 mm) placed by a single operator in private practice, between March 2004 and March 2010. The inclusion criteria were patients who had short dental implants (≤9 mm) placed and restored with single-unit, nonsplinted restorations and had follow-up records. Exclusion criteria included patients who had implants with lengths longer than 9 mm placed, restorations that were multiunit or splinted, and/or who failed to follow-up after treatment. Table 1 shows the distribution of implants used in this study. In all cases, implants were placed in a location and orientation such that they would be axially loaded when restored.

Variables recorded included implant success, implant manufacturer, diameter, length, whether perimplant bone augmentation procedures were included in the procedure, and whether each patient had a diagnosis of diabetes mellitus or reported smoking cigarettes. Criteria for implant survival were defined as the ability to support a functional restoration and the absence of pain, mobility, infection, or radiographical lesions (ie, pathologic findings). Conversely, a failed implant was one that exhibited pain, lack of mobility, infection, or the presence of radiological lesions. All failed implants were removed from the patient. Overall, 221 short implants were placed in 168 patients (74 men, 94 women, aged 34–87 years [mean = 61 years]). Implant lengths were 6 (n = 16), 8 (n = 166), 8.5 (n = 2), or 9 mm (n = 34); the implant diameters ranged from 3.7 to 5.6 mm. Implants were placed in the anterior (n = 6) and posterior regions of maxillary (n = 38, 11 premolar and 27 molar regions) and mandibular arches (n = 176, 34 premolar and 142 molar regions). Follow-up ranged from 21 to 94 months (mean = 37 months). All implants placed were restored with single-unit, nonsplinted restorations.

Results

When reviewing records, 13 patients admitted to smoking cigarettes, 18 had diabetes mellitus, and 114 implants had simultaneous bone augmentation procedures (10 sinus lifts and 104 bone augmentation procedures). The $\chi^2$ test did not show a significant association between short implant’s survival and variables such as smoking cigarettes, diabetes mellitus, and bone augmentation procedures ($P > 0.05$) (Table 2). Therefore, the first null hypothesis for this study was not rejected. By using descriptive statistics (n, %), 9 Straumann (4.8 × 8 mm, n = 8; 4.1 × 8 mm, n = 1), 2 Astra (4 × 8 mm, n = 1; 5 × 9 mm, n = 1), 19 BioHorizons (4.7 × 8 mm) failed (n = 13), corresponding to a 94.1% cumulative survival rate. By jaw, implant survival rates were 88.6% (39/44) for maxillary and 96.0% (169/176) for mandibular implants; the second hypothesis was not rejected as well. Time of implant failure was before restoration and/or within the first 4 months of placement (early, n = 12), but there was 1 late failure (4.8 × 8 mm) in a male patient 4.5 years after restoration. This subject had an osteotomy sinus lift and a diagnosis of periimplantitis. Of the 12 early failures, 4 were in the maxilla (2 premolars and 2 molars), and 8 were in the mandible (2 premolars and 6 molars).

The early failures were 11 implants of 8 mm long (implant diameters were 4, 4.1, 4.7, and 4.8 mm) and a 5- × 9-mm implant. Of those patients with failure, 1 had diabetes, 4 had onlay grafts, but no one smoked. The only late failure was an implant placed in the maxillary first molar region. Subsequently, 6 of the 12 failed implants were replaced, and all replaced implants were successful.

Discussion

Various definitions have been used to describe a short implant. These include an implant length of less than 11 mm,24,25 10 mm,24,26 or 8 mm.16,24 A more precise definition would be an implant with a designed intrabony length of 8 mm or less.16,19 For this study, the author’s definition of a short implant was one with a length less than or equal to 9 mm. Currently, the minimum required implant length below which implant survival is compromised is not known; however, previous studies reported that implants as short as 6 mm could have a survival rate comparable with longer length implants.15–24

As previously noted, the survival rates of short implants in this and other studies may be related, in part, to the use of textured implant surface modification such as moderately rough surfaces (SLActive Starummann), which have been reported to support osseointegration more reliably than machined (turned) surfaces.22,27–32 Furthermore, the observation that the majority of stresses on a loaded implant is absorbed into the crestal bone at the first few threads, regardless of implant length, may also

Table 2. Analysis of the Association Between Diabetes, Augmentation Procedures, Smoking, and the Survival of Short Implants

<table>
<thead>
<tr>
<th></th>
<th>No</th>
<th>Yes</th>
<th>Total</th>
<th>$\chi^2$, P</th>
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<tr>
<td>Diabetes</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>11</td>
<td>203</td>
<td>0.32</td>
</tr>
<tr>
<td>Yes</td>
<td>16</td>
<td>2</td>
<td>18</td>
<td>—</td>
</tr>
<tr>
<td>Augmentation procedures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>99</td>
<td>8</td>
<td>107</td>
<td>0.40</td>
</tr>
<tr>
<td>Yes</td>
<td>109</td>
<td>5</td>
<td>114</td>
<td>—</td>
</tr>
<tr>
<td>Smoking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>196</td>
<td>12</td>
<td>208</td>
<td>0.77</td>
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<tr>
<td>Yes</td>
<td>12</td>
<td>1</td>
<td>13</td>
<td>—</td>
</tr>
<tr>
<td>Total</td>
<td>208</td>
<td>13</td>
<td>221</td>
<td>—</td>
</tr>
</tbody>
</table>

It seems that none of these variables were significantly associated with the survival of short implants used in this study ($P > 0.05$).
be a factor for the survival of short dental implants. Pierrisnard et al. studied stress analysis around dental implants of the same width (3.75 mm) and different lengths (10, 8, and 6 mm), using finite-element analysis with a 3-dimensional linear elastic model. It was shown that peak stress was located in the first groove of the first thread and that, in areas apical to the first 3 cervical millimeters, the stress intensity was low. This is significant to the current study in that any variation in length of implant in softer cancellous bone has little influence on bone stress. This mirrors the work done by Meijer et al, who studied the stress distribution around implants and showed there was a stress peak in the cervical portion of the implant. Hedén also showed a higher level of stress in cortical bone around the neck of the implant. For achieving equitave stress distribution around short implants, occlusal scheme is an important consideration. Although stress studies have shown that increased implant length has little effect on periimplant bone stress, it has also been shown that lateral forces place much more stress on bone than vertical load and should be avoided, especially when considering the limited bone-implant interface that is achievable with short implants. It is, therefore, advisable to place short implants in a location and orientation such that they will be axially loaded when restored, which was done in this study. However, the magnitude and the duration of the stress distributed on the implant-supported single crown is relatively small; most short implants are placed in the posterior region with axial loading force on the prosthesis, which is less damaging to the bone-implant surface.

Research on splinting has shown both advantages and potential disadvantages to implant splinting. In this study, only nonsplinted implants were selected to eliminate the variable of splinting. The reasons that the restoring clinician did not splint these implants were primarily the lack of an adjacent implant abutment to help support the prosthesis and to facilitate hygiene around the implant by the patient.

This study had several limitations. First, although the present survival/failure criteria had been previously reported in the dental literature, it lacked important information on changes in the crestal bone levels. Second, long-term (≥5 years) outcomes were missing from this study, which only followed up patients for an average of 3 years. Third, the effects of other variables on implant survival, such as differences in implant micro/macro-architecture or surface treatments, were not evaluated. More research is needed to address these unanswered questions.

**CONCLUSIONS**

This study showed a high success rate of short implants restored with single-unit, nonsplinted restorations. These findings suggest that, in situations where short implants failed, it was most likely to occur during the first 4 months of implant functioning; if the implants did survive 4 months, their survival prognosis for up to 3 years was excellent.

**DISCLOSURE**

The authors claim to have no financial interest, either directly or indirectly, in the products or information listed in the article.

**REFERENCES**

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