A Prospective Multicenter Study on Radiographic Crestal Bone Changes Around Dental Implants Placed at Crestal or Subcrestal Level: One-Year Findings

Claudio Gatti, MD, DDS¹/Fulvio Gatti, DDS¹/Maurizio Silvestri, DDS²/Francesco Mintrone, DDS³/Roberto Rossi, DDS, MSc⁴/Gabriele Tridondani, DDS⁵/Giacomo Piacentini, DDS²/Paola Borrelli, DDS, PhD⁶

Purpose: To compare the peri-implant radiographic crestal bone changes around implants placed at the subcrestal or crestal level. Materials and Methods: Systemically healthy patients with at least two missing teeth requiring implant-supported fixed prosthetic restorations were enrolled in the study. Implants were randomly placed either 1 mm subcrestally or at the bone crest level. Radiographic examination was performed using the long-cone parallel technique and customized film holders. Digital periapical radiographs were obtained at the time of implant placement (T₀), at the time of prosthesis delivery (T₁), and 12 months (T₂) after prosthetic loading. Marginal bone levels were measured at the mesial and distal aspects of each implant with digital image software. Results: A total of 54 implants were present for the radiographic analysis at the 12-month follow-up. No implant showed mechanical or biologic complications throughout the follow-up period. The implant survival percentage was 100%. After 1 year, the mean bone loss was 0.711 ± 0.721 mm in the subcrestal group and 0.224 ± 0.418 mm in the crestal group. Furthermore, only the subcrestal group showed statistically significant radiographic bone resorption at the end of the follow-up. Conclusion: Within the limitations of this study, implants placed at the crestal level showed greater peri-implant bone stability during the 1-year follow-up. Studies with larger samples and longer follow-up are needed to confirm the results of this investigation. Int J Oral Maxillofac Implants 2018;33:913–918. doi: 10.11607/jomi.6509

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The maintenance and stability of peri-implant bone levels are a prerequisite for a good functional and esthetic prognosis of implant-supported prosthetic rehabilitations.

After dental implant placement, crestal bone undergoes resorption and remodeling processes.¹

Radiographic marginal bone level is considered to be an important parameter for evaluating peri-implant health and long-term clinical outcomes.²⁻⁴

After 1 year of functional loading, a radiographic reduction of the bone level from the implant-abutment junction (IAJ) of 0.42 mm and 0.40 mm on the mesial and distal aspects, respectively, can be observed around two-piece tapered implants with a rough surface.²

Different mechanical and biologic factors have been evaluated to explain this fact.

In particular, it seems that the re-establishment of the peri-implant biologic width, formed by the junctional epithelium and supracrestal collagen fibers, leads to crestal bone remodeling,⁵,⁶ and this is independent of the surgical technique⁷ or the implant system employed.⁸

Other factors can have an impact on the amount of bone resorption around implants, such as the repeated connection/disconnection of the abutment during the prosthetic phase⁷,⁸ and the three-dimensional position of the implant. If the coronal aspect of the implant is placed close to the adjacent teeth/implants or to a thin residual buccal bone, crestal resorption can occur.⁹

The apico-coronal position of the implant can play a role in marginal bone remodeling, but data from the literature are limited and controversial.⁴,¹⁰,¹¹
In fact, clinical studies demonstrated that a more apical position of the IAJ was associated with greater stability of the bone margin,\textsuperscript{12,13} while other investigations reported an increased extent of the inflammatory infiltrate related to a more apical position of the implant-abutment interface compared with the bone crest.\textsuperscript{14}

The primary aim of this study was to evaluate radiographic peri-implant hard tissue remodeling of TSIII Osstem implants placed at the crestal and subcrestal levels in partially edentulous patients; the secondary aim was to assess the implant survival percentage at 12 months.

**MATERIALS AND METHODS**

**Study Design**

A prospective multicenter study was designed to evaluate the clinical and radiographic effects of implants placed 1 mm below the alveolar crest level or at the bone crest level on radiographic hard tissue changes and implant survival.

The study was conducted at four centers in Italy.

One group was represented by implants inserted 1 mm subcrestally, while the other group consisted of implants placed at the bone level.

Radiographic parameters were evaluated at baseline (T\textsubscript{0}), at the time of prosthetic delivery 3 months after implant insertion (T\textsubscript{1}), and at 12 months (T\textsubscript{2}).

**Investigator Meeting**

An investigator meeting was performed in which the implant system was thoroughly revised. A calibration meeting was performed before starting the study.

**Sample**

This study was conducted in accordance with the revised World Medical Association Declaration of Helsinki. All patients signed informed consent forms after being informed of all risks and benefits.

Implants were randomly assigned to one of the two groups and placed either at the subcrestal or crestal level.

Adult patients aged 20 to 85 years were consecutively enrolled in the study.

The inclusion criteria were as follows: good systemic conditions (ASA I and ASA II), at least two missing teeth to be replaced by dental implants, and sufficient crestal bone in a buccolingual dimension.

Implants had to be inserted with a minimum torque of 20 Ncm to be included in the study. Patients were excluded from the study if any of the following criteria were present: heavy smokers (≥ 20 cigarettes/day), contraindications to implant treatment (metabolic disorders, hematologic disorders, taking bisphosphonates), head or neck irradiation in the 12 months before implant surgery, chemotherapy, pregnancy and lactation, active periodontal disease at the time of implant placement, absence of teeth or fixed restorations in the opposite arch, or previous bone augmentation procedures in the site of implant insertion.

**Implants and Implant Sites**

The implants employed in this study were Osstem TSIII conical, 3.5 and 4 mm diameter of variable length, with internal conical connection and sandblasted, acid-etched (SA) surface. Matching abutments were used, so the abutment diameters were either 3.5 or 4 mm.

Implant sites had to be free of infection at the time of implant placement.

In the case of tooth extraction, at least 2 months of healing passed before implant surgery was performed. Flapless placement was excluded.

**Presurgical Treatment**

Each patient underwent a careful clinical and radiographic periodontal examination.

All the enrolled subjects were screened with the Periodontal Screening Recording (PSR) method and categorized as periodontally healthy (classes 0, 1, and 2), moderate (class 3), or advanced periodontitis (class 4).

Classes 1 and 2 were treated with periodontal etiologic therapy consisting of oral hygiene instructions and full-mouth supragingival scaling.

Class 3 and 4 patients were treated with periodontal etiologic therapy consisting of oral hygiene instructions and full-mouth supra- and subgingival scaling, and periodontal surgery was performed when needed.

All patients had to belong to class 0 at the time of implant placement. Full-mouth plaque score (FMPS) and full-mouth bleeding score had to be < 15% at the time of implant surgery.

Implant length and diameter were determined in relation to the available bone.

**Surgical Procedure**

Systemic antibiotic prophylaxis (amoxicillin + clavulanic acid, 2 g) was performed 1 hour prior to surgery. In patients allergic to penicillin, systemic macrolides were administered (azithromycin, 500 mg).

Intraoral mouthrinses with 0.2% chlorhexidine digluconate were performed for 2 minutes, and local anesthesia was administered (articaine 1:200,000) before starting the surgery.

Surgical interventions were performed under sterile conditions.

A midcrestal incision was performed, and a full-thickness flap was elevated to expose the alveolar ridge. No releasing incisions were made when possible.
Bone flattening was performed when necessary before implant site preparation. Implant sites were prepared according to the manufacturer’s instructions under copious sterile irrigation. Before implant insertion, a sealed envelope was opened containing the treatment assignment for each implant.

Implants had to be randomly inserted by two modalities:

- 1 mm subcrestally, referring to the stop mark on the bur of the Osstem kit (subcrestal group)
- At the bone crest level, referring to the bur mark of the Osstem kit (crestal group)

Sinus elevation was allowed when necessary, as long as it was performed with the Osstem Cas kit. All implants were placed at a minimum distance from the neighboring teeth of 1.5 mm, and the distance between two adjacent implants was at least 3 mm.

A screw-retained healing abutment was connected to the implant and flap sutured, attempting for primary closure using 4/0 or 5/0 sutures.

An intraoral radiograph with the long-cone paralleling technique was performed using individualized film holders. The position and the angulation of the film holder were standardized for each patient using individual wax bites (Tenawax, Industria Zangardi) in order to allow reproducibility during the follow-up period. All the radiographs were scanned and analyzed with ImageJ software, based on Java (Sun Microsystems).

A calibrated examiner not involved in the clinical part of the study performed all the measurements (G.T.). To take into account the possible distortion of the films, the linear dimensions of the digital images were calibrated using platform height and implant length as double cross-references.

The distance between the IAJ and the bone crest was assessed to the nearest tenth of a millimeter at the mesial and distal aspects for every implant. The mean of the two values was the endpoint variable of the study.

A positive value was assigned if the bone crest was apical to the IAJ, the value was zero if the IAJ was at the bone crest level, and the value was negative if the bone crest was coronal to the IAJ.

**Peri-implant Radiographic Evaluation**

Radiographic examinations were performed at the time of implant placement (T₀), at the time of prosthesis delivery (T₁), and 12 months (T₂) after functional loading (Figs 1 to 3).

Intraoral periapical radiographs were taken to evaluate the peri-implant marginal bone level using the long-cone paralleling technique and individual film holders. The position and the angulation of the film holder were standardized for each patient using individual wax bites (Tenawax, Industria Zangardi) in order to allow reproducibility during the follow-up period. All the radiographs were scanned and analyzed with ImageJ software, based on Java (Sun Microsystems).

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**Statistical Analysis**

The sample was described by means of the usual descriptive statistics: mean and standard deviation for continuous variables.

Normality distribution of the endpoint variable was tested by the Shapiro-Wilk test and by the skewness and kurtosis values compared with their standard
Table 1  ANOVA Mixed Model

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<th>Variability source</th>
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<th>df</th>
<th>P</th>
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<td>Time</td>
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<td>1.17</td>
<td>75.74&lt;.001</td>
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<tr>
<td>Placement</td>
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<td>51</td>
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<tr>
<td>Interaction (time-placement)</td>
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<td>1.48</td>
<td>75.74&lt;.001</td>
</tr>
<tr>
<td>Center</td>
<td>3.76</td>
<td>1</td>
<td>51</td>
</tr>
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</table>

*Due to the violation of sphericity, the Greenhouse-Geisser correction was applied.

Fig 4 Mean ± SD values (95% CI) of radiographic bone level changes by time period and placement.

DISCUSSION

The present study demonstrated that during the first year of function, implants placed both at the crestal and subcrestal levels presented a reduction of radiographic bone levels. Thoroughly analyzing these results, implants placed at the crestal level showed 0.224 ± 0.418 mm bone loss, while implants placed at the subcrestal level showed a bone resorption of 0.711 ± 0.721 mm between the baseline and the end of follow-up.
Two aspects emerge from the interpretation of these data. The crestal group showed great peri-implant bone level stability during the entire follow-up period as opposed to the subcrestal group. In the latter, the greater bone loss occurred in the first 3 months after implant insertion. These results are significant from a clinical point of view.

A systematic review reported that bone resorption ranged from 0.26 ± 0.22 mm to 1.8 ± 0.39 mm for implants placed at the crestal level and from 0.05 mm to 1.40 ± 0.50 mm for implants placed at the subcrestal level with a follow-up between 6 and 60 months.10

According to the present study, it must be pointed out that even if the subcrestal group showed greater bone loss, this can be considered as “physiologic” if compared with data from the literature.1–4,10

A possible explanation for this may be that during the first weeks of healing, the connective tissue and the junctional epithelium proliferate and form a biologic seal around the healing abutments.1

Furthermore, the IAJ after abutment connection and the prosthetic functionalization may be an area of bacterial infiltration and mechanical stress accumulation, which may also lead to bone loss.15,16

Some animal studies were performed to investigate the impact of crestal and subcrestal implant placement on peri-implant marginal bone.13,14

In one of these studies, matching abutments were employed, and a greater bone resorption was found at implants placed 1 or 2 mm under the bone crest level, compared with implants placed 1 mm above or at the crest level. The authors attributed this to a different behavior of tissues surrounding dental implants, and the possibility that a biologic width of less than 2 mm could be established.

However, this is in contrast with the results of other previous studies,17,18 in which no statistically significant differences were found between implants inserted at the crestal and subcrestal levels, even when using matching abutments.18

In a histologic study by Degidi et al,19 implants placed at the crestal level showed 0.5 to 1.5 mm of marginal bone resorption, while implants placed subcrestally showed an overgrowth of bone on the implant platform.

These data are in contrast with the results of the present investigation, in which the subcrestal group showed statistically significantly greater bone loss than the crestal group.

In a recent study by Aimetti et al,20 a mean bone crest resorption of 0.32 mm was found around two-piece platform-switching implants placed 1 mm subcrestally after 2 years of function.

These data show limited bone remodeling if compared with the results of the subcrestal group in the present study.

However, in the present investigation, matching abutments were employed, and this could have an influence on the amount of peri-implant bone resorption.

Furthermore, in the present study, a flattening of the bone crest was performed before placing the implants when necessary, which was not done in the study by Aimetti et al.20 This may lead to greater bone resorption after implant placement, but provides a uniform bone level around all the implant surfaces.

It must also be taken into account that the present study used tapered implants. The preparation of the implant site in the subcrestal group can cause stress on marginal bone, which can turn into greater resorption after implant placement.

However, in the present investigation, implant diameter was properly selected in order to have sufficient bone on buccal and distal/palatal aspects.

It has been documented that the repeated disconnection of the abutment may be related to crestal bone loss and may cause mucosal recession.7,8,21

The present study tried to avoid any interference with the healing process by performing implant-abutment disconnection only one time, when the prosthesis was connected to the implant.

This investigation presents some limitations: the measurements were performed on periapical radiographs, which may not be precise in the exact determination and may underestimate peri-implant bone crest levels.22

**CONCLUSIONS**

Within the limits of this study, TSIII Osstem implants placed 1 mm subcrestally showed greater bone resorption than those placed at the crestal level, which showed peri-implant bone level stability 1 year after insertion. Further studies with longer follow-up are needed to draw more definitive conclusions.

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