Case Series

Retrospective Evaluation of Crestal Bone Changes Around Implants With Reduced Abutment Diameter Placed Non-Submerged and at Subcrestal Positions: The Effect of Bone Grafting at Implant Placement

Theofilos Koutouzis,* Michael Fetner,* Alan Fetner,† and Tord Lundgren,*‡

Background: There is limited information regarding the effect of grafting of the osteotomy after subcrestal implant placement. The primary aim of this study is to retrospectively evaluate the effect of bone grafting of the defect between the bone crest and the coronal aspect of implants with reduced abutment diameter placed non-submerged and at subcrestal positions.

Methods: Records of 50 consecutive patients treated with subcrestally placed dental implants grafted with a xenograft (Group A) and 50 consecutive patients with subcrestally placed dental implants without any grafting material (Group B) were reviewed. For each implant, the radiographs after placement were compared to images from the last follow-up visit and evaluated regarding the following: 1) degree of subcrestal positioning of the implant, 2) changes of marginal hard-tissue height over time, and 3) whether marginal hard-tissue could be detected on the implant platform at the follow-up visit.

Results: The mean marginal loss of hard tissues was 0.11–0.30 mm for Group A and 0.08–0.22 mm for Group B. Sixty-nine percent of the implants in Group A and 77% of the implants in Group B demonstrated hard tissue on the implant platform. There were no statistically significant differences between the groups regarding marginal peri-implant hard-tissue loss.

Conclusion: The present study fails to demonstrate that grafting of the remaining osseous wound defect between the bone crest and the coronal aspect of the implant has a positive effect on marginal peri-implant hard-tissue loss.

KEY WORDS
Bone transplantation; dental implants; osseointegration; radiology; retrospective study; titanium.

Tooth restorations using implant-supported prostheses for functional and esthetic rehabilitation of patients has become an established, widely used, and successful treatment modality in modern dentistry. One method to measure the success of dental implant treatment is to evaluate marginal peri-implant bone-level changes and stability over time.

The location of the fixture–abutment interface (FAI) can be of major importance when the goal is to construct esthetic restorations. In these situations the FAI is often placed in a more apical position to create an ideal emergence profile for the prosthetic construction.1 However, several animal studies have reported that placement of the FAI in a subcrestal position may result in peri-implant marginal bone loss.2,3

In one recent animal study4 where FAI was placed 2 mm subcrestally, it was suggested that osseointegration might occur coronal to FAI. The authors in this study indicate that the result may depend on certain surface characteristics of the implant components. Similar findings

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have been reported in another animal study by Weng et al.,5 where implants placed in a subcrestal position presented bone growth onto the implant shoulder in nearly all of the histologic sections. In this study, implants with a microstructured surface treatment, including the cervical collar and extending onto the implant shoulder, were used.

There is limited information regarding clinical studies of two-part implants being placed in subcrestal positions. Our group6 reported in a recent case series of two-part implants being placed in subcrestal implant shoulder, were used.

Including the cervical collar and extending onto the nearly all of the histologic sections. In this study, implant placement. The sites were grafted with a hydroxyapatite bone-grafting material.

The aim of the present study is to evaluate the effect of bone grafting of the defect between the bone crest and the coronal aspect of the fixture–abutment complex, for the patients in Group A the remaining osseous wound defect between the bone crest and the coronal aspect of the implant was grafted.1 The implant sites were healed and of sufficient width for placement of an implant with a 3.5- or 4.5-mm diameter. The grafted defects for Group A were produced by the preparation of the implant bed and with the use of abutments with reduced diameter. The same protocol was followed for the patients in Group B except that bone grafting was not performed and the residual osteotomy coronal to the implant platform was left unaltered. Each patient received 500 mg of amoxicillin four times daily for 7 days from the day of implant surgery.

The distribution of implants according to jaw of placement and type of abutment used after implant placement is shown in Table 1. For Group A, 37 patients had one implant placed, whereas 11 patients received two implants. Two patients received four and six implants, respectively. Sixty-four implants had a diameter of 3.5 mm and five were 4.5 mm, whereas the length varied between 9.5 and 14 mm.

For Group B, 32 patients had one implant placed and 14 patients received two implants. In addition, three patients received four implants and one patient received six implants. Sixty-six implants had a diameter of 3.5 mm and 12 were 4.5 mm, whereas the length varied between 9.5 and 14 mm.

The final prosthetic constructions were completed 3 to 4 months after implant placement according to the implant manufacturer’s manual. For implants that received permanent abutments after implant placement, no abutment disconnection was performed and abutment level impressions were taken to fabricate the permanent prosthesis. Implants that received healing abutments were subjected to a single abutment disconnection to replace the healing abutments with the appropriate permanent abutments. After abutment replacement, abutment-level impressions were taken for permanent crown fabrication. Careful oral-hygiene instructions were given to all patients at the placement of the permanent prostheses and, in addition, oral hygiene was reinforced at follow-up visits.

Postoperative radiographs were taken immediately after the surgical procedure, at crown placement, and at the last follow-up visit. The periapical radiographs were taken in a standardized manner using a paralleling device¹ and a digital imaging software system.³

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³ DEXIS, Des Plaines, IL.
The interpretation of the radiographs for Group A has been described in a previous report.⁶ Two periodontists (TL and TK) worked together to interpret the radiographs of Group B in a similar manner (Fig. 1). Thus, for each implant the radiographs were evaluated regarding the following: 1) degree of subcrestal positioning at surgery, 2) changes of marginal bone height over time, and 3) whether bone could be detected on the implant platform at the follow-up visit. Changes in marginal bone height were calculated by the distance between the fixture shoulder and the first visible bone-to-implant contact. In situations where bone was seen above the reference point, it was still recorded as zero to avoid introducing bias in the results. The presence or absence of bone on the implant shoulder was represented by (+) or (−), respectively. All measurements were determined at the mesial and distal surface of each implant using a magnification (×7) of the images. The radiographs were downloaded as 16-bit, JPEG files and analyzed with an image processing system.** The geometry of the implant was used to assess the distortion of the images. In situations where mesial or distal sites on the implant were not visible on the radiographs, a decision was made to exclude the implant site from the analyses. The error of the method used for appraising the measurements on the radiographs was calculated by reassessing 10 randomly selected cases including 40 sites. The mean difference between repeated measurements of the 40 sites was found to be 0.03 ± 0.2 mm.

For description of the data, mean values, standard deviations (SD), and cumulative frequencies were calculated. The primary outcome variable was peri-implant hard-tissue level changes from the time of implant placement (baseline) to the last follow-up examination. Peri-implant mineralized hard-tissue level data were analyzed on the site and implant level. Intragroup and intergroup comparisons were performed by the use of Mann-Whitney U test. Fisher exact test was used to evaluate differences in frequencies of implant surfaces and implants that did not experience marginal hard-tissue loss. The same test was applied to evaluate differences in frequencies of implants and implant surfaces that exhibited hard tissue on the platform between the two groups. A P value of <0.05 was considered to be statistically significant.

**RESULTS**

For both groups the overall survival rate from baseline to the last recorded follow-up visit was 100%. From the total 294 sites, 287 were available for radiographic interpretation: 131 for Group A and 156 for Group B. The mean follow-up time was 14 months for both Group A (range: 9 to 20 months) and Group B (range: 8 to 24 months). At surgery in Group A, implants were placed 1.37 mm (mesial) and 1.28 mm (distal) subcrestally, and at the last recorded follow-up visit 61 of 69 sites still demonstrated a subcrestal location. Similarly, Group B implants were placed 1.57 mm (mesial) and 1.49 mm (distal) subcrestally, and 70 of 78 sites still demonstrated a subcrestal location at the last recorded follow-up visit.

The mean marginal hard-tissue loss from the time of implant placement to the last follow-up examination for the two groups according to jaw and site is illustrated in Table 2. For Group A, the mean loss of marginal hard tissue was 0.11 ± 0.30 mm calculated on site level (n = 131) and 0.11 ± 0.27 mm calculated on implant level (n = 69). Similarly for Group B, the mean marginal hard-tissue loss was 0.08 ± 0.22 mm on implant level (n = 78) and 0.08 ± 0.25 mm on site level (n = 156). There were no statistically significant differences between the two groups for both site- and implant-level analysis (P > 0.05).

For Group A, implants that received permanent abutments at the time of implant placement demonstrated a mean marginal hard-tissue loss of 0.08 ± 0.26 mm (site-level analysis). For the same group, implants that received healing abutments at the time of implant placement had 0.12 ± 0.32 mm mean marginal hard-tissue loss (site-level analysis). Similarly for Group B, implants with permanent abutments had 0.08 ± 0.25 mm and implants with healing abutments had 0.09 ± 0.25 mm mean hard-tissue loss (site-level analysis). There were no statistically significant differences within and between groups for implants receiving permanent or healing abutments at the time of implant surgery (P > 0.05).

The mean marginal hard-tissue loss was 0.12 ± 0.28 mm for the 3.5-mm diameter implants and 0.04 ± 0.11 mm for the 4.5-mm diameter implants of Group A (site-level analysis). Similarly, for Group B, the mean marginal hard-tissue loss was 0.1 ± 0.26 mm for the 3.5-mm diameter implants and 0.03 ± 0.13 mm for the 4.5-mm diameter implants (site-level analysis). There was no statistically significant difference between diameter implants for Group

**Table 1.**

**Distribution of Implants According to Jaw of Placement and Type of Abutment Placed During Surgery**

<table>
<thead>
<tr>
<th>Group</th>
<th>Maxilla</th>
<th>Mandible</th>
<th>Healing Abutment</th>
<th>Permanent Abutment</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>51</td>
<td>18</td>
<td>46</td>
<td>23</td>
</tr>
<tr>
<td>B</td>
<td>41</td>
<td>37</td>
<td>46</td>
<td>32</td>
</tr>
</tbody>
</table>

**Image J Software, National Institutes of Health, Bethesda, MD.**
The cumulative percentage of implants and sites showing loss of peri-implant hard tissues during the observation period is illustrated in Figures 2 and 3. In Group A, 75% of the implants and 84% of the sites did not experience any hard-tissue loss. For Group B, 79% of the implants and 85% of the sites did not experience any hard-tissue loss. There were no statistical significances regarding the frequency of implants and implant surfaces exhibiting loss of bone between the two groups.

DISCUSSION

The present study fails to demonstrate that grafting of the remaining osseous wound defect between the bone crest and the coronal aspect of the implant had a positive effect on marginal peri-implant hard-tissue changes and stability during the observation time. All implants described in this report have a reduced abutment diameter in relation to the fixture diameter, and a Morse taper implant–abutment connection. The fixtures were placed in subcrestal positions and presented minimal peri-implant hard-tissue loss during the observation period. From a clinical perspective, the peri-implant bone loss was minimal in both the grafted group (0.11 mm) and non-grafted group (0.08 mm). The small difference in mean marginal hard-tissue loss between the groups was not statistically significant and may depend on differences in fixture placement depth. Implants in Groups A and B were placed 1.32 and 1.53 mm in a subcrestal position, respectively. In a previous report that described only Group A, a positive correlation was found between the depth of implant placement and the frequency of mineralized tissue on the implant platform. Thus, the depth of placement in relation to the bone crest may be of clinical importance for minimizing hard-tissue loss for this specific implant system. However, from these data the authors cannot recommend the optimal subcrestal depth of implant placement. This

A (P > 0.05). However, there was a statistically significant difference between diameter implants for Group B (P < 0.05).

The percentage of implant sites exhibiting hard tissue on the platform at the last follow-up examination according to jaw and site is illustrated in Table 3. Group B exhibited a statistically significant greater frequency of implant surfaces with hard tissue on the platform in the maxilla compared to Group A (86% versus 67%; P < 0.05). In addition, within Group B there was statistically significant greater frequency of implant surfaces with hard tissue on the platform in the maxilla compared to the mandible (86% versus 67%; P < 0.05).
question should be addressed in a separate prospective study.

The present study demonstrates that mineralized tissue could be observed on the platform of the implant above the FAI. Specifically, 69% of the implants in Group A and 77% of the implants in Group B exhibited hard tissue on the platform at the last follow-up examination. Bone grafting of the coronal part of the osteotomy after placement of the implants in a subcrestal position did not improve the radiographic outcome. Thus, the fact that a high frequency of implants exhibited hard tissue on the platform should be attributed to factors other than the bone grafting procedure.

Subcrestal position of the FAI has been reported to have a negative influence on marginal bone-level changes in some animal studies.\(^2\,3\,7\,9\) In an experimental study in dogs, Hermann et al.\(^3\) reported that placement of two-part implants with the FAI 1 mm below the crestal bone resulted in pronounced crestal bone loss after 6 months of healing. In this study, the authors used custom-made implants with an FAI microgap of 50 \(\mu\)m. Similarly, Jung et al.\(^2\) reported that the greatest amount of loss of bone occurred in implants placed with the FAI 1 mm below the bone crest compared to implants placed with FAI 1 mm above or at the level of the bone crest. In this study, implants with non-matching implant–abutment diameters were used. However, the amount of crestal bone loss was smaller compared to the study by Hermann et al.\(^3\) Todescan et al.\(^7\) in a similar animal experiment evaluated the healing around implants with an external hex design that were placed either 1 mm above, level with, or 1 mm below the crestal bone. They reported that the first marginal bone-to-implant contact was located between 1.6 and 2.5 mm apical to the FAI, with the shortest distance

Table 2.
Marginal Hard-Tissue Loss From Time of Implant Placement to the Last Follow-Up Examination for Different Jaws and Mesial and Distal Sites (site-level analysis)

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>Group A (n)</th>
<th>Group A Mean Loss (mm)</th>
<th>Group A SD</th>
<th>Group B (n)</th>
<th>Group B Mean Loss (mm)</th>
<th>Group B SD</th>
<th>(P) Intergroup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jaw</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maxilla</td>
<td>95</td>
<td>0.12</td>
<td>0.33</td>
<td>80</td>
<td>0.07</td>
<td>0.23</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Mandible</td>
<td>36</td>
<td>0.05</td>
<td>0.21</td>
<td>76</td>
<td>0.10</td>
<td>0.23</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>(P) intragroup</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mesial</td>
<td>68</td>
<td>0.09</td>
<td>0.26</td>
<td>78</td>
<td>0.07</td>
<td>0.25</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Distal</td>
<td>63</td>
<td>0.12</td>
<td>0.35</td>
<td>78</td>
<td>0.10</td>
<td>0.24</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>(P) intragroup</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Total</td>
<td>131</td>
<td>0.11</td>
<td>0.30</td>
<td>156</td>
<td>0.08</td>
<td>0.25</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

Table 3.
Percentage of Implant Sites Exhibiting Hard Tissue on the Platform at the Last Follow-Up Examination for Different Jaws and Mesial and Distal Sites

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>Group A (n)</th>
<th>Group A Hard Tissue on the Platform (%)</th>
<th>Group B (n)</th>
<th>Group B Hard Tissue on the Platform (%)</th>
<th>(P) Intergroup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jaw</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maxilla</td>
<td>95</td>
<td>67</td>
<td>80</td>
<td>86</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>Mandible</td>
<td>36</td>
<td>72</td>
<td>76</td>
<td>67</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>(P) intragroup</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mesial</td>
<td>68</td>
<td>71</td>
<td>78</td>
<td>83</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Distal</td>
<td>63</td>
<td>67</td>
<td>78</td>
<td>71</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>(P) intragroup</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
<td>&gt;0.05</td>
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<td>Total</td>
<td>131</td>
<td>69</td>
<td>156</td>
<td>77</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

\(^*\) Fisher exact test \(P<0.05\); Group B versus Group A for maxilla.
\(^†\) Fisher exact test \(P<0.05\); maxilla versus mandible for Group B.
measured for the implants that were placed in the subcrestal position. Similar findings have been reported by Pontes et al.,8,9 who placed implants with the FAI at the bone crest, 1 and 2 mm apical to this position. After 4 months of healing, all implant groups had the first bone-to-implant contact apical to the FAI. None of those animal studies reported bone formation above the FAI when implants were placed in a subcrestal position.

In contrast to the previously described studies,2,3,7-9 only two animal experiments4,5 have reported more favorable outcomes for subcrestal positioned implants with bone formation close to or even above the FAI. Welander et al.4 observed osseointegration coronal to the FAI when placing implants with the FAI 2 mm subcrestally. The test implants in this study had a surface modification extending to the implant margin that included the shoulder part of the implant and a conical interface between the abutment and the implant. Similar findings were reported by Weng et al.,5 showing that implants with subcrestal position presented bone growth onto the implant shoulder in nearly all histologic sections. In this study, implants with a reduced abutment diameter in relation to the fixture diameter, a Morse taper implant–abutment connection, and a microstructured surface treatment including the cervical collar and extending onto the implant shoulder were used. The results of these reports4,5 are in agreement with the findings of the present study. In the present study, we also use implants with a reduced abutment diameter in relation to the fixture diameter, a Morse taper implant–abutment connection, and a microstructured surface treatment including the cervical collar and extending onto the implant shoulder.

The fact that peri-implant bone could be maintained close to or over the FAI may indicate minimal microbial contamination of the interface and minimal micromechanical movement between the fixture and the abutment in such implants. A recent in vitro study10 reported that implants with similar characteristics as

Figure 2.
Cumulative distribution of implant surfaces according to marginal bone-level changes between implant placement and follow-up examination. Each dot represents an implant surface.
the ones that followed in the present study had minimal contamination of the FAI microgap after incubation in a bacterial solution of *Aggregatibacter actinomycetemcomitans* (previously *Actinobacillus actinomycetemcomitans*) and *Porphyromonas gingivalis*. However, implants in this study were evaluated under non-loading conditions and this might have an effect on the favorable findings. In another in vitro study, the dynamic behavior of dental implants with different fixture–abutment connection designs was evaluated with an applied force up to 200 N at an angle of 30 degrees. The implant system in the present study does not exhibit micromovements when loaded at 100 N and at 200 N. The authors speculated that certain implant designs would minimize the pumping effect between the fixture and the abutment and thus prevent marginal peri-implant bone loss.

The effects of altered vertical implant positioning in patients were reported by Hämmerle et al. One-stage transmucosal implants were placed with the border between the rough and smooth surface 1 mm subcrestally compared to implants placed with the rough/smooth border positioned precisely at the alveolar crest. Implants in the subcrestal group lost a mean of 2.26 mm of marginal bone height compared to 1.02 mm in control implants during a 12-month period. The authors concluded that subcrestal placement of implants with smooth or polished collars should not be recommended.

The implant system reported in the present study has an altered horizontal relationship between the fixture diameter and abutment diameter. Studies have reported minimal marginal peri-implant loss of bone for implants with such a design. The main explanation of the favorable outcomes was the increased distance from the FAI to the crestal bone by reducing the risk of inflammatory-induced loss of bone. Wennström et al. reported mean (SD) bone-level changes from the time of crown placement to the first year of 0.02 (0.65) mm measured at the implant level. This study differed from the present study by taking baseline measurements at the time of permanent crown placement and not directly after surgery. Furthermore, they included gain of marginal...

**Figure 3.**
Cumulative distribution of implants according to marginal bone-level changes between implant placement and follow-up examination. Each dot represents an implant.
The present study only records observed losses. If the mineralized hard tissue was seen above the reference point, it was still recorded as zero. Norton, using a similar implant system, reported an average marginal loss of bone of 0.65 mm over a 37-month period. In this study, no gain of marginal bone was included as in the present study. Minimal loss of bone has been reported by Buser et al. in a case series that described placement of implants after a period of 4 to 8 weeks of teeth extraction in combination with simultaneous guided bone regeneration. In this study, implants with reduced abutment diameter were followed for 12 months from the time of implant placement and showed a mean bone loss of 0.18 mm.

The impact of the altered horizontal relationship between the fixture diameter and abutment diameter on marginal loss of hard tissue is supported by the observed differences between different diameter implants. For Group A the mean marginal loss of hard tissue was 0.12 mm for the 3.5-mm diameter implants and 0.04 mm for the 4.5-mm diameter implants. The fact that a statistically significant difference was not observed is mostly caused by the small number of implants with 4.5 mm diameter (five implants). However, for Group B a statistically significant difference was observed with 4.5-mm diameter implants showing 0.03 mm and 3.5-mm diameter implants showing 0.1 mm of mean marginal hard-tissue loss, respectively. Because the abutment diameter for the implant system used has a stable dimension at the FAI level, use of wider diameter implants leads to increased distance from the FAI to the crestal bone. The fact that a greater number of implants with 4.5-mm diameter were used for Group B compared to Group A (12 versus five implants) may partially explain the observed differences between the groups.

The favorable findings of the present study might also be explained by the limited disturbance of the zone of connective tissue interaction by means of abutment disconnection and reconnection. More specifically, 23 implants in Group A and 32 implants in Group B had permanent abutments placed at the time of the implant placement, which were retained throughout the treatment. These implants demonstrated similar mean marginal hard-tissue loss (0.08 mm) that was less compared to mean marginal hard-tissue loss for implants that received healing abutments at the time of implant placement. Although the differences were not statistically significant, this finding may indicate that placing the permanent abutments at the time of implant placement has a positive effect on marginal hard-tissue retention and may partially explain the better results for the implants in Group B. This is in agreement with Abrahamsson et al. They demonstrated in an animal experiment that disturbance of the zone of connective tissue interaction through a series (five times) of abutment disconnection and reconnection can compromise the mucosal barrier and result in a more apically positioned zone of connective tissue. In a subsequent animal study by the same group, they reported that a single abutment shift after a second-stage surgery did not have an effect on marginal bone-level alterations.

Several limitations of the current study should be mentioned, such as the retrospective nature, the lack of clinical data, and the short follow-up time. In addition, the radiographic assessment was limited to the mesial and distal bone levels, and there was a lack of method in obtaining reproducible radiographs. Further prospective clinical studies using standardized methods and three-dimensional radiography would be of interest to validate the optimal vertical positioning of an implant in relation to the alveolar crest.

CONCLUSIONS

The present study fails to demonstrate that grafting of the remaining osseous wound defect between the bone crest and the coronal aspect of the implant has a positive effect on marginal peri-implant hard-tissue changes and stability. In addition, minimal loss of mineralized hard tissue and hard-tissue healing that extended onto the implant platforms was observed for most of the implants.

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