

# Influence of Flap Design on Peri-implant Interproximal Crestal Bone Loss around Single-tooth Implants

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*The anterior maxilla represents a therapeutic challenge for single-tooth replacement with implants. The surgical trauma delivered to soft and hard tissues during implant placement can influence the future esthetic result. The clinician should use surgical techniques that prevent esthetic complications, such as increased crown length or loss of interdental papillae, without compromising osseointegration. This prospective study investigated the interproximal crestal bone loss occurring after placement of single-tooth implants using 2 different flap designs: a widely mobilized flap design that included papillae, and a limited flap design that protected papillae. The interproximal crestal bone loss was of practical importance and statistically significantly less following the use of a limited flap design versus the widely mobilized flap procedure. (INT J ORAL MAXILLOFAC IMPLANTS 2001;16:61–67)*

**Key words:** alveolar bone loss, comparative study, dental papillae, implant-supported dental prosthesis, preprosthetic oral surgical procedures, single-tooth dental implants, surgical flaps

Loss of the anterior dentition can be a significant problem for the patient and a challenge for the dentist. Among the possible therapeutic options are various restorative choices, such as the fixed prosthesis, bonded restoration, removable partial denture, or orthodontic space closure. Growing preference is now being given to the placement of endosseous implants, which have demonstrated high success rates in appropriate indications with careful surgical technique.<sup>1–8</sup>

It is not known to what extent the trauma to the soft and hard tissues created by the surgical flap influences peri-implant bone loss. This may have consequences on the long-term esthetic results, as evidenced by studies by Tarnow and coworkers of

the effect of the distance from the contact point to the crest of the bone on the presence or absence of papillae.<sup>9</sup>

The aim of this prospective study was to determine to what extent the surgical flap used during implant placement influences peri-implant interproximal crestal bone loss.

## MATERIALS AND METHODS

### Surgical Techniques

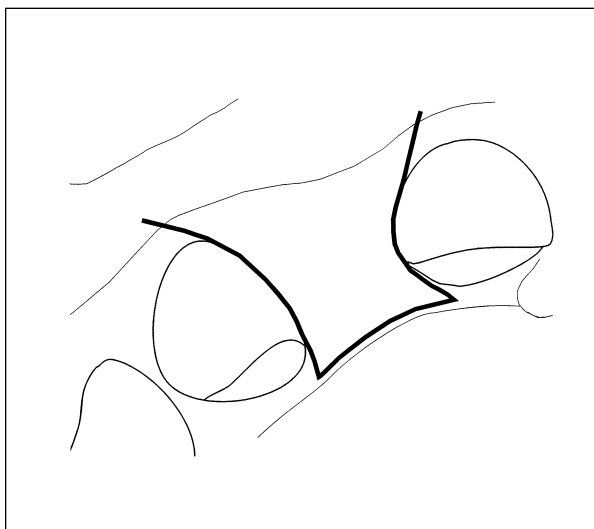
Two flap techniques were utilized for placement of single-tooth implants: the conventional technique with a widely mobilized flap that included the interdental papillae, and a limited flap design that protected the interdental papillae.

*Widely Mobilized Flap.* For this procedure, the mucoperiosteal flap, including the interdental papillae, is elevated for placing the implants (Fig 1a). The flap can also be extended to allow inspection of the labial bone. The interproximal crestal bone is denuded of the periosteum.

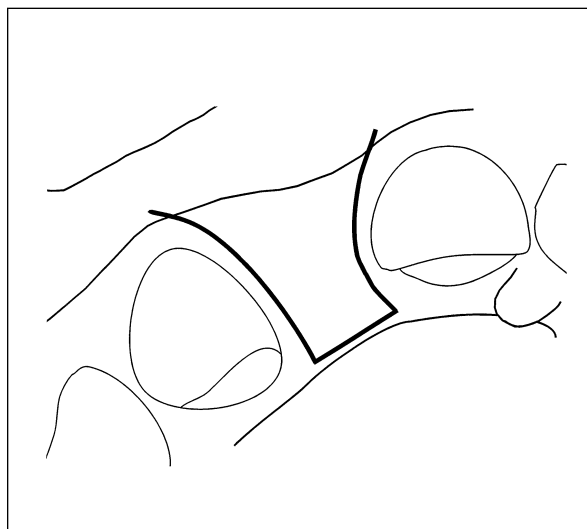
*Limited Flap Design.* The goal of this surgical technique is less traumatic preparation of the soft tissues. The interdental papillae are preserved as much as possible; for that purpose, they are not

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**Fig 1a** Widely mobilized flap, which includes the interproximal papillae.



**Fig 1b** Limited flap design, which protects the papillae (minimum width of the interdental papilla is 1 mm).

included in the mucoperiosteal flap but maintained at a width of 1 to 2 mm attached to alveolar bone (Fig 1b). All incisions should include the periosteum and are made with a No. 11 scalpel blade (Aesculap AG, Tuttlingen, Germany). The incision is made from the distofacial flap margin, 1 to 2 mm from the tooth adjacent to the edentulous space, and extended palatally in a curvilinear fashion to a point approximately 4 mm palatal to the alveolar crest. The other side of the incision is made in a similar manner. To sever the periosteum at the palatal extent, the incisions are then redrawn with the scalpel tip.

The palatal ends of the incisions are connected with a horizontal cut that extends down to bone. The mucoperiosteal flap is detached using a small elevator, avoiding harm to the papillae and any other traumatic manipulation. The mucoperiosteal flap is elevated to the extent required for placement of the implants. The flap can be extended to allow inspection of bone contours on the labial aspect if there is concern that the cortical plate may be perforated during preparation of the implant site.

### Study Design

This study included data of patients treated with non-splinted single-tooth Frialit-2 implants (Friadent, Mannheim, Germany) by different surgeons of the Collaborative Research Department A7 "Surgery of Dental Implants, Control and Documentation" of the Special Research Project 175

"Implantology" (German Society of Research), University of Tübingen, between August 23, 1990, and December 30, 1996.

For the evaluation of interproximal bone behavior, implants were selected for which the flap design was wide (WF) on one side (mesial or distal) and limited (LF) on the other. The distance between the selected implant and the adjacent tooth or implant had to be at least 1 mm (Fig 2). All radiographs (standardized intraoral films taken immediately after surgery, at the time of crown placement, and at 1 year post-restoration) had to be available and sufficient for evaluation.

Uncovering of the implant was performed with a tissue punch or by flap mobilization without harming the papillae. To avoid dependent data caused by patients with multiple implants, only 1 implant per patient was included in the evaluation.<sup>10</sup> Patients with more than 1 implant provided information from 1 randomly selected implant. Twenty-one implants in 21 patients fulfilled all the above-mentioned conditions.

**Patient Age and Gender.** At the time of implant placement, 7 patients were 20 years old or younger, 9 patients were 21 to 40 years old, and 5 were over 60. The study included 7 females and 14 males.

**Region.** Fourteen implants were placed in the central incisor region, 2 in the canine region, and 1 in the premolar region of the maxilla. Four implants in the mandibular molar region were also included in the study.

**Implants.** One implant was placed immediately after tooth extraction, 10 were delayed-immediate, and an additional 10 were late implant placements. The most frequently used length was 15 mm ( $n = 11$  implants). Seven implants were 13 mm long, one was 11 mm long, and two were 10 mm long. The implant diameters were as follows: 6 implants were 3.8 mm in diameter, 7 were 4.5 mm, 5 were 5.5 mm, and 3 were 6.5 mm.

**Radiographs.** Radiographs were used to determine the interproximal crestal bone height.<sup>11</sup> The interproximal crestal bone height is defined as the measured distance between the first step of the Frialit-2 implant and the most coronal point of the interproximal crestal bone (Fig 2). Measurements were done from digitized radiographs using Friacom software (Friadent), which yields an accuracy of 0.1 mm.<sup>12</sup> The baseline value to determine the amount of bone loss was the interproximal crestal bone height measurement on the radiograph made immediately after implant placement.

The evaluation was done in the following steps:

1. For each implant interproximal area, the bone loss (ie, the difference in interproximal crestal bone height between the time of implant surgery and crown placement and the time of implant surgery and 1 year after crown placement) was computed.
2. For these time intervals, the value of the bone loss at the LF area was subtracted from bone loss at the WF area of the same implant. These data represented the outcome variable to be analyzed statistically.
3. The mean of the outcome values was tested for the null hypothesis to be zero.

The results were illustrated by a box-plot value distribution of both groups at the time of crown delivery and 1 year later.

**Statistical Methods.** The Student's *t* test for paired data was applied at the 2-sided 5% level to compare statistically the surgical techniques with respect to the outcome variables. Calculations were performed with the help of a statistics program (SAS, version 6.12, Cary, NC).<sup>13</sup>

## RESULTS

The mean interproximal crestal bone loss was statistically significantly lower after the use of an LF than with a WF procedure (Fig 3). At the time of crown placement, the mean interproximal bone loss was 0.29 mm (SD 0.46) in the LF sites and 0.79 mm



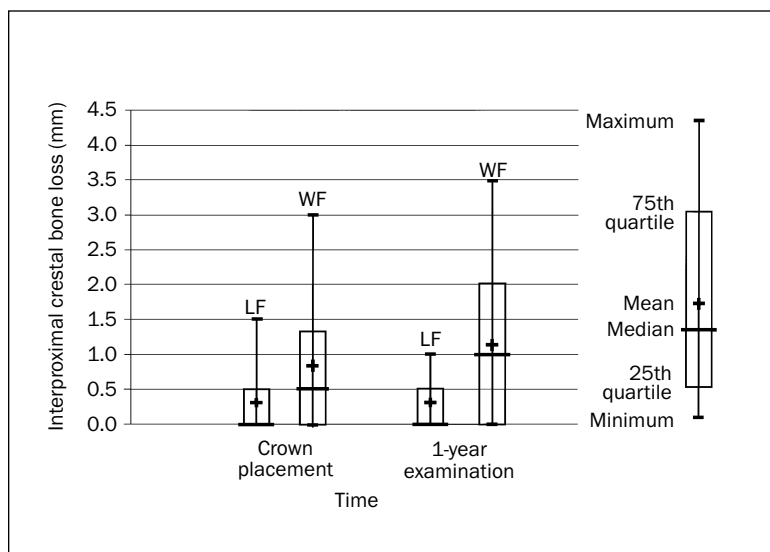
**Fig 2** Measurement specifications.<sup>11</sup> To measure the interproximal crestal bone height, a reference line is used that corresponds to the apical edge of the highest step of the implant. The distance between the tooth and the implant was measured as shown above.<sup>21</sup>

(SD 0.87) for the WF sites. One year after crown placement, the mean interproximal crestal bone loss in the LF sites was 0.29 mm (SD 0.38). In the WF sites, the mean bone loss was 1.12 mm (SD 1.14) (Fig 3). These differences are of clinical importance. At both follow-up time points, the median value of the LF sites was 0 mm, while in the WF sites, it was 0.5 mm at crown placement and 1 mm 1 year later.

The data for the differences between limited and wide flap mobilization had a normal distribution at both the time of crown placement and the 1-year examination. At the time of crown placement, the mean difference in bone loss between the 2 flap modalities since implant placement was 0.49 mm (SD 0.96), where  $P = .03$  (*t* test). The mean difference in bone loss 1 year later was 0.83 mm (SD 1.23), where  $P = .006$ .

## DISCUSSION

The higher bone loss rates with the WF sites were related to the fact that whenever a papilla is detached



**Fig 3** Distribution of values for the interproximal crestal bone loss. An explanation of the box-plot design is provided on the right. The data are divided into 3 sections: the upper and lower quartiles of data are above and below the box, and the box contains the second and third quartiles. The line and the cross within the box mark the median and mean values, respectively. The upper horizontal line represents the highest value. The lower horizontal line is defined in analogy. LF = limited flap design; WF = widely mobilized flap design.

from bone, the interdental bone in proximity to the adjacent tooth is denuded from the periosteum (Fig 4a). This can affect the nutrition of the bone and papillae, depending on the duration of surgery, and may result in an individually unpredictable degree of resorption of the interproximal crestal bone. This bone loss increases the distance between the crestal bone and the interproximal contact of the crown (Figs 4b to 4d). Furthermore, sufficient interdental bone height is crucial for the morphology and nutrition of an intact interdental papilla. Recession of the interdental papilla, with an adverse esthetic impact, can follow<sup>9</sup> (Fig 4e). This loss of substance can also be explained by the observation on histopathologic studies that, following surgery, wound healing in the terminal portion of the papilla is delayed relative to the labial or oral mucosa.<sup>14</sup>

Following loss of the interdental papillae, the interproximal root surfaces may become exposed and cause tooth sensitivity. This has been observed frequently with certain periodontal surgical techniques.<sup>15,16</sup> A decrease in interproximal crestal bone height (in the range of 0.5 to 1.59 mm) after a full-thickness periosteal flap is raised has also been observed by other authors.<sup>17-20</sup>

Based on the results of this investigation, the use of a limited flap design is recommended to minimize interproximal crestal bone loss and possible

loss of the papillae. This approach conserves the papillae during single-tooth implant placement (Figs 5a to 5h). The limited flap design is also advantageous if the 2 mucosal wound edges are brought together during closure. As a result, a better seal is obtained than with a mucosal margin apposed to a root. Mucosal margins can be freshened with a curette prior to closure, allowing a small amount of bleeding in the suture line and the formation of a fibrinous clot, resulting in a good seal. This is particularly important when membranes are used and tight closure is desirable. With adequate adaptation of the margins, scar formation usually does not occur (Figs 5e, 5g, and 5h). The postulated minimum width of the interdental papilla (1 mm), remaining firmly attached to the adjacent tooth and bone, assures adequate blood supply to the papillary tip and prevents necrosis.

## CONCLUSION

The use of a limited flap design for single-tooth implants is indicated to avoid possible loss of the papillae and minimize interproximal crestal bone loss. Good esthetic outcomes can be achieved predictably when the corresponding surgical technique and principles described above are used.

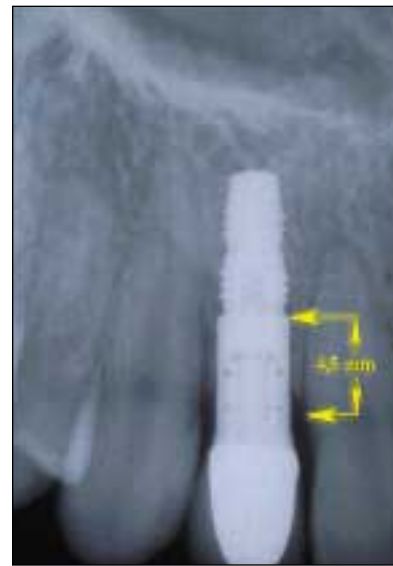
**Fig 4a** Female patient, 16 years of age, with agenesis of the maxillary lateral incisors, June 1993. The mucoperiosteal flap, including the papillae, is detached. The bone is denuded in proximity to the adjacent teeth.



**Fig 4b** Radiograph taken immediately after implant placement.



**Fig 4c** The interproximal crestal bone is located close to the cemento-enamel junction of the adjacent teeth. The distance from the point of reference (first step of the implant) to the highest point of the interproximal crestal bone is 7.5 mm mesially.



**Fig 4d** Radiograph taken immediately after placement of a crown. In this patient, a resorption of 3 mm of interproximal crestal bone can be observed. This bone loss increases the distance between the crestal bone and the interproximal contact point of the crown.<sup>9</sup>

**Fig 4e** Intraoral situation immediately after crown placement. Recession of the interdental papillae with an adverse esthetic impact can be observed.





**Fig 5a** Male patient, 15 years of age, February 1991, with agenesis of the maxillary right lateral incisor. Immediately preoperative photograph.



**Fig 5b** Intraoperative photo, showing an incision that spares the interdental papillae. The incision may be extended labially and superiorly if more exposure is desired.



**Fig 5c** The mucoperiosteal flap is carefully detached using a small elevator, avoiding harm to the papillae and any other traumatic manipulation.



**Fig 5d** The implant is placed.



**Fig 5e** The patient in June 1991, prior to stage 2 surgery. No scars are visible.



**Fig 5f** Intraoral situation after uncovering with a tissue punch and placement of the gingiva former.



**Fig 5g** One month later. The definitive restoration is in place.



**Fig 5h** Five years post-restoration. In the interim, the maxilla has grown slightly. A small diastema has opened up, and the crown looks shorter compared to the adjacent teeth. However, this did not bother the patient and he did not desire another crown. The papillae and the peri-implant mucosa have no scarring and are completely healthy.

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