Initial Crestal Bone Loss After Implant Placement with Flapped or Flapless Surgery—A Prospective Cohort Study

Frank-Michael Maier, Dr Med Dent, M Sc

**Purpose:** Some initial loss of bone around dental implants is generally expected. There is reason to believe that reflecting a mucoperiosteal flap promotes crestal bone loss in the initial phase after an implant has been inserted. The objective of this study was to compare the effect of flapless implant insertion on initial bone loss with that of conventional placement after elevation of a mucoperiosteal flap. **Materials and Methods:** Eighty patients were randomly assigned either to the flapless group (test) or to the group with a full-thickness flap (control). In total, 195 implants were included in the study: 95 of these were inserted flapless (test group), and 100 were inserted by raising a mucoperiosteal flap (control group). Healing occurred unsubmerged for both groups. To assess changes in the peri-implant bone level, the height of the mesial and distal peri-implant bone was measured on digitally calibrated radiographs taken at the time of implant placement and 12 months afterward. **Results:** After 1 year, a mean cumulative crestal bone loss of 0.24 ± 0.62 mm was measured. A mean bone loss of 0.55 ± 0.57 mm was found in the group with the mucoperiosteal flap, while a slight mean gain in bone height of 0.09 ± 0.49 mm was found in the test group, a statistically significant difference (P < .001). **Conclusion:** Flapless implant insertion caused less peri-implant bone loss than implant insertion with flap preparation. Therefore, the flapless procedure represents a protective and promising method in implant surgery. INT J ORAL MAXILLOFAC IMPLANTS 2016;31:876–883. doi: 10.11607/jomi.4283

**Keywords:** dental implants, flapless implant insertion, initial bone loss, taper connection, transgingival healing, transmucosal healing

Within the first year after implant insertion, an increased amount of peri-implant bone resorption has been observed.¹ Several studies of implants with submerged healing showed a mean marginal bone loss of 0.9 to 1.6 mm within the first year after uncovering and loading; 0.05 to 0.13 mm of bone loss per year was measured subsequently.²⁻⁵ The cause of the increased initial bone loss within the first year after insertion is not fully understood. However, based on data available to date, there is evidence that the following factors influence crestal bone loss:

- Implant design
- Formation of the biologic width
- Implant surface
- Insertion depth
- Platform switching
- Postsurgical manipulation
- Microgaps between the implant and abutment and stability of the implant-abutment connection
- Overload by occlusal forces
- Peri-implantitis

The effect of the surgical trauma caused by raising a mucoperiosteal flap is also a subject of scientific investigation. The discussion revolves around the idea that the attendant temporary interruption of the blood supply to the outer layers of the bone could possibly cause increased alveolar ridge resorption.¹⁹⁻²¹ Furthermore, the regeneration of the bone injured by implant surgery is negatively influenced when a pedicled mucoperiosteal flap is dissected.²²,²³

The objective of the present study was to compare flapless implant placement with placement after elevation of a mucoperiosteal flap. Using radiographs, the effect on bone loss around implants with a conical implant-abutment connection (Ankylos, Dentsply) was measured after 1 year of loading.

**MATERIALS AND METHODS**

**Study Design and Patient Selection**
The study was conducted from September 2003 to August 2008 at a private dental practice in Tübingen, Germany. An important inclusion criterion was that it had to be possible to place the implants without additional...
Maier et al

of a mucoperiosteal flap (Figs 1a to 1c), while the implants in the test group were inserted without a flap (Figs 2a to 2c).

Before surgery, all patients rinsed the oral cavity with a 0.1% chlorhexidine digluconate solution. A crestal incision is recommended before placement of a transmucosal implant to relieve the mucous membrane.24 To avoid tearing the mucosa when drilling, a small crestal incision (approximately 8 mm in length) was thus made during the flapless implant placement. The pilot drilling was performed with an internally cooled twist drill (diameter of 2 mm) guided by the surgical template. The subsequent steps were carried out freehand with the system drill set. The cervical reamer was applied manually to avoid high pressure on the cervical bone. The implants were screwed in manually. Where bone density was high, the screw thread was manually precut. All implants were connected to healing abutments, and transmucosal healing followed (Figs 1c and 2c). Patients were instructed to take 2 g of amoxicillin 1 hour before surgery and 1 g two times at a time interval of 8 hours following the surgery. Patients with an allergy to penicillin took 600 mg of clindamycin each time instead. As a painkiller,
400 mg of ibuprofen was recommended, which the patients could take as needed.

Examination of the implants took place 1 day after surgery, after 1 week, and after 1 month. The implants were loaded within the second and third month after insertion. All patients were instructed in oral hygiene and received a professional cleaning every 3 months.

**Radiologic Examination**

For the radiologic evaluation of the initial peri-implant bone resorption, dental films were prepared using a standardized method and assessed with the program DBS Win (version 4.5, Dürr Dental). A first radiograph was taken immediately after implant insertion (mBl0) and a second one after 12 months (mBl12). The intention was to determine the mean bone level (mBl) at the implant shoulder in millimeters (Fig 3).

For this purpose, right-angle technique x-ray holders (Dentsply-Rinn) and size 2 imaging plates for Vista Scan (Dürr Dental) were used. A negative value was determined for the subcrestal position of the implant shoulder, while a supracrestal position of the implant shoulder showed a positive value. The larger the mBl became in comparison with the negative initial value, the greater the resulting marginal bone loss was. The target parameter of this study was to determine the change of bone level in millimeters after 1 year (ΔmBl12). This change was calculated by the formula mBl12 – mBl0 = ΔmBl12 (Fig 3). A negative ΔmBl12 value meant an increase in bone level, and a positive ΔmBl12 value was associated with bone loss. The analysis of the radiographic images was performed after calibration at a magnification of eight times the original. The distortion factor was determined by the horizontal and vertical measurement of the respective implant in the radiograph. Cases with a distortion of more than 10% were excluded from analysis.

**Statistical Analysis**

The statistical analyses and graphic representations were carried out using the statistical software SPSS for Windows, Version 15.0 (SPSS) and the statistical software R Version 2.14.1 (The R Foundation for Statistical Computing). Since the initial bone level and the subsequent bone loss recorded during the period of observation in the same patient were assumed to be correlated, all statistical comparisons for these variables were made using a random intercept model. In order to assume a normal distribution of residuals, the variables mBl0, mBl12, and ΔmBl12 were subjected to the Box-Cox Transformation before statistical analysis. All subsequent significance tests performed were carried out on the two-sided significance level α = .05. Assuming a normal distribution, the t statistic for paired and unpaired samples was used as a parametric test. Since the comparison of bone loss within and between the two groups treated was the only primary endpoint at the instances of measurement, there was no correction of the significance level for multiple testing.

**RESULTS**

**Subject-Related Parameters**

Eighty patients were included in the study; 50 (62.5%) were women, and 30 (37.5%) were men. The mean ± SD age of the patients at the time of implant placement was 57.8 ± 12.6 years (range, 18 to 78 years). Patients who received a test group implant were 56.6 years of age on average, and patients who received a control group implant were 60.1 years of age on average. Smokers constituted 17.9% of the patients who received flapless implants and 9.0% of those who got implants after flap elevation. Because of the small number of subjects, the independent variables of age, insertion site (maxilla or mandible), and smoking behavior could not be included in the analysis. The maximum number of implants inserted per person in the study cohort was eight, and the minimum was one.

During the 1-year observation period, one implant was lost in each of the two groups, with a survival rate of 99.03% for the entire sample. The failed implant in the test group was lost 3 months after placement in the mandibular right first molar region. It did not osseointegrate, but there were no signs of inflammation. The implant placed to replace it was submerged and healed without complication. In the control group, the distal implant of four interforaminally placed implants in the mandibular left first premolar region was probably lost due to early and excessive loading, but the implant that replaced it was successful.

Out of 207 total implants placed, 195 implants were included in the study. Six implants from the test group...
and three implants from the control group were not considered due to distortions in the radiographs. One patient in the test group with an edentulous maxilla developed peri-implantitis at the implant in the maxillary right canine region. Although this was treated successfully, the implant was excluded from the study. Finally, the two implants that were placed as replacements for the two failed implants were not included in the study.

### Implant-Related Parameters: Crestal Bone Loss

Looking at the entire study population, the implant shoulder was positioned on average 0.48 mm below the alveolar crest (mBl\(_0\) = –0.48 ± 0.65 mm) at the time of implant placement (Table 1). In the control group (mBl\(_0\) = –0.48 ± 0.65 mm; Table 1), the implant shoulder was positioned 0.30 mm deeper than in the test group (mBl\(_0\) = –0.18 ± 0.76 mm; Fig 4a). At the time of the first measurement, the insertion depth in the control group was significantly greater than in the test group (P = .004; Table 2). After 12 months (mBl\(_{12}\)), the implant shoulder was on average still 0.1 mm below the alveolar crest (mBl\(_{12}\) = –0.1 ± 0.75 mm) overall in the cohort. In the control group, the implant shoulder was positioned, on average, 0.07 mm supracrestally (mBl\(_{12}\) = 0.07 ± 0.79 mm) and in the test group 0.27 mm subcrestally (mBl\(_{12}\) = –0.27 ± 0.66 mm; Table 3; Fig 4b). In the entire study population, a mean bone loss of 0.24 mm resulted within 1 year (ΔmBl\(_{12}\) = 0.24 ± 0.62 mm; Table 4). The development of bone level after 1 year in the control group showed a mean crestal bone loss of ΔmBl\(_{12}\) = 0.55 ± 0.57 mm (Table 2). The maximum bone loss measured was 3.0 mm, while the best measurable value of crestal bone gain was at –0.25 mm. In the test group, there was a mean bone gain of ΔmBl\(_{12}\) = –0.09 ± 0.49 mm (Table 2). The maximum value of crestal bone loss was 0.95 mm, and the largest gain in crestal bone was –2.0 mm. Comparative analysis of the two groups showed the test group to have a significantly lower average loss of crestal peri-implant bone after 1 year than the group with the mucoperiosteal flap (P < .001). The mean difference of bone loss between the test and control groups after 12 months was 0.63 mm (Fig 5).

In the subgroup analysis of the independent parameters of subcrestal and supracrestal implant placement, a possible interaction between the insertion depth and surgical procedure (flap versus flapless)

---

**Table 1** Postoperative Measurement of Insertion Depth (mm)

<table>
<thead>
<tr>
<th>Surgical method</th>
<th>N</th>
<th>Mean</th>
<th>CI (±)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>With mucoperiosteal flap (control)</td>
<td>100</td>
<td>–0.48</td>
<td>0.13</td>
<td>0.65</td>
</tr>
<tr>
<td>Flapless (test)</td>
<td>95</td>
<td>–0.18</td>
<td>0.15</td>
<td>0.76</td>
</tr>
<tr>
<td>Total</td>
<td>195</td>
<td>–0.34</td>
<td>0.10</td>
<td>0.72</td>
</tr>
</tbody>
</table>

In the control group, the implant was positioned on average 0.48 mm below the bone crest vs 0.18 mm in the test group. Overall, the position was 0.34 mm below the crest. CI = confidence interval; SD = standard deviation.

**Table 2** Changes in Bone Level (mm)

<table>
<thead>
<tr>
<th>Surgical method</th>
<th>N</th>
<th>Mean bone height postoperative (mm)</th>
<th>Mean bone height 12 months postoperative (mm)</th>
<th>Mean bone loss (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>With mucoperiosteal flap (control)</td>
<td>100</td>
<td>–0.48 P = .004</td>
<td>0.07 P = .002</td>
<td>0.55 P &lt; .001</td>
</tr>
<tr>
<td>Flapless (test)</td>
<td>95</td>
<td>–0.18 –0.27 –0.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>195</td>
<td>–0.34 –0.10 0.24</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

After 1 year, the control group bone level retreated 0.55 mm, whereas bone gain of 0.09 mm was measured in the flapless group. Overall, 0.24 mm of bone was lost.

---

**Fig 4** Bone level (a) at the time of insertion (mBl\(_0\)) and (b) 1 year later (mBl\(_{12}\)) in the control and test groups (flapless).
results may be different for other implant types. A conical, self-locking implant-abutment connection seems to have a positive effect on bone remodeling and results in a low level of initial bone resorption.\textsuperscript{25–29} A mean bone loss of less than 0.4 mm around single-tooth implants was measured radiologically during an observation period of 4 years around conical implant connections.\textsuperscript{30} In a clinical, prospective multicenter study, Morris et al observed a marginal bone loss of 0.2 to 0.5 mm and a success rate of 96.6\% in 1,419 of the same implant type after 18 months.\textsuperscript{31} The loading stress in the implant placement site has been identified as a factor influencing successful osseointegration.\textsuperscript{2} Finite element analysis has shown that subcrestally placed implants lead to lower stresses in the bone than supracrestally positioned implants.\textsuperscript{32–34} Conversely, deep subcrestal implant placement (\textgreater{} 0.8 mm) also leads to high stresses in the bone.\textsuperscript{32} On the other hand, several human studies were unable to establish that insertion depth influences formation of the biologic width or increases crestal bone loss in subcrestal insertions.\textsuperscript{35–40} In studies with implant systems featuring a self-locking taper connection, a correlation between insertion depth and bone loss also could not be found. For subcrestal placements, this implant type appeared to have a stabilizing effect on the peri-implant bone\textsuperscript{34,39,41} or even promoted the deposition of new bone in the area of the implant shoulder.\textsuperscript{27,42,43}

In the present study, the implant shoulder in the entire patient cohort was on average still 0.1 mm below the crestal bone level after 12 months. In some cases, the implant shoulder was even clearly overgrown by bone, which supports the results of these studies. On average, the implants with the flap approach were inserted 0.3 mm deeper than those with the flapless implant placement. Based on the results of the subgroup analysis, an interaction between the two independent factors “insertion depth” and “surgical approach” could be excluded. Regardless of the insertion depth, but depending on the surgical procedure, both groups showed significantly higher bone loss around the implant shoulder when a mucoperiosteal flap was reflected (Table 2).

**DISCUSSION**

**Implant Type and Insertion Depth**

In the present study, the bone remodeling around two-piece implants with a self-locking taper connection and platform switching were examined. The surgical procedure (Fig 5) bone remodeling ($\Delta mBl_{12}$) after 1 year in the control and test groups (flapless).

<table>
<thead>
<tr>
<th>Surgical method</th>
<th>N</th>
<th>Mean</th>
<th>CI (±)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>With mucoperiosteal flap (control)</td>
<td>100</td>
<td>0.07</td>
<td>0.16</td>
<td>0.79</td>
</tr>
<tr>
<td>Flapless (test)</td>
<td>95</td>
<td>–0.27</td>
<td>0.14</td>
<td>0.66</td>
</tr>
<tr>
<td>Total</td>
<td>195</td>
<td>–0.10</td>
<td>0.11</td>
<td>0.75</td>
</tr>
</tbody>
</table>

After 1 year, the bone level was 0.07 mm below the implant shoulder in the control group vs 0.27 mm above implant level in the test group. Overall, the bone level was positioned 0.1 mm above implant level.

<table>
<thead>
<tr>
<th>Surgical method</th>
<th>N</th>
<th>Mean</th>
<th>CI (±)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>With mucoperiosteal flap (control)</td>
<td>100</td>
<td>0.55</td>
<td>0.11</td>
<td>0.57</td>
</tr>
<tr>
<td>Flapless (test)</td>
<td>95</td>
<td>–0.09</td>
<td>0.10</td>
<td>0.49</td>
</tr>
<tr>
<td>Total</td>
<td>195</td>
<td>0.24</td>
<td>0.09</td>
<td>0.62</td>
</tr>
</tbody>
</table>

After 1 year, the control group bone level retreated 0.55 mm, whereas 0.09 mm of bone gain was measured in the flapless group. Overall, 0.24 mm of bone was lost.

CI = confidence interval; SD = standard deviation.

The loading stress in the implant placement site has been identified as a factor influencing successful osseointegration.\textsuperscript{2} Finite element analysis has shown that subcrestally placed implants lead to lower stresses in the bone than supracrestally positioned implants.\textsuperscript{32–34} Conversely, deep subcrestal implant placement (\textgreater{} 0.8 mm) also leads to high stresses in the bone.\textsuperscript{32} On the other hand, several human studies were unable to establish that insertion depth influences formation of the biologic width or increases crestal bone loss in subcrestal insertions.\textsuperscript{35–40} In studies with implant systems featuring a self-locking taper connection, a correlation between insertion depth and bone loss also could not be found. For subcrestal placements, this implant type appeared to have a stabilizing effect on the peri-implant bone\textsuperscript{34,39,41} or even promoted the deposition of new bone in the area of the implant shoulder.\textsuperscript{27,42,43}

In the present study, the implant shoulder in the entire patient cohort was on average still 0.1 mm below the crestal bone level after 12 months. In some cases, the implant shoulder was even clearly overgrown by bone, which supports the results of these studies. On average, the implants with the flap approach were inserted 0.3 mm deeper than those with the flapless implant placement. Based on the results of the subgroup analysis, an interaction between the two independent factors “insertion depth” and “surgical approach” could be excluded. Regardless of the insertion depth, the flap, as an independent variable, had a significant effect on crestal bone resorption in the area of the implant neck.

**Surgical Procedure**

The results of the present study confirm findings of other recent studies that more bone loss is associated with flap elevation than with flapless implant insertion.\textsuperscript{34,45} However, many findings about the two placement techniques have been contradictory. Bone loss of 0.7 mm to 2.14 mm has been shown in some animal studies after flapless insertion,\textsuperscript{21,46,47} while in another study, no statistically significant difference was recorded.\textsuperscript{46} Flapless insertion resulted in higher and earlier implant stability in one animal study,\textsuperscript{49} while

© 2016 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY. NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.
in another, flapless implant placement in recent extraction sockets resulted in no significant advantage compared with placement in healed extraction sites in which a mucoperiosteal flap was raised.\textsuperscript{50,51} In a prospective human clinical trial, a higher bone level resulted after flap elevation and immediate implant placement after tooth extraction than it did with a transmucosal procedure.\textsuperscript{52} Another prospective clinical study from the same year confirmed this result, demonstrating significantly lower peri-implant bone resorption for implant placement after flap elevation, as compared with flapless insertion.\textsuperscript{53}

Despite the inconsistent study results, the findings of the present study indicate that flapless implant is a promising method\textsuperscript{54–56} that confirms the approximately 99% survival rate found for transmucosally inserted implants followed through a 4-year period in a multicenter study in humans.\textsuperscript{56,57} A review based on a MEDLINE search of relevant literature has also confirmed the effectiveness and efficiency of the transmucosal placement method.\textsuperscript{58}

**Radiographic Measuring Method**

Standardized radiographs are subject to inaccuracies that result from distortions due to nonparallel alignment of the sensor plane toward the implant axis. Another problem is that the positioning of the x-ray tube cannot be reproduced exactly toward the sensor plane. Because of changes in the occlusal surface by the definitive prosthetic restoration, the bite planes for the follow-up examination often cannot be exactly repositioned. To avoid these problems in the present study, the radiographs were digitally calibrated based on the implant dimensions. Cases with high distortion were excluded. Only the change in the bone level mesial and distal to the implants could be measured with the technique used, whereas the critical zone of bone loss is typically on the buccal. This area cannot be assessed by the use of dental films. However, since peri-implant bone loss is a three-dimensional process,\textsuperscript{59} buccal bone loss caused by remodeling would also involve the proximal area. Clinically, relevant buccal bone loss would also have been noticed by the emergence of vestibular recessions, which was not the case with any of the implants in the present study. Accurate readings of three-dimensional bone loss are not possible even with today’s computed tomographic (CT) or cone-beam CT (CBCT) technology. Metal artifacts and the strong digital contrasting of the images do not allow detailed measurement of the peri-implant bone. In addition, the use of CTs cannot be justified according to Section 23 of the German x-ray ordinance (§ 23 Röntgenverordnung).

**Disadvantages of Flapless Implant Insertion**

A disadvantage of flapless insertion compared with the nonsubmerged method is the reduced field of view and difficult evaluation of bone conditions. This may even result in a longer duration of surgery than when using the full-flap technique. Due to the lack of visibility in the flapless approach, the mucosal level was used as an intraoperative reference point. This led in the test group to a shallower implant insertion (0.3 mm on average) compared with the control group. The lower insertion depth had no unfavorable effects on the crestal bone resorption. In the control group, the implant shoulder was at about bone level on average after 1 year, whereas the implant shoulder in the test group was on average 0.27 mm below bone level despite the lower insertion depth.

The disadvantages of less visibility during a flapless approach can be compensated by the use of three-dimensional imaging techniques for diagnosis (CBCT) and template-guided insertion based on it.\textsuperscript{50–63} Of course, the high exposure to radiation and the relevant x-ray regulations must be taken into account.

A further potential problem of flapless surgery is the increased risk of vestibular perforation. If a perforation of the marginal bone around the implant remains untreated, the formation of a recession and, in the worst case, implant loss can occur. Since no vestibular recessions were observed during follow-up in the flapless group, the probing of bone seems to provide adequate safety for flapless implant placement.

**CONCLUSIONS**

In the first months after implant placement, numerous factors influence the behavior of the peri-implant bone in the marginal area. These factors decide whether bone loss occurs or whether the peri-implant tissue remains stable. The way soft tissue is handled during surgery has an effect on bone remodeling. The present study shows that implant placement without elevation of a mucoperiosteal flap significantly reduces bone loss. Flapless insertion represents a protective and promising method in implant surgery.

**ACKNOWLEDGMENTS**

The author would like to thank Mrs Ute Vollmer for her help with the independent allocation of the patients and collection of data and Dr Tanja Kottmann and Dr Konrad Neumann for compiling the statistics. This study was not supported by payments or materials. All costs were borne by the author. After completion of the study, the author received contributions for lectures, case studies, videos and pictures, as well as material testing and development from Dentsply Implants.
REFERENCES


