Comparison of clinical outcomes of sinus bone graft with simultaneous implant placement: 4-month and 6-month final prosthetic loading

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Objectives. The aim of this study was to compare the survival rate and surrounding tissue condition of sinus bone grafts with simultaneous implant placement between 4-month and 6-month occlusal loading after implantation.

Study design. Twenty-seven patients (61 implants) who were treated with sinus bone grafts (sinus lateral approach) and simultaneous Osstem GS II implant placement from July 2007 to June 2008 were included in this study. Of these patients, 14 (31 implants) were in the 4-month loading group, and 13 (30 implants) were in the 6-month loading group. We investigated the implantation type (submerged or nonsubmerged), sinus membrane perforation, type of prosthesis, opposed tooth type, primary and secondary stability of implants, and crestal bone loss around implant and surrounding tissue conditions.

Results. The amounts of crestal bone-loss at the final recall time (12.56 ± 5.95 mm after loading) of the 4-month and 6-month loading groups were 0.19 ± 0.33 mm and 0.39 ± 0.86 mm, respectively. However, the difference between groups was not statistically significant (P = .211). The width of keratinized mucosa, gingival index, plaque index, and pocket depth of the 4-month and 6-month loading groups were 2.50 ± 1.69 mm and 1.73 ± 1.40 mm (P = .081), 0.72 ± 0.83 and 0.59 ± 0.69 (P = .671), 1.11 ± 0.96 and 0.76 ± 0.79 (P = .226), 3.56 ± 0.98 mm and 3.65 ± 1.06 mm (P = .758), respectively. The primary stabilities of implants in the 4-month and 6-month loading groups were 61.96 ± 12.84 and 56.06 ± 15.55 (P = .120), and the secondary stabilities were 71.85 ± 6.80 and 66.51 ± 11.28 (P = .026), respectively. The secondary stability of the 4-month group was significantly higher than that of the 6-month group. There was no statistical difference (P > .05) between the 4-month and 6-month loading groups regarding the implantation type (submerged or nonsubmerged), sinus membrane perforation, type of prosthesis, or opposed tooth type. In the 4-month and 6-month groups, all of the implants survived until the final recall time.

Conclusions. For the cases in which the residual bone was >3 mm and primary implant stability could be obtained, we conclude that loading is possible 4 months after the sinus bone graft and simultaneous implant placement. (Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;111:164-169)

Restoration of the maxillary posterior teeth by implants is difficult because of the pneumatization of the maxillary sinus that develops when the edentulous state is present for an extended period of time, and anatomic limitations, such as poor bone quality of the residual alveolar bone, exist. The high occlusal forces of mandibular teeth also make posterior maxillary dental restoration a challenge. This area of the mouth is known to have low success rates.1 Although cases of maxillary posterior-tooth restoration using short-length implants have been reported, the long-term follow-up data are not sufficient, and this procedure has not been sufficiently proven. Therefore, the procedure that augments the vertical bone quantity through a maxillary sinus lift and subsequent placement of implants of appropriate length has been widely used. Based on numerous reports of bone grafts in the maxillary sinus and the corresponding loading times after implant placement, it was found that the cases with 5- to 6-month healing periods were most abundant. Balshi2 reported that it was adequate to allow 8-10 months of healing when bone replacement graft materials, such as Bio-Oss, were used alone, and in the cases that used a mixture of autogenous bones and Bio-Oss at a 1:1 ratio, the healing period could be shortened to 6-8 months. Jensen3 reported that it was
desirable to allow different healing periods based on different variables. Considering that the standard healing time is four months, Jensen recommended 1.2 times as long for cases in which the height of residual bone was <5 mm, and 0.8 times as long for cases with the heights >9 mm.

The present study was conducted to evaluate whether the survival of implants and the condition of adjacent tissues of the cases with the prosthetic loading 4 months after placement were different from the cases with loading at 6 months.

MATERIALS AND METHODS

This study was conducted prospectively on the patients who underwent sinus bone grafts using a lateral approach and simultaneous implant placements performed by a single oral and maxillofacial surgeon from July 2007 to June 2008. The approval from the Institutional Review Board at Seoul National University Bundang Hospital (B-0810-062-010, Seoul, Korea) was obtained before the onset of study. The subjects were male and female patients in whom the residual bone height to the maxillary sinus floor was >3 mm and with primary stability of the implant. All subjects were nonsmokers, generally healthy, and without oral parafunctions such as bruxism. Twenty-eight patients were selected and signed informed consent forms after listening to the explanation of the study purpose. According to the order of their surgeries, the subjects were assigned randomly to either group I (4-month loading) or group II (6-month loading), with 14 patients in each. However, 1 patient from group II did not have implant placement owing to personal reasons and therefore was excluded from the study. In the end, the study was conducted on 27 patients and 61 implants, and the average age of patients was 54.09 ± 11.25 years. In group I, there were 9 male patients with 14 implants placed and 5 female patients with 12 implants placed. In group II, there were 8 male patients with 20 implants placed and 5 female patients with 15 implants placed.

Treatment procedure

Surgery was performed under local anesthesia or intravenous conscious sedation. After a crestal and bilateral oblique releasing incision, surgical areas were exposed sufficiently by the full-thickness mucoperiosteal flap elevation. An oval lateral window was formed by a surgical round bur, removed and stored in saline solution to use as bone-graft material later. Careful sinus membrane elevation was performed and the presence or absence of perforation was evaluated. For cases with perforation, the size was measured using a periodontal probe. Perforations of <2 mm were sealed with oxidized cellulose (Surgicel; Johnson & Johnson, New Brunswick, NJ) and tissue adhesive (Greenplast; Greencross, Suweon, Korea). For perforations larger than 3 mm, resorbable collagen membranes (BioArm; ACE Surgical Co., Brockton, MA) were used. The removed lateral window was transplanted into the roof area of the maxillary sinus as the bone-graft material, and the mixture of allogenic bone (Orthoblast II) and xenogenic bone (Biocera; Oscotec, Cheonan, Korea) was grafted to approximately two-thirds of the inside of the sinus cavity. Using a surgical stent, the initial and serial drillings of the implant placement area were performed. The final drilling was performed with a smaller diameter than the final implant diameter, and countersinking was not performed. The Osstem GS II system (Osstem Implant, Seoul, Korea) was used for the implants. The primary stability was measured with the Osstell Mentor (Integration Diagnostics, Savedalen, Sweden), and for the cases with implant stability quotient (ISQ) <60, cover screws were connected and submerged. For the cases with ISQ >61, healing abutments were connected. An additional bone graft was performed in the lateral area of the sinus and covered with a resorbable collagen membrane, and the primary closure of the wound was performed.

After surgery, antibiotics (amoxicillin + clavulanic acid), a nonsteroidal antiinflammatory drug (ibuprofen) and chlorhexidine gargling were prescribed for 1 week. Sutures were removed after 10 days. In all cases, no postsurgical infection or complications were detected. For group I, the second surgery and/or impression taking were performed after 3.5 months, and the secondary implant stability was measured. The final prosthesis was placed after 4 months. For group II, the second surgery and/or impression taking was performed after 5.5 months. The final prosthesis was placed after 6 months. The upper prosthetic treatment was performed by 1 prosthodontist.

The following features of the implants in the research subjects were measured and analyzed. The method of implant placement (submerged or nonsubmerged), the presence or absence of the perforation in the maxillary sinus membrane during surgery, the type of upper prosthesis, the type of opposing tooth, the value of the primary and secondary implant stability, the survival rate of implants, and the condition of adjacent tissues were examined. The presurgical and postsurgical heights of residual bone, the height of residual bone 1 year after surgery, and the amount of surrounding alveolar bone resorption of the implant fixture at the last follow-up time were measured using the measurement tool provided by the radiologic imaging digital solution Impax (Afga Corp., Mortsel, Belgium). For the presurgical height of residual bone, the height from the maxillary sinus floor in the anticipated implant location to
the alveolar ridge was measured. For the residual bone height immediately after surgery and 1 year after surgery, the height from the new maxillary sinus floor to the alveolar crest was measured.

For statistical analysis, the SPSS 12.0 KO program for windows, release 12.0.1 (SPSS, Chicago, IL), was used, and the results were validated at the 5% significance level. The subjects were divided into 2 groups depending on the period from placement to prosthesis (4-month group and 6-month group), and the Fisher exact test was performed to analyze differences between the 2 groups in the type of upper implant prosthesis, the type of opposing tooth, maxillary sinus membrane perforation, and the type of placement (submerged or nonsubmerged). After the final follow-up observation, the t test was used to analyze the crestal bone loss in the vicinity of implant fixture in the 2 groups and the primary and secondary stability values. In addition, the Mann-Whitney U test was used to evaluate the difference in the pocket depth, width of keratinized mucosa, plaque index, and gingival index between the 2 groups.

RESULTS

One implant from the 6-month group involving a simultaneous bone graft in the maxillary sinus and implant placement failed; therefore, the implant was removed and immediately replaced with a wide implant. Including the one repositioned implant, all implants survived to the last follow-up observation time.

The cases from each group with perforation in the maxillary sinus membrane are shown in Table I, and a statistically significant difference between the 2 groups was not detected ($P = .216$ [Fisher exact test]). The placement methods for each group (submerged or nonsubmerged) are shown in Table II, and a statistically significant difference between the 2 groups was not detected ($P = .379$ [Fisher exact test]). The upper prostheses of each group are shown in Table III, and a statistically significant difference between the 2 groups was not detected ($P = .491$ [Fisher exact test]).

$T$able I. Number of sinus membrane perforations during the operation

<table>
<thead>
<tr>
<th>Occlusal loading</th>
<th>4 months</th>
<th>6 months</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No perforation</td>
<td>20</td>
<td>19</td>
<td>39</td>
</tr>
<tr>
<td>1-2 mm</td>
<td>2</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>3-4 mm</td>
<td>4</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>&gt;5 mm</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
<td>35</td>
<td>61</td>
</tr>
</tbody>
</table>

$P$ value* $=.216$

$*$Fisher exact test.

$T$able II. Implantation types in relation to occlusal loading group

<table>
<thead>
<tr>
<th>Occlusal loading</th>
<th>4 months</th>
<th>6 months</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submerged</td>
<td>18</td>
<td>28</td>
<td>46</td>
</tr>
<tr>
<td>Nonsubmerged</td>
<td>8</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
<td>35</td>
<td>61</td>
</tr>
</tbody>
</table>

$P$ value* $=.379$

$*$Fisher exact test.

$T$able III. Final prosthesis types in relation to occlusal loading group

<table>
<thead>
<tr>
<th>Occlusal loading</th>
<th>4 months</th>
<th>6 months</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed partial (pontic included)</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Fixed partial (splinted)</td>
<td>19</td>
<td>30</td>
<td>49</td>
</tr>
<tr>
<td>Single crown</td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
<td>35</td>
<td>61</td>
</tr>
</tbody>
</table>

$P$ value* $=.491$

$*$Fisher exact test.

The period from the completion of prosthesis to the last follow-up observation averaged 12.56 ± 5.95 months; that for the 4-month group was 13.81 ± 4.95 months, and for the 6-month group 11.63 ± 6.50 months. At the last follow-up observation, an average 12.56 months after prosthesis, the amount of alveolar resorption in the vicinity of the implant fixture was an average 0.30 ± 0.68 mm; that for the 4-month group was 0.19 ± 0.33 mm, and for the 6-month group 0.39 ± 0.86 mm. The difference between these values was not statistically significant ($P = .211$ [t test]).

The width of keratinized mucosa, gingival index, and probing pocket depth of the 4-month and the 6-month groups averaged 2.50 ± 1.69 mm and 1.73 ± 1.40 mm ($P = .081$ [Mann-Whitney U test]), 0.72 ± 0.83 and 0.59 ± 0.69 ($P = .671$ [Mann-Whitney U test]), and 3.56 ± 0.98 mm and 3.65 ± 1.06 mm ($P = .758$, [Mann-Whitney U test]), respectively. The plaque index was 1.11 ± 0.96 for the 4-month group and 0.76 ± 0.79 for the 6-month group, and a statistically significant difference between the 2 groups was not detected ($P = .226$ [Mann-Whitney U test]; Table V).

The preoperative residual bone height averaged 5.02 ± 1.88 mm, with averages of 5.38 ± 1.95 mm in the 4-month group and 4.52 ± 1.71 mm in the 6-month
DISCUSSION

Maxillary sinus bone grafts and implant placements have been classified as simultaneous or delayed placement, and the benefits of the 2 types of placements are controversial among investigators. Greatly different success rates have been reported for this procedure, and therefore the procedure should be performed according to the treatment concept of surgeons and after sufficient consultation with patients. It has been reported that good results could be obtained if the patients who could achieve sufficient primary stability of the implant are selected appropriately, regardless of the residual bone amount and even if implant placement is performed simultaneously. In contrast, Tawil and Mawla reported that, in cases with residual bone height of <5 mm, when the bone graft in the maxillary sinus and the implant placement were performed simultaneously the survival rate of implants was 56%, and in cases with residual bone height of >5 mm the survival rate was 100%. They mentioned that the residual bone amount was an important factor in the selection of which procedure to use. For the patients with 3-5 mm of alveolar bone, Peleg et al. performed the elevation using autogenous bone grafts and the simultaneous placement of hydroxyapatite-coated implants. They observed the implants during 4 years of follow-up, reported the effectiveness of the method, and introduced the method to perform bone grafts and implant placements simultaneously for cases with thin alveolar bone (<3 mm) by performing a block-type bone graft and thus improving the stability. In addition, numerous investigators have reported that, if the residual bone amount is sufficient and sufficient primary stability of implant is obtained, good results are obtained by maxillary sinus bone grafts and simultaneous implant placements.

On the other hand, the prognosis for performing maxillary sinus bone grafts first and placing implants...
second is good, and the delayed technique can reduce the risk of the infection of grafted bones. In addition, it has been reported that, compared with simultaneous implantation, delayed implantation allowed placement of implants in appropriate positions.\textsuperscript{10,13-16}

Examining earlier research results on the selection of simultaneous versus delayed placement, it was found that the residual bone amount and the primary implant stability were important factors. If the cases are chosen appropriately to achieve the primary stability of implants, even if implant placement is performed simultaneously and regardless of the residual bone amount, good results may be obtained. On the other hand, if stability is considered to be important, it is desirable to place implants after a sufficient waiting period after maxillary sinus bone grafts. However, the success rate was not noticeably higher for the delayed placement cases than for the simultaneous placement cases with excellent primary stability. In the present study, for cases in which the minimum residual bone height was >3 mm, maxillary sinus bone grafts and implant placements were performed simultaneously. The primary stability value after implant placement averaged 58.57 ± 14.65, with averages of 61.96 ± 12.84 in the 4-month group and 56.06 ± 15.55 in the 6-month group, and the difference was not statistically significant.\textsuperscript{11,12}

Many reports suggest that the prosthetic loading period of implants placed in the maxillary sinus bone graft area ranged from 2 to 13 months, and cases that averaged 5-6 months of healing were most prevalent.\textsuperscript{1} Factors that affect the osseointegration of implants are diverse, such as the amount and bone quality of the residual alveolar bone, the bone graft materials used, the diameter and length of the implant, the design and surface treatment, the type of prosthesis, and the condition of opposing teeth. Thus, it is difficult to clearly recommend a specific healing period.

Balshi\textsuperscript{2} reported that, when bone substitution materials, such as Bio-Oss, were used alone, it is desirable to allow 8-10 months of healing, and in cases that used a mixture of autogenous bone and Bio-Oss at a 1:1 ratio, the healing period could be shortened to 6-8 months. In cases that grafted with autogenous bone compared with bone substitution materials alone, the healing period could be shortened by 3-4 months. When a mixture of hydroxyapatite and autogenous bone at a ratio of 2:8-6:4 is used, 4-6 months of healing could be allowed, and the ratio of the regenerated vital bone accounts for \( \text{\sim}28\%-48\% \).\textsuperscript{17,18} Jensen et al.\textsuperscript{19-23} mentioned that it is desirable to allow different healing periods, depending on the age, residual bone height, osteoporosis, bone graft materials, sinus membrane perforation, smoking, drinking, diabetes mellitus, chemotherapy, and so on.

In the present study, in the presence of the minimum residual bone that could ensure primary implant stability, maxillary sinus bone grafts and implant placements were performed simultaneously. Efforts were made to standardize research conditions by grafting the mixture of a small amount of autogenous bone, allogenic bone, and xenogenic bone as the bone graft material and by selecting the identical implant system. Furthermore, by having a single surgeon and prosthodontist perform the implant procedures on every patient in this study, surgical and prosthetic variables were minimized. Regarding the method of implant placement (submerged or nonsubmerged), the presence or absence of perforation in the maxillary sinus mucosa, the type of upper prosthesis, and the type of opposing teeth, statistically significant differences between the 4-month and 6-month groups were not detected. Factors other than the loading time did not exert great effects between the 2 groups, supporting the validity of the comparison results according to the loading time of this study.

In this study, 1 implant in the 6-month loading group failed; however, immediately after removal it was replaced with a wide implant. Including the replaced implant, all implants survived to the last follow-up observation. It was confirmed that the primary implant stability of the 2 groups were good, and a significant difference between the 2 groups was not detected. Over time, the secondary stability improved. At the time of the last follow-up, the sinus bone graft resorption, crestal bone loss, and soft tissue condition (width of attached gingiva, plaque index, gingival inflammatory index, and probing depth) around the implants between the 2 groups were not different.

CONCLUSION

Between the cases with 4-month and 6-month loading times after simultaneous maxillary sinus bone graft and implant placement, the short-term prognosis was not greatly different. If cases are chosen appropriately to achieve primary stability, even in the cases in which bone grafts and implant placements are performed simultaneously and loading is placed at the time point of 4 months after placement, good results can be obtained.

REFERENCES