Factors affecting changes in sinus graft height between and above the placed implants

Ofer Mardinger, DMD, BMEdSc,a Gavriel Chaushu, DMD, MSc,b Sheli Sigalov, DMD,c Ran Herzberg, DMD,d Binyamin Shlomi, DMD,e and Devorah Schwartz-Arad, DMD, PhD, Tel-Aviv, Kfar-Saba, and Ramat-HaSharon, Israel
TEL-AVIV UNIVERSITY, SAPIR MEDICAL CENTER, AND SCHWARTZ-ARAD DAY-CARE SURGICAL CENTER, TEL-AVIV MEDICAL CENTER

Objective. The aim of this study was to compare the radiographic dimensional changes of sinus graft height above and between placed implants, and evaluate the factors effecting these changes with 2 different grafting materials and both combination.

Study design. The study group comprised 42 patients (50 sinus augmentation procedures). Four consecutive panoramic radiographs were evaluated for changes in sinus graft height between and above the placed implants. Factors that may influence graft height reduction were evaluated.

Results. The mean percentage of autogenous bone height reduction was 23% between implants and 13% above the implants. Bovine xenograft showed a mean of 6.5% graft height reduction between implants and 0% above implants. The only 2 parameters that correlated with reduction of graft height above and between the implants were time elapsed from surgery and the type of bone graft. Autogenous bone graft presented significantly more reduction (P < .022), whereas anorganic bovine bone graft had only minor or no changes in height.

Conclusion. The most important factor influencing reduction in vertical bone height on the time axis, following sinus augmentation is the grafting material, followed by the presence of a functional implant. Anorganic bovine bone was found superior in graft height maintenance in an up to 10 years of follow-up. (Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;111:e6-e11)

Maxillary sinus floor augmentation in conjunction with simultaneous or delayed placement of endosseous dental implants is a commonly used technique for reconstruction of the severely resorbed maxilla. Numerous clinical studies have reported the clinical outcomes of placing implants in the augmented maxillary sinus.1

The maintenance of the sinus bone graft height has clinical importance in some situations. Primarily, the need for long-term integrated bone coverage of the implant, in case of marginal bone loss combined with reduction in grafted bone height, may influence the implant stability and its survival.

In cases of compromised dentition and partial early teeth loss, it is recommended that sinus floor augmentation will augment area above the residual compromised dentition to serve as a future base for implant placement. In such cases, the bone graft height should be maintained and support the future implants for many years.

Maintenance of sinus bone graft height is also important in cases of late implant failure in grafted sinus bone. In cases of graft height reduction, there will be a need for preliminary redo sinus augmentation or reimplantation despite its complexity and the lower implant survival rates.2

Literature review yields short-term studies3,4 and only a few long-term studies dealing with radiographic changes in graft height after maxillary sinus floor elevation.5-10 The purpose of the present study was to compare the radiographic dimensional changes of sinus graft height above and between the placed implants and to evaluate the probable factors effecting these changes with different grafting materials.

MATERIAL AND METHODS

The files of 89 patients following sinus augmentation were reviewed for this study. Forty-seven patients with inadequate data (poor-quality radiographs or <9
months postrehabilitation follow-up) were excluded. The study group comprised 42 patients (27 women, 15 men, mean age 60 ± 9, range 40-83 years) treated in either a private surgery center (n = 39), Tel Aviv University (n = 1), or Tel Aviv Medical Center (n = 2) between 1994 and 2004. The mean follow-up was 45.7 ± 26 (range 9-121) months. A total of 50 maxillary sinus augmentations (8 patients following bilateral sinus augmentation) with or without simultaneous implant placement were included, with a total of 154 placed implants. Three different grafting materials were used: intraoral autogenous bone alone; anorganic bovine bone (Bio-Oss; Geistlich Pharma, Wolhusen, Switzerland) alone; and a mixture (1:4) of 20% autogenous bone and 80% anorganic bovine bone. The study design was approved by the ethics committee of the Tel-Aviv University.

The surgical technique was described previously.11-13 Prophylactic oral premedication was routinely used. The preferred regimen comprised amoxicillin (1 g) and dexamethasone (8 mg) given 1 hour before surgery and oral rinse with 0.5% chlorhexidine for 2 minutes. Clindamycin (600 mg) was the drug of choice for patients allergic to penicillin. The lateral wall approach was used for sinus grafting in all cases. Local anesthesia was administered using a maxillary nerve block via a greater palatine approach.11 A window was cut using a low-speed round bone bur. The sinus membrane was carefully reflected from the sinus floor and medial sinus wall. Once there was sufficient exposure, the membrane was examined for perforations. If no visible perforations were observed, the space was filled with saline solution and the patient was asked to gently perform the Valsalva maneuver. Air bubbles indicated the presence of a perforation. An overlapping collagen resorbable membrane (Bio-Gide; Geistlich) was used to repair perforations. Implants were placed using a surgical guide based on prewaxed casts. The grafting materials were gently condensed into the compartment. The fenestrated lateral wall of the maxillary sinus was covered with a resorbable collagen membrane (Bio-Gide), and the mucoperiosteal flap was repositioned and sutured with a 3/0 resorbable suture (Vicryl; Johnson & Johnson/Ethicon, Somerville, NJ). Simultaneous implant placement was performed only when primary implant stability could be achieved. When primary implant stability could not be achieved, a delayed 2-stage protocol was used, and implant placement was performed 6 months later. All implants were restored by fixed prostheses (bridge).

Four panoramic radiographs were evaluated: before surgery (T₀), and 1 year (T₁), 1-5 years (T₂), and 5-10 years (T₃) after implant placement. Morphometric measurements were done following tracing of the implant body, residual maxillary bone, original maxillary sinus floor, and grafted sinus floor by using a caliper. The measured implant length divided by the actual length was used for correction of the magnification error of the radiograph. The measurements were undertaken by a single investigator who was not involved in the treatment of the patients (SS).

Statistical analysis

Analysis of variance for repeated measurements with time (T₁-T₃) was used to compare between grafting
groups and between subjects with Pearson correlation test to access the change in vertical height along time at the 2 locations. The level of statistical significance was defined as $P < .05$. All data are expressed as a means ± SD.

**RESULTS**

General health: 54.7% (23) of the patients were healthy (ASA 1), 38.1% (16) had minor systemic problems (ASA 2), and 7.2% (3) major (ASA 3).

Smoking habits: 23.8% (10) patients were smokers, 23.8% (10) past smokers, and 52.4% (22) nonsmokers.

Residual alveolar ridge height at T0 was 4.4 ± 1.9 mm (range 1-9 mm). Most of the ridges were type C according to Jensen’s classification.14

In 62% of procedures (31), implants were placed simultaneously, and placement was delayed in 38% (19).

A total of 50 implants from 4 different manufacturers were evaluated. Thirty-seven implants were hydroxyapatite coated and 13 had a commercially pure titanium surface. Twenty-nine of the evaluated implants were in the site of the first molar, 11 in the second molar site, 8 in the second premolar site, and 2 in the first premolar site. Mean implant length was 14.16 ± 1.7 (range 10-16 mm) and mean width was 4.1 mm ± 0.5 (range 3.75-5 mm). Four of the 50 examined implants failed, yielding a survival rate of 92%.

In each sinus augmentation, only 1 implant was evaluated: the most distal one. Tables I and II summarize the mean bone loss above and between the implants on the time axis. The mean time elapsed from surgery was 29.7 ± 13 months at T2 and 75.25 ± 17.4 months at T3.

Figure 2 compares the percentage of graft lost above and between the implants for the 3 different grafting materials. The mean percentage of autogenous bone height reduction between implants was 23% and 13% above the implants. Bovine xenograft showed a mean of 6.5% graft height reduction between implants and 0% above implants.

No statistically significant correlation was found between the demographic parameters (gender, general health, and smoking habits), site characteristics (residual ridge height and classification), surgical characteristics (simultaneous vs delayed implant placement, grafting materials, and membrane perforation), and implant characteristics (manufacturer, coating, location, length, and width) and changes in graft height during the follow-up.

Three parameters correlated with bone graft loss—time elapsing from surgery, bone grafting material, and presence of an implant.

A statistically significant correlation was found between the time and reduction in graft height above the implant ($P = .042$), with mean total graft height reduction from T1 to T2 0.7 ± 0.99 mm (range 0-5 mm) and from T2 to T3 0.13 ± 0.48 mm (range 0-1 mm). Significant correlation was also found regarding the graft height between the implants ($P = .001$), with mean graft height reduction between the implants from T1 to T2 1.2 ± 1.14 mm (range 0-5 mm) and from T2 to T3 .65 ± 1.05 mm (range 0-3.5 mm). Most of the graft reduction occurred in the first period of T1-T2 (61%), with 39% in the late period of T2-T3.

The use of autogenous bone graft alone resulted in a significant bone height reduction along time while the use of anorganic bovine bone graft alone resulted in only minor or no changes in bone height (Fig. 2).

**DISCUSSION**

According to the present study, the most dominant factor influencing long-term vertical stability of the grafted bone after sinus augmentation, is the grafting material. Literature review regarding radiographic changes in graft height after sinus augmentation revealed differences in radiologic methods and grafting
According to the present study and the literature review, sinus augmentation with bovine xenograft yields the best results regarding long-term stability of the graft height and implant survival rates. Some authors assume that the slow rate, or even no resorption, for up to 10 years, as confirmed by biopsies is a disadvantage. However, the lack or slow resorbable characteristics of the bovine xenograft limit the remodeling process and promote long-term maintenance the graft height (Fig. 2).

Some clinicians still consider autogenous bone as the “gold standard” for sinus augmentation; yet, its use is limited due to donor site morbidity, sparse availability and mainly the uncontrolled resorption, as supported by the present study and the literature review. Healing of autogenous bone graft is followed by remodeling, according to functional loading forces. The result is bone volume loss up to 48%.

According to the present study, the second factor that influences long-term bone graft vertical stability is the presence of a functional implant. The grafted bone height maintenance was superior above the implant compared with bone height between the implants. The result was consistent with all the investigated grafting materials (Table III).

### Table II. Graft loss above the implant (from the apex to the upper border of the graft)

<table>
<thead>
<tr>
<th>Graft type</th>
<th>Time</th>
<th>Average baseline alveolar bone height</th>
<th>Average baseline graft height</th>
<th>Bone graft loss (mm)</th>
<th>Range</th>
<th>% of bone graft loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autogenous</td>
<td></td>
<td>3.75 mm</td>
<td>12.6 mm</td>
<td>1.36 ± 1.5</td>
<td>0-5</td>
<td>10.8%</td>
</tr>
<tr>
<td></td>
<td>T1-T2</td>
<td></td>
<td></td>
<td>0.3 ± 1.8</td>
<td>0-1</td>
<td>2.3%</td>
</tr>
<tr>
<td></td>
<td>T2-T3</td>
<td></td>
<td></td>
<td>1.66 ± 1.9</td>
<td>0-5</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autogenous and ABB</td>
<td></td>
<td>4.6 mm</td>
<td>13.6 mm</td>
<td>0.73 ± 0.75</td>
<td>0-3</td>
<td>5.3%</td>
</tr>
<tr>
<td></td>
<td>T1-T2</td>
<td></td>
<td></td>
<td>0.1 ± 0.44</td>
<td>0-1</td>
<td>0.7%</td>
</tr>
<tr>
<td></td>
<td>T2-T3</td>
<td></td>
<td></td>
<td>0.83 ± 0.71</td>
<td>0-3</td>
<td>6.1%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>ABB</td>
<td></td>
<td>4.26 mm</td>
<td>13.3 mm</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>T1-T2</td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
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<tr>
<td></td>
<td>T2-T3</td>
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<td></td>
<td>Total</td>
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<td>0</td>
<td>0</td>
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</tbody>
</table>

ABB, Anorganic bovine bone.

![Fig. 2. Graft height reduction related to augmentation material between (blue bars) and above (red bars) the implants. Au, Autogenous bone; Bx, bovine xenograft.](image)
The results seemed to be in agreement with other studies.\textsuperscript{8,10} Hatano et al.\textsuperscript{8} suggested that implant loading promotes osteogenesis in the long term. Implant loading may exert a stabilizing effect on the maintenance of bone graft height.\textsuperscript{8,18}

It can be speculated that bovine xenograft is most suited for grafting areas were implant placement is expected to be performed in the long term, e.g., future implantation adjacent to existing implants placed after sinus augmentation above teeth with questionable prognosis as a future bone base for implantation. This would eliminate the need for sinus reentry and reaugmentation if the graft can keep its height, e.g., for implant placement in the molar area expecting future implant placement in the premolar area. Further clinical trials to validate this speculation are necessary.

**CONCLUSIONS**

The most important factor influencing reduction in vertical bone height on the time axis after sinus augmentation is the grafting material, followed by the presence of a functional implant. Anorganic bovine bone was found to be superior in graft height maintenance in up to 10 years’ follow-up.

**REFERENCES**


Reprint requests:
Dr. Ofer Mardinger
Department of Oral and Maxillofacial Surgery
School of Dental Medicine
Tel-Aviv University
Tel-Aviv
Israel
ofermardinger@gmail.com