Evaluation of Crestal Bone Resorption of the TiUnite® Anodized Implant System

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Abstract

Purpose: This study sought to examine the aspects of crestal bone resorption and to evaluate the clinical outcomes of the TiUnite® (Nobel Biocare, Sweden) anodized implant system.

Materials and Methods: Among the 67 patients (211 fixtures) who were treated using TiUnite(r) implants at Seoul National University Bundang Hospital between March 2004 and January 2007, 26 (91 fixtures) were considered in this study. Initial and secondary stabilities were measured using Periotest® and Ostell(tm) Mentor. The radiographic evaluation of crestal bone resorption was carried out by measuring the change in crestal bone level at the time of surgery compared to that 1 year after loading. Panoramic radiograph and periapical radiograph were used. Based on the radiographic findings, the shapes of crestal bone resorption were classified.

Results: The average amount of crestal bone resorption after 1 year of functional implant loading was 0.30 mm. There was no saucerization in 40 implant fixtures (43.9%), although more than 1 thread were exposed in 51 implant fixtures (56.6%). The success rate of the implants was 94.5%, and the survival rate was 100%.

Conclusions: Good clinical outcomes and minor crestal bone resorption were noted in this study. Saucerization for the establishment of biological width was not a general finding in the TiUnite® anodized implant system.

Keywords: TiUnite®, crestal bone resorption, saucerization, anodized, implant
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Introduction

Since dental implant was introduced by Brånemark\(^9\) in 1965, there has been remarkable development in the implant system particularly the surface treatment method. Albrektsson, et al\(^2\) reviewed the clinical studies on the implant systems based on the classification of fixture surface treatment methods: machined, sandblasted and acid-etched (SLA), dual acid-etched, titanium plasma-sprayed (TPS), hydroxyapatite (HA)-coated, and anodized surface. In addition, many comparative studies were performed on the clinical outcomes of various implant systems including the success and survival rate\(^3,5\).

From the clinical aspect, crestal bone resorption has been considered an important property of implant systems. Albrektsson, et al\(^6\) suggested less than 1.5mm bone loss following implant placement and 0.2mm bone loss per year after occlusal loading. Smith and Zarb\(^7\) defined the success criteria for implant as less than 0.2mm bone loss per year. Moreover, there have been many studies on factors affecting crestal bone resorption\(^8\). Some researchers suggested that the microgap was related to the cortical bone resorption in the study on peri-implant bone resorption\(^8,10\). Chun, et al\(^11\) reported that the different abutment types had influences on the stress distribution in bone. Tarnow, et al\(^12\) reported the cortical bone resorption of the peri-implant area for the establishment of biological width. Unfortunately, anodized surface implants such as TiUnite\(^\circledR\) (Nobelbiocare, Sweden) were not included in such study. Although many studies on the clinical outcomes of anodized surface implants have been carried out\(^2,13\), few studies dealt with the aspects of crestal bone resorption.

This study sought to examine the aspects of crestal bone resorption and to evaluate the clinical outcomes of the TiUnite\(^\circledR\) anodized implant system developed in 2002.

Materials and Methods

Among the 67 patients (211 fixtures) who were treated using TiUnite\(^\circledR\) implants in Seoul National University Bundang Hospital between Mar. 2004 and Jan. 2007, 26 (91 fixtures) were considered in this study. All 26 patients were checked more than 1 year after the completion of the prosthetic procedure. In the clinical and radiographic examination, all threads of the implant fixtures were confirmed to be located under the alveolar crest level at the time of surgery. Cases wherein the threads were exposed above the alveolar crest level were excluded since measuring the exact level of graft margin in the radiograph was difficult. Moreover, there were differences between grafted bone and natural crestal bone in terms of resorption pattern (Fig. 1). All the operations in this study were performed by an oral surgeon based on the same surgical protocol. All the prosthodontic procedures were also performed by a prosthodontist. As a post-operative prescription, the subjects were instructed to take 375mg

Table 1. Classification of crestal bone resorption

<table>
<thead>
<tr>
<th>Classification</th>
<th>Definition</th>
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<tbody>
<tr>
<td>A</td>
<td>No crestal bone resorption on both sides</td>
</tr>
<tr>
<td>B</td>
<td>Horizontal bone resorption on one side (platform level)</td>
</tr>
<tr>
<td>C</td>
<td>Saucerization on one side</td>
</tr>
<tr>
<td>D</td>
<td>Horizontal bone resorption on one side (≥ 2-thread exposure)</td>
</tr>
<tr>
<td>E</td>
<td>Horizontal bone resorption on both sides (platform level)</td>
</tr>
<tr>
<td>F</td>
<td>Saucerization on one side, horizontal bone resorption on the other side (≥ 2-thread exposure)</td>
</tr>
<tr>
<td>G</td>
<td>Horizontal bone resorption on one side (platform level), horizontal bone resorption on the other side (≥ 2-thread exposure)</td>
</tr>
<tr>
<td>H</td>
<td>Saucerization on both sides</td>
</tr>
<tr>
<td>I</td>
<td>Saucerization on one side, horizontal bone resorption on the other side (≥ 2-thread exposure)</td>
</tr>
<tr>
<td>J</td>
<td>Horizontal bone resorption on both sides (≥ 2-thread exposure)</td>
</tr>
</tbody>
</table>

Figure 1. Example of exclusion criteria; vertical ridge augmentation cases were excluded because evaluating the exact bone level on the radiographs was difficult.
amoxicillin with clavulanic acid 3 times a day for 5 days.

1) Clinical evaluation
For the evaluation of clinical outcomes, fixture length, and fixture diameter, the implant site, condition of occlusion, additional surgical procedure, graft material, membrane, and complication were recorded.

2) Crestal bone resorption
The radiographic evaluation of crestal bone resorption was carried out by measuring the change of crestal bone level at the time of surgery compared to that 1 year after implant loading. Panoramic radiograph and periapical radiograph were used; the average of the mesial side and distal side was calculated. The inter-thread distance was used as the reference point. The inter-thread distance of TiUnite™ implants varied according to the diameter of implant fixture (3.3D : 0.5mm; 3.75D : 0.6mm; 4.0D : 0.6mm; 5.0D : 0.8mm).

3) Classification of crestal bone resorption
Based on the radiograph taken at the final follow-up check, the shapes of crestal bone resorption were classified into 10 types (Table 1, Figs. 2 and 3). In this study, saucerization referred to the wedge-shaped crestal bone loss in the first thread. Horizontal bone resorption as the most common pattern of bone loss in periodontal disease meant generalized or flat-shaped crestal bone loss. Crestal bone resorption involving more than two threads was considered serious.

4) Success and survival rate
The success of implant was defined as follows: 1) no clinical symptoms including mobility or pain; 2) less than 1.5mm bone loss following implant placement and 0.2mm bone loss per year after occlusal loading. If these were not

<table>
<thead>
<tr>
<th>Table 2. Distribution of implants according to length and diameter</th>
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<tbody>
<tr>
<td>Diameter of Fixture (mm)</td>
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<tr>
<td>--------------------------</td>
</tr>
<tr>
<td>3.3</td>
</tr>
<tr>
<td>3.75</td>
</tr>
<tr>
<td>4.0</td>
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<tr>
<td>5.0</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3. Distribution of opposing teeth</th>
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<tbody>
<tr>
<td>Natural teeth</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>30</td>
</tr>
</tbody>
</table>
met, the implant was considered a failure. The implants that worked functionally were considered to have survived.

Results

A total of 91 implants were placed on 26 patients. The range of the patients’ age was between 33 and 70 years (mean: 55.5 years). There were 12 male and 14 female patients. The sizes of the implants used are shown in Table 2. The frequently used fixture size had a diameter of 4.0 mm and a length of 11.5 mm. The state of occlusion is shown in Table 3, with implant or natural teeth occupying a major portion. Among the cases, only 14 implants were placed in a one-stage implant surgery (15.4%); the rest were placed in a two-stage implant surgery (n=77, 85.7%). Most of the additional surgical procedures were bone-added osteotome sinus floor elevation (BAOSFE, n=18, 19.8%) followed by ridge expansion osteotomy (REO, n=9, 9.9%), extraction and immediate implantation (n=8, 8.8%), horizontal ridge augmentation (n=7, 7.7%), buccal concavity area graft (n=5, 5.5%), and free gingival graft (n=2, 2.2%). More than 2 graft materials were usually mixed and applied, with BioOss® as the graft of choice. In the case of guided bone generation, BioGide® was chosen as the membrane. No post-operative complications were observed.

1) Crestal bone resorption

One year after implant loading, the amount of crestal bone resorption ranged from 0.0 mm to 1.9 mm (mean: 0.30 mm (SD 0.52)). The amount of crestal bone resorption was more than 1.5 mm in 5 fixtures (5.5%).

2) Classification of crestal bone resorption

There was no saucerization (types A, B, E) in 40 fixtures (43.9%); more than 1 thread was exposed over the crestal level (types C, D, F, G, H, I, J) in 51 fixtures (56.6%). Either proximal side of the thread exposure above the crestal level was classified as thread-exposed model (Table 4).

Table 4. Distribution of crestal bone resorption types (n=91)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Number</th>
<th>Classification</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A*</td>
<td>25</td>
<td>Type F</td>
<td>6</td>
</tr>
<tr>
<td>Type B*</td>
<td>7</td>
<td>Type G</td>
<td>0</td>
</tr>
<tr>
<td>Type C</td>
<td>7</td>
<td>Type H</td>
<td>24</td>
</tr>
<tr>
<td>Type D</td>
<td>4</td>
<td>Type I</td>
<td>6</td>
</tr>
<tr>
<td>Type E*</td>
<td>8</td>
<td>Type J</td>
<td>4</td>
</tr>
</tbody>
</table>

* No Saucerization
3) Success and survival rate
Implant cases showing bone resorption of more than 1.5mm were regarded as failure in this study. The success rate was 94.5%. All implants have been maintained functionally until the point of final follow-up. Thus, the survival rate in this study was 100%.

Discussion
There are many factors related to the occurrence of crestal bone resorption following implant fixture placement. Implant loading and subsequent trauma, peri-implantitis, implant design, and implant surface would be considered possible factors. Kozlovsky, et al.\(^{14}\) reported the correlation between prosthodontic loading and peri-implantitis in an animal study. In said study, bone loss was aggravated by peri-implantitis under prosthodontic overloading, whereas bone loss was minimal under prosthodontic loading without peri-implantitis. van Steenberghe\(^ {15}\) reported that prosthodontic overloading and peri-implant inflammation were related to marginal bone loss. Many studies on crestal bone resorption among different implant shapes or surface structures were conducted. Hansson, et al.\(^ {16}\) reported that the Astra internal-hex type implant with microthread reduced peak stresses loaded on the alveolar crest to 60~80% of other implant systems. According to Astrand, et al.\(^ {16}\), the clinical results of the Astra internal-hex type implant showed a higher survival rate (98.4%) than the Branemark-turned surface implants (94.2%). Cochran\(^ {18}\) reported that the ITI (SLA surface) implant showed a higher rate of BIC (bone to implant contact) and survival (99%) than TPS-surfaced implants. Furthermore, there were many studies wherein the TiUnite\(^ {®}\) implant system showed better clinical results including crestal bone resorption compared with the former Brånemark MK III\(^ ®\) machined surface\(^ {19, 20}\).

In this study, after the TiUnite\(^ {®}\) implant surgery, the average crestal bone loss was 0.30 mm (SD 0.52). The success rate was 94.5%, and the survival rate was 100%. In cases wherein additional surgical procedure was performed due to poor bone quality and quantity, crestal bone resorption did not increase definitely in the TiUnite\(^ {®}\) implant system.

Bone regeneration was also noted for the coverage of thread exposure (3~10mm) in two cases. In the case of GBR, there were case-to-case differences from the aspect of marginal bone resorption. Such difference was believed to be due to the host factor and degree of difficulty of the surgical procedure.

The main purpose of this study was to evaluate the clinical outcomes of the TiUnite\(^ {®}\) implant including the amount and shape of crestal bone loss. Thus, cases of vertical ridge augmentation -- which tended to be heavily biased in a comparative study -- were excluded. Since such exclusion criterion had rationales, evaluating the crestal bone loss in vertical ridge augmentation cases was difficult due to many related factors during the healing periods as well as in the course of surgery. Moreover, bone resorption was significantly affected by the graft materials.

In this study, the overall success rate was 93.1%; the survival rate was 100%. This study showed the good prognostic value of the TiUnite\(^ {®}\) implant. In many previous studies, the Brånemark TiUnite\(^ {®}\) implant system showed good clinical outcomes including acceptable crestal bone resorption, high success rate, and high survival rate. The amount of crestal bone resorption 1 year after implant loading was 0.8~1.3 mm; the survival rate was 93.4~100% in many studies.\(^ {21-25}\) Moreover, considering the clinical outcomes in this study including the survival rate and success rate as a result of the examination of the aspect of crestal bone resorption, no saucerization was observed in 40 fixtures (43.9%). These results meant that “saucerization” -- which was for the establishment of biological width -- was not a common finding in the TiUnite\(^ {®}\) anodized implant system.

As described earlier, although Tarnow conducted a comparative study on the external hex-type implants, anodized surface implants such as TiUnite\(^ {®}\) were not included in such study. Thus, the results of this study were meaningful. Recently, platform switching has been recommended for the prevention of saucerization\(^ {26}\). Conventional prosthodontic technique was applied in this study.

Conclusion
In this study, less alveolar crestal bone resorption was observed following Brånemark TiUnite\(^ {®}\) implant placement.
Good treatment prognosis was noted in most cases. Based on the results, saucerization as the sub-crestal bone loss for the establishment of biological width can be said not to be a general finding in the TiUnite®-anodized implant system.

References