The Clinical Outcome of Dental Implants Placed through Skin Flaps

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Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

Abstract

Objective and Study Design. The incidence of peri-implantitis, marginal bone loss, implant success, and survival rates of 52 dental implants placed through the skin paddle and 23 implants through the neighboring gingiva were investigated. Mixed linear model was adopted to analyze the influence of radiation and skin paddle on marginal bone loss and peri-implantitis.

Results. The incidence of peri-implantitis in implants placed through the skin flaps was higher (32.7%) than that of implants placed through the oral mucosa (8.7%). According to the mixed linear analysis, no significant difference in the amount of marginal bone loss was observed between the 2 groups: implants placed through the skin graft had marginal bone loss of $0.39 \pm 0.14$ mm at 1 year and $0.50 \pm 0.23$ mm at 5 years, and implants placed through the oral mucosa had marginal bone loss of $0.32 \pm 0.12$ mm and $0.52 \pm 0.21$ mm at the same time intervals. The 1-year and 2- to 5-year cumulative survival rates of the implants placed through the skin were 100% and 98%, respectively, and those of implants placed through the oral mucosa were 95.65%. The 1-year and 2- to 5-year cumulative success rates of the implants placed through the skin were 92.30% and 79.38%, respectively, and those of implants placed through the oral mucosa were 91.30% and 82.59%, respectively.

Conclusion. Implants can be successfully placed and maintained in lining defects covered with a skin paddle; hence, this treatment modality may be considered reasonable and reliable for the functional and aesthetic rehabilitation of patients with oromaxillofacial reconstructions.

Keywords

transcutaneous implant, transmucosal implant, implant through skin paddle, peri-implantitis, marginal bone loss, oromandibular reconstruction, mucosal lining defect

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Introduction

Maxillomandibular tumor ablation frequently results in defects of various tissues, including the lining mucosa, teeth, and bone. In such instances, vascularized tissue flaps (eg, forearm free flap, fibular free flap) that include parts of the extraoral skin can be microtransferred.1-4 Dental implants are often placed through the grafted skin paddle to restore function and esthetics.5,6 The nature of peri-implant tissue in implants placed through the skin paddle may differ considerably from that of implants placed through a normal oral mucosa.1,3

It is generally accepted that a small band of well-keratinized attached gingiva around the implant is necessary for optimal peri-implant soft tissue health and implant longevity. However, implants placed through the skin are surrounded by a thick layer of mobile tissue that may be vulnerable to peri-implantitis. Scientific literature on peri-implant tissue within reconstructed jaws is limited to few reports and findings, including peri-implant tissue hyperplasia, plaque accumulation, bleeding on probing (BOP), and increased pocket depth (PD).2-4 Studies on longevity of dental implants placed through grafted skin tissue reported varying success rates, from 64% to 100%.1,5-7 Most of the studies were on dental implants placed in vascularized bone flaps or native bone, and only a few focused on implants placed in transplanted skin flaps or mucosa, with or without vascularized bone graft for jaw reconstruction.

The aim of this study was to investigate the incidence of peri-implantitis, marginal bone loss, and the survival and success rates of dental implants placed through the lined skin paddle of various free flaps.
Study Design

Patients

The study was done over a 15-year period, from 1995 to 2010, on 17 patients (8 men and 9 women) within the age range of 47 to 73 years and with an average age of 48.7 years. Seventy-five implants—52 through skin flaps and 23 through neighboring gingiva—were placed on reconstructed oral mucosal defects at the Department of Oral and Maxillofacial Surgery, Seoul National University Dental Hospital. The study protocol was reviewed by the Institution Review Board of Seoul National University Dental Hospital (IRB 081/07-14). Fourteen patients underwent resection of the mandible, while the other 3 had maxilla resected. The primary pathologies were 6 cases of squamous cell carcinoma, 3 osteosarcomas, 3 ameloblastomas, 2 ameloblastic carcinomas, 1 adenoid cystic carcinoma, 1 mucoepidermoid carcinoma, and 1 malignant melanoma. Types of flaps used for the reconstruction included 12 cases of fibular osteocutaneous flap, 2 combinations of latissimus dorsi flap and fibular flap, 2 radial forearm flaps, and 1 dorsalis pedis free flap. The dental implants used were mostly external hexa submerged type (Mark II, Mark III, Groovy—total of 40 fixtures, Nobel Biocare, Zurich, Switzerland; USII—33 fixtures, Ostem, Seoul, Korea). Two nonsubmerged implants were placed in a maxillary reconstruction case with dorsalis pedis free flap graft (Tissue Level SLA, Straumann, Basel, Switzerland).

Five patients underwent postoperative radiation therapy, with doses between 60 to 70 Gy. Dental implants were placed more than 12 months after the cessation of radiation therapy. None of the patients had history of previous or ongoing bisphosphonate or hyperbaric oxygen therapy.

Clinical Parameters of Peri-Implantitis

Occurrence and severity of peri-implantitis in dental implants placed through the grafted skin tissue were compared to that of implants placed through the oral alveolar mucosa via 3 clinical parameters: PD, BOP, and amount of marginal bone loss around the implant. PD and BOP were assessed according to previous literatures.4,5 PD of the implants were measured on the mesial, distal, lingual, and vestibular aspects of the implants with a plastic periodontal probe (Plast-O-Probe, de Trey, Germany). The highest PD value of each implant was recorded for statistical evaluation. The amount of marginal bone loss was measured with panoramic and periapical radiographs.

Presence of peri-implantitis was determined per criteria previously established by several authors: PD ≥ 5 mm, positive BOP, and marginal bone loss dichotomously expressed as present or absent.8,9 To evaluate the effect of exposure to therapeutic radiation, patients were classified as either previously having undergone or not having undergone radiation therapy.

Marginal Bone Loss

The osseous-implant interface was studied on panoramic and periapical radiographs. The crestal bone level was measured and calculated at 1- and 5-year intervals. Crestal bone levels of both mesial and distal aspects of the implants were assessed, and a mean value of marginal bone loss was obtained for each dental implant at 1- and 5-year intervals.

Implant Success Criteria and Survival Rate

Implants were considered successful when the following criteria were met: (1) absence of persistent pain, (2) absence of peri-implant infection with suppuration, (3) absence of mobility, (4) absence of continuous peri-implant radiolucency, and (5) marginal bone resorption < 1.5 mm in the first year of function and < 0.2 mm per year in the subsequent years.5,10 The 1- and 2- to 5-year cumulative survival and success rates were assessed with the Kaplan-Meier method.

Statistical Analysis

Dichotomous variables—radiation and soft tissue type—were descriptively analyzed via the mixed linear model, with peri-implantitis as a dependent variable. This statistical method was adopted to analyze the influence of radiation and soft tissue type on marginal bone loss and to adjust for the multiple implants placed in the same patient. The values were considered statistically significant when \( P < .05 \). Statistical analysis was performed using SPSS 20 for Windows (SPSS Inc, Chicago, Illinois, USA).

Results

At the time of follow-up, all 17 patients had functioning prostheses: 15 with implant-supported fixed prostheses, 1 with a bar-supported overdenture, and 1 with a magnet-retained implant-supported overdenture. The prostheses were retained and supported by 72 functioning implants (Figure 1). There were 3 implants without function that were not connected to prosthodontic devices.

Transplanted skin tissue surrounding 52 implants and oral mucosa surrounding 23 implants were observed. Due to the major tissue resections involved, the oral mucosa around dental implants consisted mostly of unattached gingiva (Figure 2). In the mixed linear analysis, soft tissue type was correlated to the presence or absence of peri-implantitis (Table 1). Results showed that peri-implantitis was significantly more prevalent in skin tissue type (32.7%) than in mucosa (8.7%; \( P = .02 \)).

According to the mixed linear analysis, radiation therapy of more than 12 months before implant placement did not have statistically significant effect on the occurrence of marginal bone loss (\( P = .61 \)) (Table 2). Statistical analysis also indicated that soft tissue type was not a significant factor in the development of marginal bone loss (\( P = .30 \)).

Dental implants placed through the skin showed postoperative marginal bone loss of 0.39 ± 0.14 mm at 1 year and 0.50 ± 0.23 mm at 5 years, and implants placed through the mucosa resulted in bone loss of 0.32 ± 0.12 mm and 0.52 ± 0.21 mm at 1 and 5 years, respectively. Patients who received radiotherapy showed marginal bone loss of 0.53 ± 0.31 mm at 1 year and 0.89 ± 0.39 mm at
5 years, whereas patients without prior radiotherapy exhibited marginal bone loss of \(0.38 \pm 0.10\) mm and \(0.47 \pm 0.20\) mm at the same time intervals (Table 3).

Two dental implants in 2 patients—one placed through the grafted skin (latissimus dorsi flap) and the other placed through the oral mucosa (adjacent to fibular skin paddle)—were removed at 5 years and 1 year, respectively (Figure 3). One- and 2- to 5-year cumulative survival rates of implants placed through skin were 100% and 98%, respectively. Four implants showed postoperative marginal bone loss > 2 mm at 1 year, and 6 implants exhibited bone resorption > 2.3 mm and were diagnosed with peri-implantitis at 5 years. The 1- and 2- to 5-year cumulative success rates of the implants placed through skin were 92.30% and 79.38%, respectively. On the contrary, the cumulative survival rates of the implants placed through the mucosa were 95.65% at both 1 and 5 years.

Figure 1. Clinical photographs and panoramic views of implants placed through the skin paddle. Four implants were placed in the reconstructed mandible that underwent hemimandibulectomy with an osteocutaneous fibular flap due to osteosarcoma. A, Intraoral photograph showing the lateral leg skin lined at the intraoral mucosal defect. The patient received postoperative elective irradiation and high-dose methotrexate chemotherapy. B, At the time of implant installation, the subcutaneous fat was debulked and thinned to reduce the thickness and mobility of skin around the implant. C, Four dental implants (USII, Osstem, Seoul, Korea) were placed at the reconstructed vascularized fibula. D, Intraoral view after abutment connection. E, Intraoral photograph showing the final prostheses in situ. F, Postoperative panoramic radiogram after the first stage of implantation. G, Postoperative panoramic radiogram, 1.5 years after implantation. H, Postoperative panoramic radiogram, 4 years after implantation, showing minimal marginal bone loss.

Figure 2. Clinical photographs of implants through the fasciocutaneous forearm free flap. Without defatting and debulking procedure, implants were placed at right mandible. A, Four implants were placed through the skin paddle in the anterior arch of right mandible (arrowhead). Two implants were placed through the mucosa at the posterior mandible (arrow). B, During the follow-up, 2 implants through the forearm skin showed marginal bone changes resulting in fixture thread exposure (arrowhead). Nevertheless, the implants tolerate well without any overt symptom of peri-implantitis.
years, and the success rates were 91.30% at 1 year and 82.59% at 2-5 years (Table 4). One implant showed postoperative marginal bone loss > 2 mm at 1 year, and 2 implants were diagnosed with peri-implantitis at 5 years.

### Discussion

Maxillofacial trauma or tumor ablation often results in compound defects in the oromandibular region, and such defects require bone, soft tissue, and dental implants for the proper restoration of form and function. In many instances, intraoral soft tissue defect is lined with a skin flap, such as jejunal flap, instead of mucosa. A major drawback of using skin for the reconstruction of intraoral soft tissues is a hyperplastic/inflammatory response of peri-implant skin and subcutaneous tissues, resulting in the formation of granulomatous tissue that may cause pain and bleeding. This phenomenon has been described in previous studies.

Results of this study showed that the implants placed through the skin flaps had a higher incidence of peri-implantitis (32.7%) than those placed through the mucosa (8.7%). The mixed linear analysis reaffirmed higher prevalence of peri-implantitis in implants through skin compared with that of implants through mucosa ($P < .05$). Theoretically, peri-implantitis is an inflammatory process affecting the soft and hard tissues surrounding dental implant in the normal periodontium. We have attempted to detect the presence of peri-implantitis by evaluating PD ($\geq 5$ mm), BOP (positive), and marginal bone loss. However, it would be difficult to define peri-implantitis in an implant placed through the skin due to its distinctive attributes, and these observations may not necessarily reflect the pathologic condition in this population. Therefore, the examination of the inflammatory process was challenging in this study.

Skin flaps were more mobile than normal attached gingiva. Such qualities may create an environment less conducive to oral hygiene. Contrary to our findings, those of Kwon et al showed a higher incidence of peri-implantitis around implants placed in mucosa (48%) than those in skin tissue (44%), and the researchers concluded that soft tissue origin seemed to have little influence on the development of peri-implant disease. However, Kwon et al also stated that irradiation did not increase the occurrence rate of peri-implantitis. In this study, incidence of peri-implantitis in irradiated tissue was 28.57%, while that of nonirradiated tissue was 24.07%. Although the results indicated higher incidence of peri-implantitis in irradiated patients, statistical analysis showed that correlation between radiation therapy and peri-implantitis was not statistically significant.

The marginal bone loss around implants placed through the skin flaps was less than that previously published in the literature. Schwartz-Ard et al reported an average marginal bone loss of 0.78 to 1.22 mm over 8 years in immediate or delayed placement of implants in edentulous jaws. In this study, 5-year marginal bone loss was 0.50 mm in the skin group and 0.52 mm in the mucosa group. Chiapasco et al stated that more peri-implant bone resorption occurred in implants placed in jaws reconstructed using fibular flaps compared to those placed in native bone—1.7 mm of peri-implant bone loss in the maxilla and 1.45 mm in the mandible lined with revascularized fibular flap due to extreme atrophy. Results of this study showed much less marginal bone loss around implants placed through the skin tissue. This may indicate that the type of soft tissue—whether oral mucosa or extraoral skin—has small influence on the amount of peri-implant marginal bone loss. Gbara et al investigated the long-term marginal bone loss around dental implants placed in the upper and lower jaws reconstructed with microsurgically reanastomosed fibular flaps. The amount of marginal bone loss was divided into 3 groups: < 1 mm (53%), 1 to 2 mm (29.9%), and > 3 mm (17%). However, the presence or absence of skin tissue around the implants was not clarified. The authors concluded that the fibula flap seemed resistant to peri-implant bone resorption process.

The local environment of an irradiated oral cavity is unfavorable to dental implants compared to the

### Table 1. Mixed Linear Analysis for Radiotherapy and Soft Tissue Type Based on the Clinical Signs of Peri-implantitis

<table>
<thead>
<tr>
<th>Parameter Group</th>
<th>Peri-implantitis</th>
</tr>
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<tbody>
<tr>
<td>Radiotherapy</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>41</td>
</tr>
<tr>
<td>Yes</td>
<td>15</td>
</tr>
<tr>
<td>Soft tissue type</td>
<td></td>
</tr>
<tr>
<td>Mucosa</td>
<td>21</td>
</tr>
<tr>
<td>Skin</td>
<td>35</td>
</tr>
</tbody>
</table>

### Table 2. Statistical Analysis of the Influence of Radiation and Soft Tissue Type on the Marginal Bone Loss

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>SE</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiotherapy</td>
<td>0.37</td>
<td>0.72</td>
<td>.61</td>
</tr>
<tr>
<td>Soft tissue origin</td>
<td>0.84</td>
<td>0.80</td>
<td>.30</td>
</tr>
</tbody>
</table>

### Table 3. Marginal Bone Loss Classified by Radiotherapy and the Soft Tissue Types around the Implant

<table>
<thead>
<tr>
<th>Radiotherapy</th>
<th>Marginal Bone Loss, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 Year (n = 14)</td>
</tr>
<tr>
<td>No</td>
<td>0.38 ± 0.10</td>
</tr>
<tr>
<td>Yes</td>
<td>0.53 ± 0.31</td>
</tr>
<tr>
<td>Soft tissue type</td>
<td></td>
</tr>
<tr>
<td>Mucosa</td>
<td>0.32 ± 0.12</td>
</tr>
<tr>
<td>Skin</td>
<td>0.39 ± 0.14</td>
</tr>
</tbody>
</table>

### Table 4. Marginal Bone Loss, mm (n = 14) and Standard Error (SE), Years

- **Radiotherapy**: No = 2 mm (17%), No = 1.7 mm (53%), No = 1 to 2 mm (29.9%), No > 3 mm (17%)
- **Soft tissue type**: Skin = 2 mm (17%), Skin = 1.7 mm (53%), Skin = 1 to 2 mm (29.9%), Skin > 3 mm (17%)
nonirradiated. Irradiation leaves bone less viable and prone to infection. Furthermore, the quantity and quality of saliva, as well as oral microflora composition, change considerably after irradiation.\textsuperscript{4,15,16} Implants placed through the skin flaps after irradiation may be more vulnerable to inflammation because of these local environmental changes that can result in additional marginal bone loss. In this study, there was more marginal bone loss in patients who received radiotherapy ($0.89 \pm 0.39$ mm at 5 years) than in patients who did not ($0.47 \pm 0.20$ mm). The difference was not statistically significant, but such may be due to the small sample size. Landes and Kovacs compared the bone loss of nonsubmerged ITI implants in irradiated and nonirradiated oral cancer patients with early telecope loading and found that much more bone loss occurred in the irradiated area ($1.4 \pm 0.9$ mm) than in the nonirradiated area ($0.4 \pm 0.5$ mm).\textsuperscript{17} Furthermore, they found that 71% of bone loss occurred in the first half of 24-month study period in the irradiated group, while 100% of total bone loss occurred during the same period in the nonirradiated group. In other words, nonirradiated tissue did not show any bone loss after 1 year of implantation, while irradiated tissue exhibited continuous bone loss during the latter half of the 24-month study period.

Heberer et al evaluated sandblasted, acid-etched surface and SLActive implants in irradiated oral squamous cell carcinoma patients and reported bone loss of $0.3$--$0.4$ mm during the average observation period of 14.4 months.\textsuperscript{18} Success and survival rates of implants placed in the native bone are reported to be very high, with a 10-year cumulative survival rate of 97.9%.\textsuperscript{19,20} There have been many studies on the survival rate of implants in reconstructed jaws with free vascularized bone grafts, such as the fibular flap. However, studies on success and survival rates of dental implants placed through skin flaps are hard to find. Chiapasco et al reported that cumulative implant success and survival rates were 98.6% and 93.1%, respectively, in 16 patients who underwent mandibular reconstruction with vascularized bone grafts.\textsuperscript{10} Garrett and colleagues’ study showed 3 implant failures in a total of 58 implants in 17 patients with mandibular fibular flap reconstruction.\textsuperscript{21} Roumanas et al presented with 3 implant failures among 54 implants placed in 15 patients, few of which received adjuvant radiation therapy.\textsuperscript{22} Sclaroff et al reported a success rate of 97.5% in a study on 83 dental implants in 16 patients with vascularized fibular flaps.\textsuperscript{23} In this study, the overall success rate was lower in implants placed through the skin tissue than those placed through the mucosa, possibly due to higher incidence of peri-implantitis. The survival rate, however, was higher in implants placed through the skin flaps than those placed through the oral mucosa. The use of vascularized bone grafts may have contributed to the high implant survival rate. History of radiation therapy did not show a

**Figure 3.** Illustrative case showing peri-implantitis conditions. A, Seven dental implants (Mark II, Nobel Biocare, Zurich, Switzerland) were placed through the lined skin, which was previously reconstructed with fibular osteocutaneous free flap. B, Panoramic radiogram showing occlusal rehabilitation with fixed prosthodontics with 7 implants placed. C, During the maintenance, one implant (located right most; arrow) was submerged owing to difficulty of hygiene care, and the other implant (located at the right second premolar area; arrowhead) suffered progressive peri-implant bone loss and inflammation. D, E, Ultimately, the second premolar area implant was removed, and the neighboring implant was still affected with peri-implantitis (arrow). Panoramic radiogram shows the crater-like marginal bone loss (arrow).

**Table 4.** Survival and Success Rates of Implants Placed through the Skin Flap

<table>
<thead>
<tr>
<th>Implant</th>
<th>Cumulative Rate, %</th>
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<tbody>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>1 year</td>
<td>Skin</td>
</tr>
<tr>
<td></td>
<td>Mucosa</td>
</tr>
<tr>
<td>2-5 years</td>
<td>Skin</td>
</tr>
<tr>
<td></td>
<td>Mucosa</td>
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statistically significant amount of influence on either the success or the survival of dental implants. This study showed that skin implants could serve patients well for many years with minimal measured degradation in implant support. Therefore, based on the results of this experiment, it seems reasonable to devote resources to restore function and aesthetics, which will enhance the nutritional status and psychological well-being of patients in otolaryngology and maxillofacial surgery. However, soft tissue proliferation around implant abutments was a common phenomenon in implants placed through skin flaps; as such, tissue movement, plaque accumulation, and ineffective oral hygiene efforts may affect peri-implant health and possibly the long-term retention of the implant. The entire procedure should aim to create an optimal soft tissue bed for subsequent implant rehabilitation in terms of tissue contour and thickness. Oral hygiene should be well maintained, and regular recall visits are a prerequisite for long-term success, for they allow early detection and treatment of inflammation, infection, and bone resorption. Although the incidence of peri-implantitis was higher in implants placed through the skin flap than those placed through the mucosa, the amount of marginal bone loss was negligible. Implants can be successfully placed and maintained in lining defects restored with skin flaps as long as previously noted considerations for minimizing peri-implantitis are well abided. This study offers both surgeons and patients with reliable evidence to consider the value of investing resources to such restoration and reconstruction.

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Author Contributions

Bo-Han Li, data analysis and design of the work, drafting the work, final approval of the version to be published, accountability for manuscript; Soo-Hwan Byun, data analysis and design of the work, drafting the work, final approval of the version to be published, accountability for manuscript; Soung-Min Kim, substantial contributions to the conception of the work, drafting the work, final approval of the version to be published, agreement to be accountable for all aspects of the work; Jong-Ho Lee, substantial contributions to the conception of the work, drafting the work, final approval of the version to be published, agreement to be accountable for all aspects of the work.

Disclosures

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