Maintenance of interdental soft tissue and the need for esthetics are being increasingly recognized as important criteria for implant success. Statistically significant correlations have been found between the incidence of implant failure and vertical bone loss adjacent to implants. Thus, it is widely recognized that peri-implant bone resorption before loading may compromise implant success. This study aims to evaluate the effect of flap elevation on peri-implant bone loss during the healing period. Twenty sites around 10 implants were included in the study, and the effect of 2 different flap designs on the crestal height of bone was evaluated. The results of the study have shown that flap elevation can lead to increased bone loss during the healing period, with statistically significant results up to the 90-day period.

**Key Words:** dental implants, flap design, esthetics, crestal bone loss

**INTRODUCTION**

The term osseointegration was introduced to describe living bone in direct contact with the surface oxide layer of a titanium implant after healing. The initial protocol backed by basic research involved a commercially pure, machined, cylindrical, threaded, titanium implant placed with a careful surgical procedure emphasizing sterile technique. Low-speed drilling to minimize temperature increases in the living bone with tight initial fit of the implant in the osteotomy and submerged, unloaded healing for up to 6 months were described. A second surgery to uncover and allow prosthetic use of the implants followed.1

The introduction of osseointegration has led to the successful placement of implant-supported restorations in edentulous and partially edentulous patients.2–4 Initially, the esthetic aspects of implant-supported prostheses were neglected. However, the increase in patient awareness and demand and the arrival of less invasive treatment options have made esthetics a very crucial part of implant dentistry. Various studies have demonstrated that successful, long-term function of implant-supported single-tooth restorations can be achieved.5,6

Since the beginning of placement of root-form implants, implant surgery has undergone several changes and different surgical techniques have been used. Replacement of teeth in the anterior and premolar regions poses additional problems of esthetics. Trauma to soft and hard tissues during implant surgery can influence the future esthetic result. Clinicians should use surgical techniques that prevent esthetic complications such as loss of interdental papillae, without compromising osseointegration. In a comprehensive article on the management of soft tissues, Cranin7 reviewed the description of incisions, the handling of soft tissues, and grafting procedures for use in implant surgery. Other studies have evaluated several incision designs and compared the results of each.8–11

Studies have shown that when dental implants are placed after reflecting soft tissue flaps, there is generally some bone resorption. When soft tissue flaps are reflected for implant placement, blood supply from the soft tissue to the bone is disrupted, thus leaving poorly vascularized bone without a part of its vascular supply, promoting bone resorption.
during the initial healing phase. Some authors have also shown that a flapless approach to implant placement causes minimal surgical trauma, pain, and swelling since soft tissue trauma is greatly reduced.\textsuperscript{12} But this technique is not generally used because it is a blind surgical technique. Because the underlying bony topography cannot be assessed in this technique, it requires more experience before it is used.

The aim of this clinical study was to evaluate the interproximal crestal bone loss using 2 different flap designs around an implant: a conserved flap on one side that protected 1 to 2 mm of the attached gingiva on the edentulous ridge and an extensive flap on the other side that included the interproximal attached gingiva in the flap in the same patient. The difference in bone loss between the conserved flap design and the extensive flap design on either side of the implants was compared.

\begin{table}
\centering
\caption{Inclusion and exclusion criteria}
\begin{tabular}{|l|l|}
\hline
\textbf{Inclusion Criteria} & \textbf{Exclusion Criteria} \\
\hline
Patients requiring single-tooth replacement in the anterior and premolar region & Patients with complicating medical history such as uncontrolled diabetes, bleeding disorders, osteoporosis; patients on radiation therapy; and immunocompromised states \\
Patients who had completed their final growth & Untreated periodontitis \\
Patients with adequate bone volume for the dental implant procedure without the need for bone grafting & Smokers \\
& Patients with bruxism \\
\hline
\end{tabular}
\end{table}

\section*{Materials and Methods}

\subsection*{Patient selection}
Patients with partial edentulism, with a single tooth missing in the anterior or premolar region, were recruited from the patient pool of the Department of Periodontics, Meenakshi Ammal Dental College and Hospital, Chennai, India. The patients were selected according to certain inclusion and exclusion criteria (Table 1). Informed consent was obtained from all patients, and clearance was obtained from the Institutional Review Board.

Information obtained from the patients included complete medical and dental history, smoking habits, and clinical and radiographic evaluation.

\subsection*{Study design}
The study was a double-blind study. The selection of patients was done by one investigator, the surgical procedures were performed by another investigator, and the statistical analyses were done by another investigator.

\subsection*{Implant design and location}
The implants used in this study were tapered Swiss Plus implants (Zimmer Dental, Carlsbad, Calif). Only 2 implant diameters were used in this study, namely, 3.7 mm and 4.8 mm. The implants made use of an internal abutment connection system. Five of the 10 implants were placed in the maxilla (2 in the incisor region, 1 in the canine region, and 2 in the premolar region), and the remaining 5 were placed in the mandible (2 in the incisor region and 3 in the premolar region).

\subsection*{Presurgical procedure}
Selection of patients was followed by full-mouth scaling, root planning, and oral hygiene instructions. Informed consent was obtained after explaining the proposed nature of the study. Orthopantamograms and intraoral periapical (IOPA) radiographs were taken for all patients, and the quantity of bone at the proposed implant sites was assessed. The study included placement of a single implant, after a flap was raised with a conserved design on one side and an extensive design on the other distal side (Figure 1).

\subsection*{Surgical procedure}
The surgical field was prepared and isolated, and the areas were anesthetized using 2% xylocaine hydrochloride with epinephrine (1:200 000). At the recipient implant site, the flap was designed with a conserved flap that preserved the attached gingiva on the ridge (maintained at a width of about 1 to 2 mm) on one side (mesial or distal) and an extensive flap design that included the attached gingiva on the other side (mesial or distal). The incision was made from the mesial (or distal) flap margin, 1 to 2 mm from the tooth adjacent to the edentulous space, and extended onto the midcrestal region of the ridge and then onto the distal (or mesial) flap margin, where the incision...
was extended into a sulcular incision around the tooth adjacent to the edentulous area so that the attached gingiva was included in the flap design (Figure 1). All the incisions were made with a Bard-Parker blade No. 15, and a mucoperiosteal flap was elevated. Using the appropriate drills, the bone was drilled until the desired depth and diameter was achieved.

The implant was then placed into the site, and a healing cap was positioned (Figure 2a–c). The flaps were then approximated and sutured using interrupted sutures (4/0 Mersilk, Ethicon, UK).

**Postsurgical procedure**
Intraoral periapical radiographs were taken. The patients received amoxicillin 500 mg 3 times a day for 5 days and ibuprofen 400 mg twice a day for 3 days. Patients were recalled after 7 days for suture removal. Recall appointments were made at the 90th and 180th day.

**Radiographic technique**
Standardized radiographs were taken to assess the position of the implant. Radiographs to make the measurements were taken using IOPAs with a paralleling cone technique. In this technique, the film packet is placed in a holder and positioned in the mouth parallel to the long axis of the tooth under investigation. The x-ray tube head is then aimed at right angles to both the tooth and the film packet. The bite of the patient was registered at baseline using a putty impression material index. This index was used while taking the radiograph at the 90th and 180th day time period. Using a film holder with fixed film packet, the putty index, and x-ray tube head positions makes this technique reproducible.

**Prosthetic technique**
After the 180th day, the healing caps were removed and the abutment attached to the implant for...
impression taking. Impressions were taken, and the final prosthesis was cemented (Figure 3a–e).

Clinical parameters

Crestal height of bone

The crestal bone height was defined as the measured distance (in millimeters) between the apical end of the first step of the Zimmer implant and the most coronal point of the interproximal crestal bone. Radiographs were used to determine the interproximal crestal bone height. It was measured at baseline, 90 days, and 180 days using standardized radiographs. The paralleling cone technique was used to standardize the radiographs. The radiographs were imported into the Schick CDR 4.0 software (Schick Technologies, Long Island City, NY), which yields an accuracy of 0.1 mm. Measurements were made using a line tool (Figure 4). The baseline value to determine the amount of bone loss was the interproximal crestal bone height measured on the radiograph taken immediately after implant placement. Figures 3 and 4 show a clinical case done using this technique, beginning from the incision until the placement of the definitive restoration 6 months after implant placement.

Measurements

For each implant interproximal area, the difference in the interproximal crestal bone height between the time of implant surgery and the 90th day and the time of implant surgery and the 180th day was computed. For these time intervals, the difference in bone loss between site A and site B was calculated. These data represented the outcome variable to be analyzed statistically. Differences in these variables were recorded and analyzed statistically.

Statistical analysis

The results were tabulated by comparing the means for the bone loss at both sites. The 2-sided Student t test for paired data was applied at the 5% confidence interval to compare statistically the flap designs with respect to the outcome variable. Calculations were performed using the SPSS statistics program version 9.0 (SPSS Inc, Chicago, Ill).

Results

A total of 20 sites were included in the study: 10 sites made use of the conserved flap (site A) and 10 sites used the extensive flap (site B) around 10 implants. The implants were placed in 10 patients in the age group of 25 to 60 years (33.90 ± 7.35). There were 6 (60%) men and 4 (40%) women.

The mean value for crest height of bone at baseline, 90 days, and 180 days for both site A and site B were statistically significant. For site A, the mean bone loss between baseline and the 90th day was 0.26 ± 0.24. The mean bone loss between baseline and the 180th day was 0.68 ± 2.14 (Table 2). For site B, there was a mean bone loss of 0.50 ± 0.21 between baseline and the 90th day. Between baseline and the 180th day, there was a mean bone loss of 1.01 ± 1.66 (Table 3).

The mean difference in bone loss between site A and site B from baseline to the 90th day was 0.23 ± 0.27, which was statistically significant (P = .03). However, the mean difference in bone loss between site A and site B from baseline to the 180th day was 0.33 ± 0.58, which was not statistically significant (P = .104).

Discussion

In contemporary implant dentistry, implant-supported restorations in the esthetic zone are considered successful only when an inconspicuous result is obtained. Creation of a soft tissue contour with intact papillae and a gingival outline that is harmonious with the gingival silhouette of the adjacent dentition is the most difficult factor in achieving an esthetically and functionally optimal result. Extensive literature has detailed that whether it is natural teeth or osseointegrated implants, the presence or absence of interdental papillae depends on the interproximal bone.

Studies done by Tarnow et al13 on the effect of distance between the contact point and the crest of the alveolar bone on the presence or absence of interdental papillae have shown the importance of the underlying crestal bone on soft tissue contour in the interdental area. Optimal implant restorations depend not only on prosthetic and technical parameters but also on biologic and surgical considerations. The success of oral implant treatment relies on the presence and maintenance of bone adjacent to implants. The crestal bone area is usually a significant indicator of implant health. Crestal bone loss during healing indicates the need for preventive therapy.14

Albrektsson et al15 have included interproximal crestal bone loss as one criterion for implant success. According to their criteria, bone loss of less than 0.2 mm annually following the implant’s first year of function is essential for long-term success. Salama et al16 studied the interproximal height of bone as a factor in achieving optimal esthetic outcomes. Adell et
al\(^2\) reported an average of 1.2 mm of marginal bone loss from the first thread during the healing period and first year after loading and 0.1 mm annually thereafter. Preserving the interdental tissue for maintaining the blood supply of the underlying bone reduces the amount of crestal bone resorption around implants, resulting in ideal esthetic and functional outcomes.

The results of this study are in agreement with the work of Adell et al.\(^2\) This study has found a bone loss

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of 0.26 ± 0.24 between baseline and the 90th day and 0.68 ± 2.14 between baseline and the 180th day at site A. At site B, the mean bone loss was 0.50 ± 0.21 and 1.01 ± 1.66 from baseline to the 90th day and from baseline to the 180th day, respectively.

The effectiveness of various incisions and flap design and their effect on healing and osseointegration have been studied.8 The Branemark protocol for implant placement calls for the mucosal incision to be made in the mucobuccal fold. However, this mucobuccal incision is not without shortcomings. Pain and significant edema have been said to be associated with an incision made in the alveolar mucosa versus one made in the keratinized tissue.

Langer and Langer17 proposed the overlapped flap as an incision design for implant surgery. Their design was an improvement in that Branemark’s objective of covering the implant and excluding the epithelium was achieved, yet the incision was made in the keratinized tissue. However, this design was limited in that it could not always be used in areas of thin tissue or narrow bands of attached gingiva.

Using the dog model, Cranin et al9 compared various types of incisions such as the crestal, para-crestal, serpentine, and visor incisions histologically. They found that the visor incision was associated with the slowest healing, the most edema, and the most inflammation.

The flap used in this study was designed in such a way that the incision was given on the crest, which consists of keratinized tissue, while preserving the interdental tissue by excluding it from the flap.

In this study, a flap design that was conserved on one side, preserving 1 to 2 mm of attached gingiva, and extensive on the other side, without preserving the tissue, was made for placement of implants. The results show higher bone loss rates on the extensive sites (site B), where the flap was extensive, compared with the other sites (site A), where a conserved flap design was used. The difference in the means between site A and site B from baseline to the 90th day was statistically significant. However, that between baseline and the 180th day was not significant (Table 4). The aim of this study was to evaluate the influence of this flap design on interproximal crestal bone loss around single-tooth implants. The effect of preserving soft tissue on one side without exposing bone and stripping the bone completely on the other side was studied by evaluating the crestal bone loss on the 2 sides.

The flap design proposed in this study preserved the interdental tissue, the goal of which was less traumatic preparation of the soft tissue. Hence, the interdental tissue was not included in the mucoperiosteal flap but was maintained at a width of 1 to 2 mm attached to alveolar bone. The loss of interdental tissue can lead to adverse esthetic outcomes. Based on the results of this study, the authors recommend the use of a conserved flap design to minimize interproximal crestal bone loss and possible loss of papillae around implants.

This loss of crestal bone could be attributed to the fact that whenever bone is stripped of its periosteum, its nutrition is affected, which could result in some amount of resorption of the crestal bone. This loss of crestal bone during the first year after placement of the implant could also be attributed to the process of wound healing at the bone-implant interface.

Although the results of this study did show a difference between the bone loss between the 2 sites, they were not profound enough to show statistical significance at the 180-day time point. The small

<table>
<thead>
<tr>
<th><strong>Time Point</strong></th>
<th><strong>Mean ± SD</strong></th>
<th><strong>P Value</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline to 90th day</td>
<td>0.26 ± 0.24</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Baseline to 180th day</td>
<td>0.68 ± 2.14</td>
<td>.34</td>
</tr>
<tr>
<td>90th day to 180th day</td>
<td>0.41 ± 1.94</td>
<td>.52</td>
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</tbody>
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*A Student paired t test was used to calculate the P value.
sample size may not have been enough to achieve statistical significance. However, the advantages of using a limited flap design to preserve interdental tissue are obvious when one looks at the lesser bone loss at site A compared with site B.

Other than the small sample size, the drawbacks encountered with the use of this flap design were that it may not be always possible to preserve tissue on either side of the flap because of available space limitations in the case of single-tooth implants. The preference for placing larger diameter implants that could greatly increase bone-to-implant contact may not always permit such a flap design.

**CONCLUSION**

Elevation of the mucoperiosteal flap during implant surgery is regarded as one of the factors that may contribute to implant bone loss during the healing period.\(^\text{18}\) Even with its disadvantages, making use of the conserved flap in cases in which there is adequate space both in anterior and posterior regions could be beneficial to the final outcome of treatment. The results of this study show that a flap design that protects the interdental tissue without exposing underlying bone is associated with lesser crestal bone loss, which could result in better interproximal contacts in the posterior regions and better esthetic outcomes in the anterior regions. In cases of single-tooth replacement, in which it is not possible to preserve interdental tissue on either side of the edentulous space because of limited available space, flapless implant surgery is suggested as one possible treatment option for enhancement of implant esthetics in keeping with the results of this study.

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