Use of 6-mm Short Implants in Japanese Patients:
Clinical, Radiologic, and Patient Satisfaction Results in a
Retrospective Study with a 2-Year Follow-up

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Implant therapy for tooth loss in the molar region is challenging due to the anatomical limitations, requiring bone augmentation procedures that are associated with high surgical complexity and long postsurgical recovery. Recently, many studies have demonstrated the usefulness of short implants. However, few studies have been performed in Japanese patients to evaluate peri-implant bone changes, changes in peri-implant epithelial tissue, and patient satisfaction. The present study included 16 patients (5 men, 11 women; mean age: 60 years) who received 26 short (6-mm) implants. Changes in peri-implant bone and epithelial tissue were measured radiographically at superstructure loading and after 2 years. Peri-implant pocket probing depth was measured at the epithelial tissue and compared at both time points. Patient satisfaction was graded using the Oral Health Impact Profile (OHIP-14) before treatment and at follow-up. The mean mesial and distal bone levels were −0.05 mm and 0.37 mm at loading, respectively, and were 0.33 mm and 0.53 mm after 2 years, respectively. Significant peri-implant bone formation for mesial and distal bone levels at both time points were determined by Wilcoxon signed-rank test. Mean probing depth increased slightly, from 3.03 mm at loading to 3.33 mm after 2 years, but no significant difference was found. The OHIP-14 found that patient satisfaction levels increased after 2 years. Using 6-mm short implants in sites with insufficient bone levels can be a highly beneficial treatment option for patients, as it avoids the need for bone augmentation. However, more long-term and detailed studies on the clinical outcomes for these implants are required. Int J Periodontics Restorative Dent 2022;42:205–213. doi: 10.11607/prd.5086

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environment, as well as the bone quality of the implant site and the loading method.

Materials and Methods

Patients were included if they met the following inclusion criteria: had good oral health, good general condition, and a sufficient bone supply; and required two-stage implant surgery and titanium-based abutments. Patients were excluded if they met any of the following criteria: had a notable medical history, a smoking habit, diabetes, or cancer; were immunosuppressed; had psychologic disorders, osteoradionecrosis; lacked a sufficient amount of bone for short implants; were undergoing orthodontic treatment; or had periodontitis. Informed consent was obtained from all patients taking part in the study. The patients were treated by one oral surgeon (K.T.) at a private Japanese dental

Fig 1 (a) Minimally invasive procedures have been advocated in recent years, including the placement of short implants. (b) Surgical insertion of a short, 6-mm implant in the maxillary molar area and (c) the radiographic view at 2 years. (d) Surgical insertion of a short, 6-mm implant in the mandibular molar area and (e) the radiographic view after 2 years.
Ten implants were placed in the maxilla and 16 in the mandible. All were inserted into mature bone, and none were accompanied by bone augmentation.

Before the procedure, maxilla anatomy and bone quality were examined through computed tomography (CT; AUGE Solio Z, ASAHI Roentgen) to determine the appropriate plan for implant placement (Fig 2 and Appendix Fig 1, available in the online version of this article at quintpub.com/journals). All implants used for the procedure were 6 mm long and a width that allowed for 1 mm or more of the surrounding bone to be retained after implant placement. Simulation software (Simplant, Dentsply Sirona) converted panoramic radiographs and CT data into useful guides for establishing bone levels and bone quality prior to surgery. The research protocol, including drilling protocol, impression methods, and superstructure wearing, is shown in Fig 3. All prosthetic constructions were in B contact in centric occlusion. During lateral excursion, occlusal contacts on constructions were avoided whenever possible.

After the superstructure was loaded, maintenance was performed twice per year. The peri-implant bone level was measured for the peri-implant tissue. Management and evaluation of clinical test data were performed independently by a single examiner (H.T.) who was not responsible for patient treatment (Fig 3).

For peri-implant bone changes, periapical radiographs were taken using an x-ray holder (Hanshin) following the parallel method, then loaded onto a computer, and bone change was calculated using ImageJ version 1.37 (National Institutes of Health). To accurately calculate peri-implant bone change, bone levels were initially measured by establishing a measurable scale: the known thread distance and implant length (Fig 4).
Regarding changes in peri-implant bone levels at loading and at the 2-year follow-up, Wilcoxon signed-rank test was performed for site and bone quality, final drilling, insertion torque, loading method, and environment surrounding the implant (implants, natural teeth, tooth loss). To evaluate peri-implant tissue, the pocket probing depth was measured using a standard periodontal probe and compared on a four-point scale at loading and at the 2-year follow-up.

Patient satisfaction was measured using Oral Health Impact Profile (OHIP-14) as described by Pommer, and Wilcoxon signed-rank test was conducted.

Statistical analyses were performed using the bell curve for Excel (version 2.00, Social Survey Research Information). Differences of changes in peri-implant bone levels

Fig 3 Research protocol for the present study, including drilling protocol, impression methods, and superstructure wearing. After the superstructure was loaded, maintenance was performed twice per year. Peri-implant bone level was measured using periapical radiographs, and the pocket probing depth was measured for peri-implant tissues.
Results

A total of 26 short, 6-mm implants (10 in the maxilla, 16 in the mandible) were placed in sixteen patients (5 men, 11 women). The mean patient age was 60.0 ± 9.9 years (range: 44 to 79 years).

Three implants were placed in type I bone (all in the mandible), 8 implants in type II (1 in the maxilla, 7 in the mandible), and 15 implants in type III (9 in the maxilla, 6 in the mandible). Osteotomy was performed following the drilling protocol according to bone quality (Appendix Fig 1a). Mean insertion torques for the maxilla were 25.5 Ncm for protocol A (4 implants), 28.6 Ncm for protocol A-V (5 implants), and 31.0 Ncm for protocol B-V (1 implant). For the mandible, mean torque values were 41.0 Ncm for protocol B-V (2 implants) and 38 Ncm for protocol B-X (14 implants). Mean insertion torque values for the 26 implants were 34.2 ± 8.1 Ncm (range: 20 to 45 Ncm). None of the implants failed between loading and the 2-year follow-up. Peri-implant bone levels calculated from periapical radiographs are as follows: At loading, mesial bone levels were 0.05 ± 0.62 mm (–1.33 to 1.73 mm) and distal bone levels were 0.37 ± 0.74 mm (–0.63 to 2.26 mm). At the 2-year follow-up, mesial bone levels were 0.33 ± 0.65 mm (–0.96 to 1.52 mm) and distal bone levels were 0.53 ± 0.63 mm (–0.5 to 2.23 mm). The difference between superstructure delivery and the 2-year follow-up was 0.38 ± 0.49 mm.
After 2 years, peri-implant bone levels were compared between patients with an insertion torque < 35 Ncm and patients with an insertion torque ≥ 35 Ncm. For the < 35 Ncm group (n = 10 implants), the mesial bone level change was 0.38 ± 0.39 mm (–0.25 to 1.12 mm), with a negative value measured for one implant, and the distal bone level change was 0.07 ± 0.4 mm (–0.98 to 0.84 mm), with negative changes for 2 implants. For the ≥ 35 Ncm group (n = 16 implants), the mesial bone level change was 0.39 ± 0.57 mm (–0.06 to 1.88 mm), with negative changes for 3 implants, and the distal bone level change was 0.29 ± 0.44 mm (–0.61 to 0.61 mm), with negative changes for 2 implants. Mean levels for both groups showed a tendency for bone formation in the surrounding area, but no statistically significant difference was found (Wilcoxon signed-rank test).

Environments adjacent to the 26 short, 6-mm implants included 17 adjacent implants, 9 natural teeth, and 26 absents (without any of these). On the mesial side, 11 were implants, 8 were natural teeth, and 7 were absent. On the distal side, 6 were implants, 1 was natural teeth, and 19 were absent. Peri-implant bone level changes were compared on the mesial side for adjacent implants (Fig 5a), natural teeth (Fig 5b), and absents (Fig 5c), and a statistically significant difference was found where implants and natural teeth were the adjacent conditions (P < .05, Wilcoxon signed-rank test; Table 1 and Appendix Fig 3).

The mean patient satisfaction before the procedure was an OHIP-14 score of 30.44 ± 14.18 (16 to 36). After 2 years, mean scores were 3.75 ± 2.57 (0 to 13) (Appendix Table 1).

Table 1 Changes in Peri-Implant Bone Level on the Mesial Side for Adjacent Natural Teeth, Implants, and Absents

<table>
<thead>
<tr>
<th>Adjacent mesial situation</th>
<th>Time point</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Superstructure delivery</td>
<td></td>
<td>2 y</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean ± SD</td>
<td>Range</td>
<td>Mean ± SD</td>
<td>Range</td>
</tr>
<tr>
<td>Natural teeth</td>
<td></td>
<td>–0.13 ± 0.63 mm</td>
<td>–1.22 to 0.79 mm</td>
<td>0.22 ± 0.63 mm</td>
<td>–0.96 to 0.95 mm</td>
</tr>
<tr>
<td>Implants</td>
<td></td>
<td>–0.03 ± 0.38 mm</td>
<td>–0.74 to 0.33 mm</td>
<td>0.36 ± 0.56 mm</td>
<td>–0.55 to 1.52 mm</td>
</tr>
<tr>
<td>Absent</td>
<td></td>
<td>0.03 ± 0.88 mm</td>
<td>–0.75 to 1.73 mm</td>
<td>0.48 ± 0.83 mm</td>
<td>–0.65 to 1.48 mm</td>
</tr>
</tbody>
</table>

A statistically significant difference was found where implants and natural teeth were the adjacent conditions.
Discussion

Due to anatomical constraints of the maxillary sinus and the mandibular canal, implant placement in the molar area often suffers from insufficient bone levels and requires bone augmentation procedures. However, with an aging patient population, an increasingly high number of patients have systemic diseases and require minimally invasive treatment. A solution for this problem is the placement of short implants.

The crown-implant ratio for short implants has been open to discussion. Okada et al concluded in an animal study that an increased crown-implant ratio may not be a risk factor for implant failure. More over, Pierrisnard et al performed a mechanical analysis study using the finite element method, reporting survival rates of 95.8% over 2 years, and Goené et al reported survival rates of 94.6% over 2 years, and Goené et al over 3 years. The present results agreed with each of these.

For the 6-mm short implants in the present study, the mesiodistal bone height was measured and compared in relation to peri-implant bone stability after superstructure loading. Examining changes in peri-implant bone showed that the bone-implant junction moved coronally over time in almost all cases. This phenomenon is believed to be caused by continuous bone remodeling. A clear conclusion cannot be drawn because this is not a comparative study, but the present study is consistent with other studies that reported that implants with an internal slip-fit joint (like those used in the present study) minimize micromotion at the implant-abutment interface and prevent microleakage, thus contributing to conservation of peri-implant bone. Both the mesial and distal bone levels exhibited mean gains during the 2-year study period. Previous studies have found similar results, reporting slight gains in marginal bone levels around implants. It can be said that this phenomenon might be related to the kind of implant-abutment connection and its level of precision.

Careful consideration of a stable drilling protocol that considers bone quality is important when creating an insertion socket, as unstable implants can yield poor results. An undersized drilling method forms an osteotomy that is smaller than the implant; this is a common technique to obtain primary stability. Drilling protocols must be applied according to the type of bone quality, and insertion torques must be controlled: The Astra Tech EV implant system used in the present study requires the surgeon to change the drilling protocol according to bone quality of the planned insertion site and to control the insertion torque (≤45 Ncm). As a result, the condition of the peri-implant bone was favorable after superstructure loading. Many studies report that treatment outcomes are worse when bone quality is type I or IV, but it is possible that this does not affect treatment outcomes if, as in the present study, the optimum drilling protocols are employed for the respective bone quality types. In this study, three 6-mm short implants were placed in type I bone quality. The insertion torque was 45 Ncm for all, which was the highest value used, but selecting drilling protocols that were suitable for the bone quality ensured stable results, with peri-implant bone level changes of +0.13 mm, ±0.00 mm, and +0.04 mm after 2 years for bone types I, II, and III, respectively.

Peri-implant bone level changes were dependent on the environments adjacent to the 6-mm short implants, and one of the most interesting results of the present study is that accelerated peri-implant bone formation was seen for sites adjacent to implants and natural teeth. When individual lost teeth are between natural teeth, the gingival attachments and blood supply of the adjacent teeth may ensure favorable peri-implant tissue retention. When there are several consecutive lost teeth, it is possible that the blood supply from the periodontal ligament of the adjacent teeth can be cut off, leading to a reduction...
in the alveolar height and width. Moreover, if the adjacent tooth is an implant, research indicates that a distance of ≤ 5 mm between the existing and newly placed implant increases the probability of peri-implant bone reduction. However, peri-implant bone reduction was not often seen in the present study. This leads the present authors to believe that the microleakage-prevention feature of the implants used in the present study contributes to peri-implant bone retention. Furthermore, if the adjacent environment includes natural teeth, accelerated peri-implant bone formation was also observed. As reported by Arabi et al, natural teeth adjacent to implants help suppress peri-implant bone reduction.

Histologic peri-implant assessment is linked to the evaluation of implant stability and treatment success. No established method is currently in place for this, but implant pocket probing depth measurements are regarded as a useful indicator in ascertaining the condition of peri-implant soft tissue. One study achieved stable, firm osseointegration in mucosa with 2- to 6-mm implant probing depths. In the present study, the mean probing depth values were within the appropriate range 2 years after superstructure loading, further supporting the evidence for the stability of the present implant treatment method.

Pommer states that the OHIP is a very useful method for evaluating implant therapy. The satisfaction levels of patients undergoing oral restoration with 6-mm short implants was considerably high in the present study, and the short implants contributed to improvements in patient quality of life. This is not a surprise, as treatment using 6-mm short implants in sites with insufficient bone levels allows for reduced surgical times without bone augmentation procedures and reduces postsurgical pain. Even so, the present study had a limited follow-up period and a small number of cases. Further studies are needed over a longer period of time.

Conclusions

By using 6-mm short implants in healed ridges of Japanese patients, stable and highly predictable clinical outcomes were obtained for soft and hard tissues after a 2-year follow-up period. Moreover, improved satisfaction was seen in patients undergoing oral restoration using these implants.

Acknowledgments

The authors declare no conflicts of interest.

References

### Appendix Table 1 Mean Patients Satisfaction (OHIP-14) Scores Before and After Treatment

<table>
<thead>
<tr>
<th>OHIP-14 question</th>
<th>Before treatment</th>
<th>After treatment (2 y)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Median</td>
</tr>
<tr>
<td>1. Words felt difficult to pronounce</td>
<td>1.94 ± 1.06</td>
<td>2</td>
</tr>
<tr>
<td>2. I felt a distortion of the sense of taste</td>
<td>2.00 ± 0.89</td>
<td>2</td>
</tr>
<tr>
<td>3. I felt pain</td>
<td>1.88 ± 0.96</td>
<td>1.5</td>
</tr>
<tr>
<td>4. I felt discomfort while eating</td>
<td>1.81 ± 1.22</td>
<td>1</td>
</tr>
<tr>
<td>5. I felt self-conscious and cared about others' opinions</td>
<td>1.81 ± 1.38</td>
<td>2</td>
</tr>
<tr>
<td>6. I felt nervous or anxious</td>
<td>1.00 ± 0.89</td>
<td>1</td>
</tr>
<tr>
<td>7. My diet has been unsatisfactory</td>
<td>2.25 ± 1.00</td>
<td>2</td>
</tr>
<tr>
<td>8. I had to interrupt food consumption</td>
<td>2.19 ± 0.83</td>
<td>2</td>
</tr>
<tr>
<td>9. I had difficulty relaxing</td>
<td>1.00 ± 1.15</td>
<td>1</td>
</tr>
<tr>
<td>10. I felt ashamed to some extent</td>
<td>1.06 ± 0.93</td>
<td>1</td>
</tr>
<tr>
<td>11. I felt irritated by my surroundings</td>
<td>0.88 ± 0.72</td>
<td>1</td>
</tr>
<tr>
<td>12. I had some difficulties during my daily life</td>
<td>1.38 ± 0.96</td>
<td>1</td>
</tr>
<tr>
<td>13. I didn’t feel satisfied about my everyday life</td>
<td>1.38 ± 1.20</td>
<td>1.5</td>
</tr>
<tr>
<td>14. I have been unable to function</td>
<td>1.38 ± 1.09</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>30.44 ± 14.18</td>
<td>29.5</td>
</tr>
</tbody>
</table>

OHIP = Oral Health Impact Profile.

The following scoring system was used for each OHIP-14 question: 0 = never (great satisfaction); 1 = hardly ever; 2 = occasionally; 3 = fairly often; 4 = very often (poor satisfaction). The lowest possible overall score is 0, and the highest possible overall score is 56.
Appendix Fig 1 (a) Drilling protocols for a 4.2-mm implant from Astra Tech Implant System EV (Dentsply Sirona). (b) Drilling protocol details for the Astra Tech Implant System EV. The amount of drilling is specified for the implant shoulder, body, and apex.
Appendix Fig 2 Variations of peri-implant bone levels on the (a) mesial and (b) distal sides between the time of superstructure delivery and the 2-year follow-up. (a) After 2 years, the average difference on the mesial sides was 0.38 ± 0.49 mm (range: -0.25 to 1.88 mm). (b) After 2 years, the average difference on the distal sides was 0.15 ± 0.42 mm (range: -0.98 to 0.84 mm). An asterisk indicates a statistically significant difference.

Appendix Fig 3 Variations in mesial peri-implant bone levels between the time of superstructure delivery and the 2-year follow-up for sites with (a) a proximal natural tooth and (b) a proximal implant. A statistically significant difference was seen for the change in peri-implant bone levels for both proximal situations (asterisk).