A Retrospective Radiographic Analysis of Bone Loss Following Placement of TiO_2 Grit–Blasted Implants in the Posterior Maxilla and Mandible

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Purpose: *Cortical bone is a determinant of implant esthetics and may contribute to the biomechanical integrity of the implant-supported prosthesis. Historically, approximately 1.0 to 1.5 mm of bone loss has occurred immediately following second-stage surgery and implant loading. Recent consideration of implant design suggests that surface topography may affect crestal bone responses at the implant interface. The aim of this retrospective study of 102 implants in 48 subjects supporting posterior fixed partial dentures was to radiographically define the behavior of crestal bone at* TiO_2 *grit–blasted implants following surgical placement and subsequent loading in the posterior maxilla and mandible.* ***Materials and Methods:*** *The crestal bone position relative to the implant reference point (junction of the crestal bevel with the* TiO_2 *grit–blasted surface) was evaluated at implant placement, at abutment placement, and 6 to 36 months following restoration, with an average recall period of 2.3 years. The implant position and dimension were recorded. A single investigator using 7× magnification assessed all radiographs.* ***Results:*** *Crestal bone loss from the time of implant placement up to 36 months following restoration ranged from 0.0 to 2.1 mm. Of the 102 implants, 14 implants showed greater than 1.0 mm of crestal bone loss. They were not clustered at any particular tooth position. Eighty of the implants showed less than 0.5 mm of radiographically measured bone loss. Mean crestal bone loss was 0.36 mm (± 0.6 mm). Averages of 0.57 and 0.24 mm loss were shown for 3.5- and 4.0-mm-diameter implants, respectively (*$P < .051$*). Bone gain was seen at several 4.0-mm-diameter implants.* ***Discussion:*** *This retrospective evaluation indicates that the radiographically measured bone loss may be expected to be less than 1 mm following placement and loading of* TiO_2 *grit–blasted implants. The close approximation of bone with the implant/abutment interface suggests the attenuation of any microgap-induced bone loss. Additional reasons for crestal bone maintenance may include factors attributed to implant surface roughness and loading along a tapered implant/abutment interface.* ***Conclusions:*** *Several clinical advantages for maintaining crestal bone at implants supporting posterior prostheses can be identified.* (Int J Oral Maxillofac Implants 2002;17:399–404)

Key words: *alveolar process, dental implants, implant design, retrospective analysis, surface properties*

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Endosseous titanium implants provide completely and partly edentulous patients a more comfortable and esthetic alternative to removable partial dentures.[1] Implant success is reliant on multiple factors: implant design, masticatory/loading conditions, surgical procedures, complications, and host factors.[2] This is particularly complex for the implant-supported posterior fixed partial denture.[3]

Success rates for implants and prostheses in posterior quadrants vary among studies, but it may be generally concluded that implant and prosthesis success for molars and posterior partial prostheses is lower than the success rates published for single-tooth implants or edentulous mandibles.[4,5] A potential

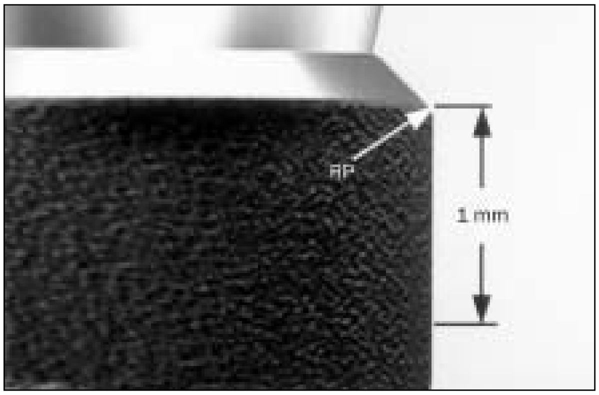


Fig 1 Schematic representation of the crestal aspect of implants used in this study. The TiO_2 grit–blasted surface extends to the machined crestal bevel, providing a rough surface in crestal bone. Note the reference point (RP) for measurement of implant/crestal bone relationships. For reference, a 1-mm region along the unthreaded crestal aspect of this implant is indicated. Implants of 8 to 17 mm in length and 3.5 or 4.0 mm in diameter were used.

complicating factor affecting implants supporting posterior prostheses is crestal bone loss. For example, 1.67 mm of bone loss was recorded for molar implants with success rates of 83% to 88%, and it was concluded that bone levels were not related to implant success.[6] However, it is unclear what the bone levels were at failed implants. Rangert and coworkers[7] identified an association between cupping crestal bone loss and implant fracture; the causal relationship remains to be defined. When osseous support factors are considered among the risk factors for implant dentistry, the crestal bone support may be critical to implant success, especially for implants shorter than 9 or 10 mm. If bone loss occurs at the first or second thread of conventional screw-type implants, then 10% to 15% of dense bone support may be lost.

The causes of crestal bone loss are attributed to many factors, and among the various hypotheses, proof for one or another cause remains elusive. The presently unexplained minimization of crestal bone loss (< 0.4 mm) at titanium dioxide (TiO_2) grit–blasted implants suggests that implant design may be a key factor.[8] While the evidence is inconclusive, various authors suggest this is the result of a combination of effects or attributes, including *(1)* limited drilling procedure and restricted second-stage surgery, *(2)* rough implant surface in crestal bone, *(3)* microthread design for implant stiffness, *(4)* loading along a conus versus flat interface, and *(5)* the absence of a significant microgap. Clinical documentation for this implant design suggests it is possible to improve upon the historically recorded and accepted criterion for crestal bone loss of 1 to 2 mm during the first year in function.[2]

Beyond a limited interpretation of possible cause and effect, existing reports of crestal bone responses have focused on the anterior single-tooth restoration or implants in the mandibular parasymphysis. Crestal bone responses at implants supporting posterior partial dentures require analysis. In an initial attempt to gain insight to this phenomenon, a retrospective analysis of patient records of 102 consecutively placed implants supporting posterior partial dentures was undertaken. The purpose of this retrospective study was to evaluate the change in crestal bone levels adjacent to the implant reference point from the time of implant placement to a period 6 to 36 months after loading.

MATERIALS AND METHODS

Records of 48 patients with ages ranging between 18 and 80 years (average = 52 years) who had implants placed in the posterior maxilla and mandible were evaluated. Fourteen were men and 34 were women. The implants were placed and restored by faculty or graduate students at the University of North Carolina School of Dentistry. The implant sites included all maxillary and mandibular premolar and molar positions. The loading period for implants was from 6 months to 5 years (mean = 2.3 years).

TiO_2 grit–blasted, parallel-sided implants of 3.5 or 4.0 mm diameter and 8 to 17 mm in length (Astra Tech, Lexington, MA) were placed using a 2-stage procedure, with abutment placement occurring 3 to 6 months after implant placement. Radiographs were taken of the implants immediately after implantation, at postoperative appointments, and at regular annual recall appointments. Several patients were recalled to provide a complete radiographic follow-up record.

The majority of radiographs were periapical films, but some initial images (at implant placement) were panoramic radiographs. Periapical radiographs were not standardized and were made by a single examiner using rectangular columnation with the use of a Rinn device (Rinn, Elgin, IL). Bone levels were measured relative to the implant reference point using the Peak Scale Lupe 7× (Structure Probe, West Chester, PA). Measurements were made from the crestal bevel to the height of the crestal bone on both the mesial and distal of each implant (Fig 1). This average bone level for each implant was recorded. Implant length and diameter were also recorded and compared to the documentation dimensions; ratios were calculated to adjust for distortion.

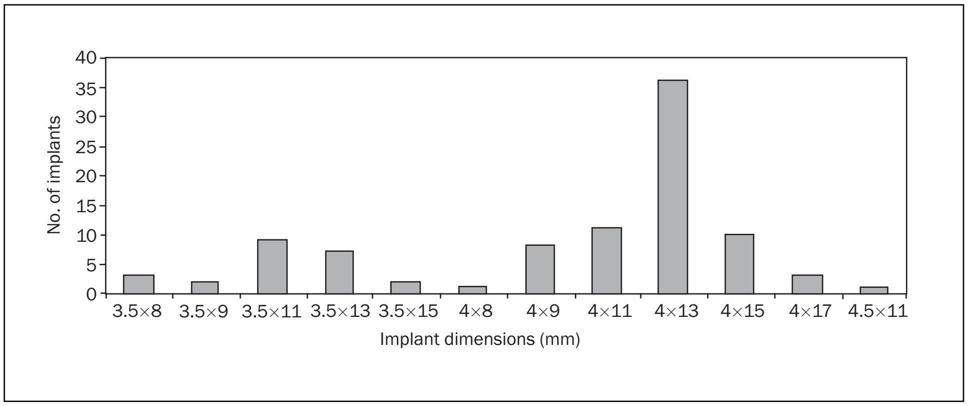
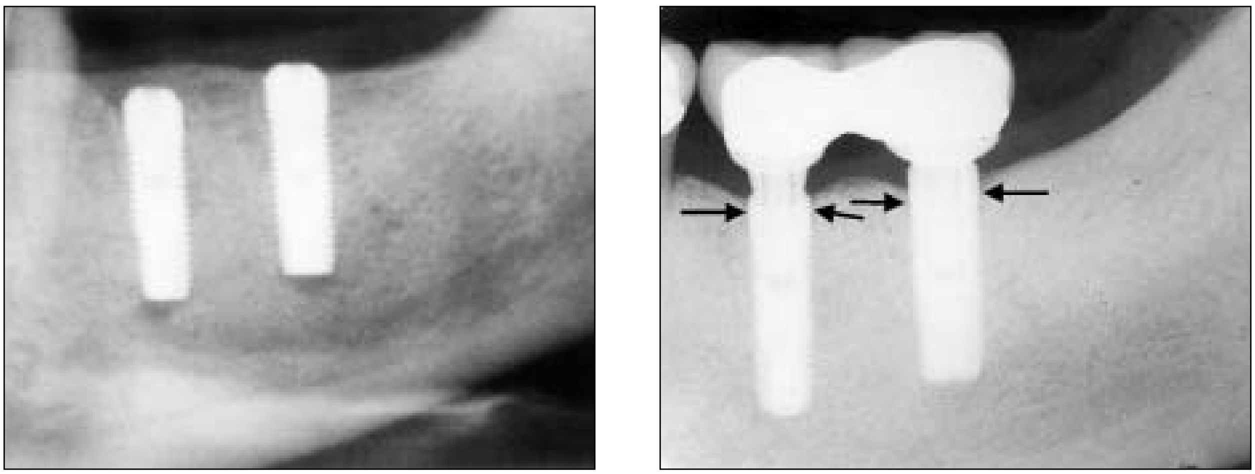


Fig 2 Distribution of implants evaluated.



Figs 3a and 3b Radiographs of implants placed for restoration of mandibular left molar and premolar. *(Left)* Level of crestal bevel at surgical placement suggests the crestal bevel was superior to or at the level of existing crestal bone. *(Right)* Level of crestal bone 1 year following loading of implants with cement-retained, porcelain-fused-to-metal fixed partial denture. Arrows indicate level of crestal bone.

RESULTS

One hundred two implants were evaluated in 48 patients. Sixty-one implants were placed in the posterior mandible and 41 implants were placed in the posterior maxilla. The number and dimensions of implants used are shown in Fig 2.

Both crestal bone loss and crestal bone gain at the transcrestal region of the implants were recorded. Of the 102 implants, more than half (62) had bone loss of 0.5 mm or less, 80 had bone loss of less than 1.0 mm, and 14 had bone loss of 1.0 mm or more. However, 4 mandibular molar position implants gained bone height, with an average of 0.5 mm.

A typical example of moderate negative crestal bone loss from mandibular implant placement to the 1-year recall period is shown in Fig 3. In a similar situation, positive crestal bone loss was also recorded at several 4.0-mm-diameter implants in the mandible as illustrated in Figs 4a to 4c. There was no difference in the bone loss at maxillary versus mandibular implants. Figures 5a to 5c exemplify the crestal bone responses at maxillary implants examined.

The length and diameter of the implants were considered as possible variables in this study. The attribution of crestal bone loss to each 3.5-mm implant evaluated is presented in Fig 6. The number of 4.0-mm-diameter implants of each length displaying 0 to 2 mm of crestal bone loss is presented in Fig 7. There was no obvious association between bone height and implant location.

When implant diameter was considered, it must be noted that one 3.5-mm implant fractured after 2.5 years of function. Crestal bone loss of 4 mm preceded fracture. For the thirty-six 3.5-mm-diameter

Figs 4a to 4c Implants replacing mandibular right molar and premolars.

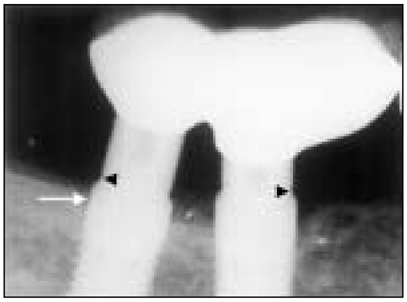


Fig 4a Note the radiographic representation of the level of crestal bone in relationship to the implant/abutment connection 1 year following loading of implants with screw-retained, porcelain-fused-to-metal fixed partial denture.

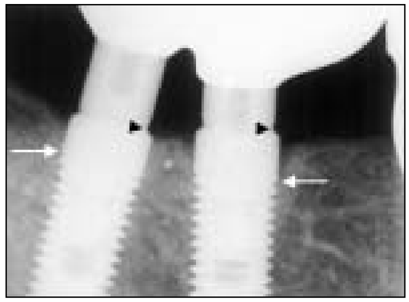


Fig 4b Note the radiographic representation of the level of crestal bone in relationship to the implant/abutment connection 2 years following loading of implants. Although implants are within 2 mm of each other, there is no loss of interproximal bone.

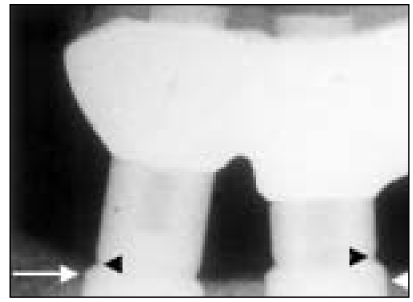


Fig 4c Note the radiographic representation of the level of crestal bone in relationship to the implant/abutment connection and the continued filling of a vertical defect on the mesial aspect of the mesial implant 3 years following loading of implants.

Figs 5a to 5c Implants replacing maxillary left first molar and second premolar.

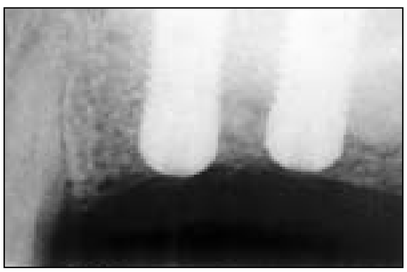


Fig 5a The radiographically indicated level of crestal implant bevel at surgical placement approximated the level of existing crestal bone.

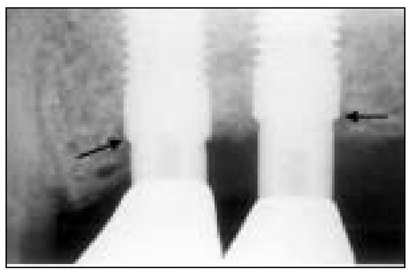


Fig 5b One year following loading of implants with screw-retained, porcelain-fused-to-metal fixed partial denture; the radiographic representation of this relationship remains unchanged.

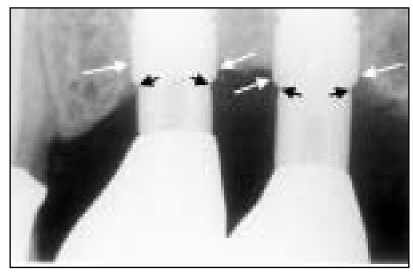


Fig 5c The radiographic representation of the crestal bone relationship to the implant abutment connection remains unchanged 2 years following loading of implants.

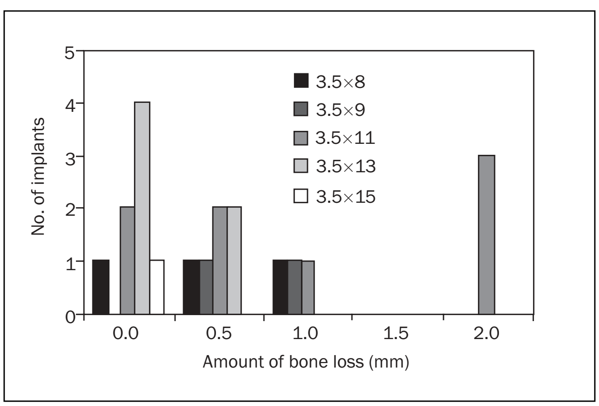


Fig 6 Distribution of bone level measurements at 3.5-mm implants.

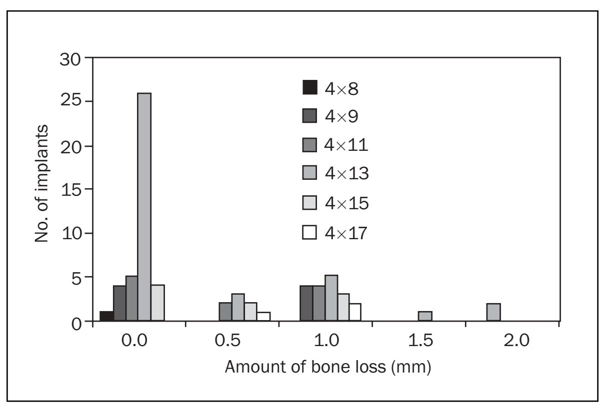


Fig 7 Distribution of bone level measurements at 4.0-mm implants. One 4.5-mm implant is included in the data set and is not plotted (bone loss was ≤ 0.5 mm).

implants placed, 5 presented with more than 1 mm of crestal bone loss. For the sixty-four 4.0-mm-diameter implants placed, 9 presented with more than 1 mm of crestal bone loss. Averages of 0.57 and 0.24 mm of bone loss were shown for 3.5- and 4.0-mm-diameter implants, respectively ($P < .051$).

DISCUSSION

This study sought to determine the crestal bone levels present at Astra Tech implants supporting posterior partial dentures in both the maxilla and mandible. The results confirm previous reports that crestal bone levels approximate the implant/abutment interface and remain stable at TiO_2 grit–blasted implants.[9–14] However, there are several important limitations to this study and key limitations to valid interpretation.

The retrospective method inherently limits the rigor of the investigation. These 48 patient records represent the set of consecutive records meeting the inclusion requirement of postsurgical and 6-month minimum post-restorative radiographs. These patients experienced no early failures, and there were no failures identified at second-stage surgery.

The radiographs were not standardized. To account for variability, the implant dimensions (width and length) were measured and compared to the documentation dimensions; and ratios were calculated to adjust for distortion. The accuracy of measurement was determined by repeat measurements by the single examiner and estimated to be 0.12 mm.

In this diverse group of patients, specific inclusion or exclusion criteria were not established. Any possible impact of peri-implant inflammation, adjacent periodontal disease, smoking, etc, was not evaluated. With the exception of aggressive bone loss preceding the fracture of one 3.5-mm implant, there was no incidence of excessive bone loss at implants and there was no recorded incident of peri-implant inflammation. One reasonable interpretation of the data is that TiO_2 grit–blasted implants are not especially susceptible to peri-implant inflammation.

These findings cannot be directly compared to other data concerning other implant systems. The stated purpose of the investigation was to determine the bone levels at these implants only. Other studies have compared bone levels at this implant with those at other implant systems. Astrand and coworkers[15] failed to distinguish crestal bone responses between the Astra Tech and Nobel Biocare implant systems (Yorba Linda, CA). In a smaller study of 15 Astra Tech and 15 Brånemark (Nobel Biocare) implants, there was less radiographic bone loss after 2 years of function at the Astra Tech than at the Brånemark implants (0.6 mm versus 1.6 mm, $P < .001$).[16] When ITI (titanium plasma spray–coated; Straumann Institut, Waldenburg, Switzerland) and Astra Tech implants were compared in periodontally compromised patients, a significantly greater number of ITI implants showed greater than 3.5 mm of bone loss after 60 months.[17] The present findings are consistent with these results, demonstrating minimal bone loss following placement and loading of posterior TiO_2 grit–blasted implants.

Radiographically measured bone loss at the 4.0-mm implants was less than at the 3.5-mm implants. One possible explanation is the greater stiffness of the wider implant.[18] This is consistent with observations made for the Astra Tech ST implant, for which radiographically measured bone loss has been repeatedly shown to be less than 0.5 mm.[11–14] A key difference between the 4.5-mm ST implant and the 3.5- and 4.0-mm implants is that the ST implant is embellished with crestal microthreads. Microthreads are not present on these 3.5- or 4.0-mm implants, and this may also contribute to the lower bone loss found at the 4.5-mm ST implant.

The present findings indicate that the level of crestal bone approximates the implant/abutment interface. This relationship of the implant/abutment interface to crestal bone is not consistent with the microgap theory to account for radiographically evident crestal bone loss.[18] Thus, alternative implant designs may allow the advantages of 2-part systems to be invoked without concern for microgap-associated crestal bone loss (Figs 3 to 5). Design factors may contribute to the preservation of crestal bone. Surface topography was shown to affect crestal bone levels at otherwise identical implants in a canine model.[19] The presence of a rough surface in the crestal bone,[20,21] as well as the predicted differences in mechanical loading of crestal bone when implant loading occurs along a conus interface versus a flat-to-flat interface, represent additional factors that may contribute to the maintenance of crestal bone near the location upon implant placement.[22]

Bone gain occurred at 5% of the implants and was restricted to the mandible. This does indicate that bone gain could be one long-term outcome at endosseous implants. Other prospective research has demonstrated similar bone gain for similar TiO_2 grit–blasted implants embellished with microthreads that were placed in the edentulous mandible.[23] Long-term evaluation of these and additional patients may provide a more generalized understanding of this phenomenon.

SUMMARY AND CONCLUSIONS

This limited, retrospective study indicates that little crestal bone loss occurred at 3.5- or 4.0-mm TiO_2 grit–blasted implants after 6 months to 3 years of loading. This reiterates the reported preservation of crestal bone observed at similar implants. Implant design factors may generate favorable responses in cortical bone. These preliminary observations merit further comparative study to elucidate the implant design factors that contribute to the radiographically observed crestal bone responses.

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