

Long-Term Evaluation of Implant Survival in Augmented Sinuses: A Case Series



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This study compared bone grafting regimens and different implant surfaces used for sinus augmentation and presented long-term implant success rates in augmented sinuses. Two hundred fifty-seven consecutive patients with 625 implants were evaluated retrospectively. In phase 1, 188 sinuses were grafted with (1) autograft alone; (2) autograft + demineralized freeze-dried bone allograft (DFDBA) + absorbable hydroxyapatite (AHA) in a ratio of approximately 1:3:3; or (3) DFDBA + AHA + nonabsorbable HA (NHA) in a ratio of approximately 1:1:1. In phase 2, grafting regimen 3 (combination of DFDBA + AHA + NHA) was used in another 69 patients. Data were analyzed based on bone grafting regimen, implant surface texture, and time of implant placement (immediate or delayed). In phase 1, graft type 3 had the lowest implant failure rate (2.7%), followed by type 2 (14.3%) and type 1 (44.4%). The overall implant failure rate was 3.6%. Smooth implants showed the highest failure rate (21.8%), followed by titanium plasma-sprayed (2.9%) and HA-coated (0.7%) implants. In phase 2, the overall implant survival rate was 92.5% after 3 years. Smooth implants showed the highest failure rate (41.7%), followed by sand-blasted, large-grit, acid-etched (6.8%) and HA-coated (3.4%) implants. All failures occurred when implants were placed simultaneously with sinus grafts. This study suggests that long-term implant success can be obtained when maxillary sinuses are augmented with a combination of DFDBA + AHA + NHA. Rough surfaces and delayed implant placement seem to increase implant success in these areas. (Int J Periodontics Restorative Dent 2008;28:163–169.)

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Atrophy of the alveolar ridge following extraction, in conjunction with periodontal disease or not, and the degree of pneumatization of the maxillary sinuses significantly limit implant placement in these areas because of decreased alveolar bone height.^{1–3} In some cases, the use of shorter implants can overcome this problem, and this has been done for many years.⁴ However, shorter implants have often been associated with higher implant failure rates, especially in areas of reduced bone density (eg, posterior maxilla) or that are subject to higher occlusal forces,^{4,5} resulting in poorer prognoses. Thus, the use of implants of adequate length and width may require elevation of the maxillary sinus and subsequent grafting.^{6–8} The lateral window approach is a commonly used technique for sinus elevation, especially when the initial alveolar bone height cannot assure primary stability of implants placed simultaneously with sinus grafts.^{9,10}

Combinations of grafting materials have been used to fill the space created by sinus elevation and to promote new bone formation.^{11–15} Autogenous bone is considered to be

the ideal grafting material, since it supplies not only viable osteoblasts but also imparts osteoinduction and osteoconduction, providing both organic and inorganic matrices as well as biologic modifiers and viable bone cells without antigenicity.¹³ However, intraoral sources of autogenous bone are limited and require an additional surgical procedure for harvesting. As a consequence, the risk of morbidity is increased. Additional grafting materials, eg, allografts, xenografts, and alloplasts, are often required to overcome this deficiency.¹² Allografts such as demineralized freeze-dried bone (DFDBA) possess osteoinductive and osteoconductive properties, whereas xenografts and alloplasts, such as hydroxyapatite (HA), may act only as a scaffold for new bone formation because of an inability to induce osteoblast activation and proliferation.^{16,17} A significant advantage of these materials is their availability, which can reduce or even eliminate the need to harvest autogenous bone from intraoral and/or extraoral sources. During sinus grafting, these materials are combined with autografts, accommodated in the sinus cavity, and adapted against the floor of the sinus. A healing period of 6 to 8 months is necessary to allow vascularization and incorporation of the grafts and subsequent maturation of newly formed bone tissue.¹⁸

Elevation of a maxillary sinus and subsequent grafting allow placement of implants of adequate length in ideal locations to withstand occlusal loading. However, the greatest part of the implant will lie in or next to augmented bone.¹⁹ Because most of the implant

surface will be in contact with grafted bone, evaluation of the long-term survival rate of implants placed in these areas and stability of the augmented bone is important. Therefore, the aims of this article are to investigate bone graft regimens used for sinus lifting procedures and to present long-term implant success rates in areas where maxillary sinuses were grafted with these materials. Factors that may positively or negatively affect the long-term success rate will also be addressed.

Method and materials

At the initial visit, a preoperative assessment, including medical/dental history, complete oral examination, and panoramic radiography, was conducted on all patients. Prior to the surgery, all patients were informed about the advantages and risks associated with this procedure. Subjects for the study were selected according to the following inclusion criteria: patients were systemically healthy and did not take any drugs at least 2 weeks before the surgery and needed sinus augmentation for proper implant placement. Smokers and patients suffering from any disease known to alter bone metabolism were excluded.

Phase 1: Evaluation of bone grafting regimens

From 1993 to 2000, 188 sinus augmentations were performed with three different bone grafting regimens. They were: (1) autograft alone, collected only from intraoral sites (eg, preparation of

implant osteotomies, tuberosity, ramus, symphysis); (2) a combination (1:3:3 ratio) of autograft, DFDBA (LifeNet), and absorbable HA (OsteoGen, Implants); and (3) a combination (1:1:1 ratio) of DFDBA, absorbable HA, and nonabsorbable HA (OsteoGraft, Japan Medical Material). A delayed implant placement approach was adopted when the initial alveolar ridge height was ≤ 4 mm. If 5 to 8 mm of alveolar bone height were present at the time of grafting, implants were placed simultaneously. In all, 466 implants were placed: 55 partially machine-polished (MP) surface implants (BIOMET/3i), 111 rough titanium-plasma sprayed (TPS) implants (POI Implants), and 300 hydroxyapatite-coated (HAC) implants (POI Implants).

Phase 2: Confirmation of previous findings

Based upon the results obtained in phase 1, a combination of equal amounts of DFDBA, absorbable HA, and nonabsorbable bovine HA (1:1:1 ratio) was used to augment maxillary sinuses in an additional 69 patients between 2000 and 2002. A total of 118 implant fixtures (10 to 15 mm in length) were placed simultaneously with sinus augmentation, and the remaining 41 were restored in a delayed approach (12 MP [BIOMET/3i], 59 sand-blasted, large-grit, acid-etched [SLA, Straumann], and 88 HAC [POI Implants]). As for phase 1, if the initial bone height was ≥ 5 mm, then implants were placed simultaneously. Otherwise, a staged approach was adopted.

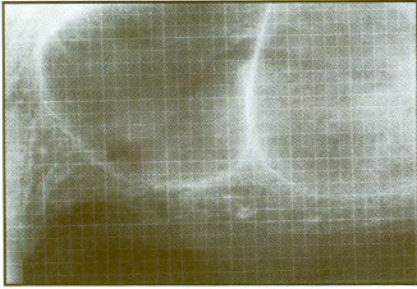


Fig 1 (left) Pretreatment radiograph. Observe the proximity between the alveolar crest and the floor of the maxillary sinus, along with the distinct septum.

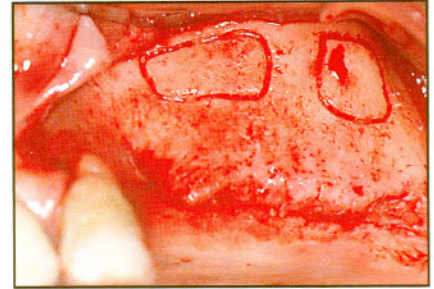


Fig 2 (right) The bone wall was fenestrated in two locations to avoid the septum.

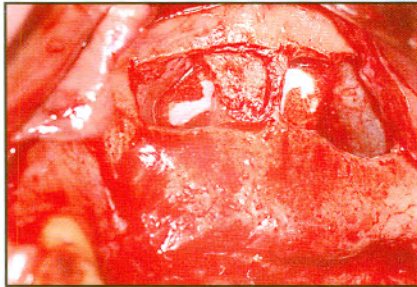


Fig 3 (left) If a perforation of the schneiderian membrane was noted, it was covered with an absorbable collagen membrane.

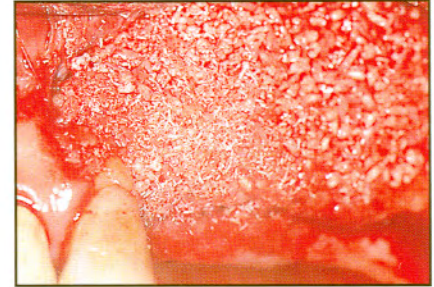


Fig 4 (right) The sinus cavity was completely filled with a combination of bone grafting materials (DFDBA + absorbable HA + non-absorbable HA).

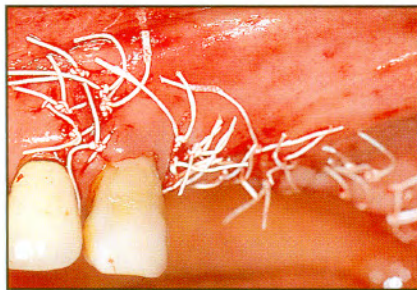


Fig 5 The grafted area was covered with another absorbable collagen membrane to exclude soft tissue cells from the wound. Next, the flap was repositioned free of tension and secured with interrupted sutures.

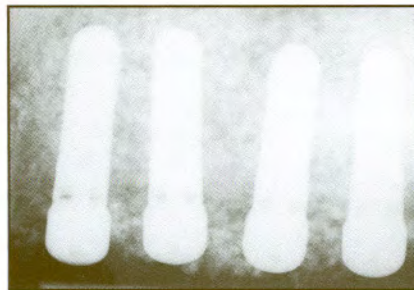


Fig 6 Six-month postsurgical radiographic examination showed significant gain in bone height. This allowed for proper implant placement at 6 months after surgery.



Fig 7 The definitive prosthesis was delivered 6 months after implant placement, properly restoring posterior occlusal function.

Surgical technique

Figures 1 to 7 illustrate the surgical procedure used in this study. Sinus elevation procedures were performed according to Tatum.¹⁰ Briefly, a lateral access window was created using diamond rotary instruments under copious irrigation until the schneiderian

membrane of the sinus became evident (Fig 2). The schneiderian membrane was then gently elevated. Absorbable collagen membrane (BioMend, Zimmer Dental) was used to cover any perforations of the schneiderian membrane, if noted (Fig 3). The space created was subsequently grafted with one of the three described

bone grafting regimens (in phase 1; in phase 2, all grafts were the same, as mentioned earlier) (Fig 4). The lateral access window was then covered with an additional absorbable collagen membrane (BioMend) to prevent soft tissue invasion and promote bone formation. Flaps were repositioned and sutured without tension (Fig 5).

All subjects received the same pharmacologic protocol of antibiotic prophylaxis: either amoxicillin 500 mg 3 times a day for 10 days or azithromycin 500 mg one time a day for 3 days in case of penicillin allergy; analgesia (ibuprofen 600 mg as needed every 4 to 6 hours); and anti-inflammatory control (dexamethasone 8 mg on the day of surgery, 4 mg on the second and third days, and 2 mg on the fourth day after surgery). All patients were advised to return 10 to 14 days later for assessment of wound healing and removal of sutures. Patients were monitored every 6 to 8 weeks, and any adverse events were recorded. When simultaneous implant placement was not possible, implants were placed 6 to 8 months later and allowed to heal for at least 6 months before loading (Figs 6 and 7).

Results

Phase 1

No significant complications were observed during the study period. Fifty-three percent of implants were placed simultaneously with sinus lifting, whereas the remaining 47% were placed in a delayed approach. Delayed implant placement was performed after an average of 6.5 months (range, 6 to 7.2 months) of healing. The criteria of Albrektsson et al were used to determine the success of each implant.²⁰ An overall survival rate of 96.4% was observed. Seventeen implants (3.6%) were mobile at the beginning of the restorative phase and were characterized as failures. All fail-

ures occurred when implants were placed simultaneously with sinus grafting. MP implants showed the highest percentage of failures (21.8%), followed by TPS (2.9%) and HAC (0.7%) implants. Implant failure was affected not only by the time of implant placement and surface configuration but also by the bone grafting regimen. The highest failure rate was observed when autogenous bone was used alone (44.4%), followed by 1:3:3 of autograft + DFDBA + absorbable HA (14.3%) and 1:1:1 combination of DFDBA + absorbable HA + nonabsorbable HA (2.7%).

Phase 2

Based on the results obtained in phase 1, the bone graft composed of DFDBA + absorbable HA + nonabsorbable HA (1:1:1) was used during phase 2, which included 69 patients and 159 implants. Again, no significant complications were observed. Implant restorations were constructed after an average of 6.2 months of healing. Of the 159 implants placed, 74.3% were placed simultaneously and the rest were placed in a staged approach. The overall survival rate was 92.5%. As in phase 1 of the study, all failures occurred in the implants placed at the time of grafting and were significantly associated with implant surface configuration. MP implants showed the highest percentage of failures (41.7%), followed by SLA (7.1%), TPS (5.9%), and HAC (3.4%) implants (Table 1).

Discussion

Sinus lifting procedures have significantly expanded the indications and improved the predictability of implant therapy by allowing placement of implants of proper length (ie, ≥ 10 mm) in the posterior maxilla.¹⁴ The long-term results presented in this article showed that when implants of sufficient length are placed, success can be maintained over the long term, even in areas of poor bone density and/or augmented bone.

Autogenous bone grafts are considered to be the ideal grafting material in implant dentistry.^{14,17} However, the highest failure rate observed in the present sample was associated with this type of bone graft. The increased failure rate could be attributed to the following factors: (1) inadequate volume of grafting material; (2) influence of osseous coagulum (bone collected from sequential drills) on the graft; (3) inadequate time (simultaneous implant placement) for proper healing before loading; and/or (4) implant surface type used in these sites. Furthermore, when autografts were used alone, less bone gain was observed. This emphasizes the need for other grafting materials to assure that adequate ridge volume can be achieved. In our study, the combination of autograft, DFDBA, and absorbable HA (1:3:3) showed gradual bone loss around the implants after loading, which was observed 6 to 7 years later. This gradual bone loss was positively correlated with an increased implant failure rate. Therefore, the bone grafting regimen was altered with the introduction of nonabsorbable HA. Nonabsorbable HA was incorporated

Table 1 Long-term success rates of implants based on surface texture (2000–2002)*

Year/ Surface texture	Subjects	Implants placed	No. of failures (%)	Failure rate
2000				
All	13	32	3	9.3%
MP		2	2 (100%)	6.2%
TPS		17	1 (5.9%)	3.1%
HAC		13	0 (0%)	0%
2001				
All	32	70	4	5.7%
MP		4	1 (25%)	1.4%
SLA		28	2 (7.1%)	2.9%
HAC		38	1 (2.6%)	1.4%
2002				
All	24	57	5	8.7%
MP		6	2 (33.3%)	3.4%
SLA		14	1 (7.1%)	1.9%
HAC		37	2 (5.4%)	3.4%
All years				
All	69	159	12	7.5%
MP		12	5 (41.7%)	3.1%
TPS		17	1 (5.9%)	0.6%
SLA		42	3 (7.1%)	1.9%
HAC		88	3 (3.4%)	1.9%

*All sinuses were grafted with DFDBA + absorbable HA + nonabsorbable HA (1:1:1 ratio). MP = machine polished; TPS = titanium plasma-coated; SLA = sandblasted/acid etched; HAC = HA-coated.

into this new bone grafting regimen to ensure that adequate bone volume would be present not only at the time of implant placement but also after functional loading. This form of HA is composed of denser particles that can be fully incorporated into the newly formed tissue instead of quickly absorbed. Studies have shown that nonabsorbable HA is an effective graft material for sinus augmentation.^{21–23} Data from phase 1 confirmed these findings. The combined DFDBA, absorbable HA, and nonabsorbable

HA (1:1:1) grafts had the best results. This was further confirmed in phase 2 (see Table 1). Another factor that could have influenced the lower failure rate observed in phase 2 is the enhanced clinical skills of the surgeon performing these procedures. It is logical to believe that more clinical experience would also improve treatment outcomes.

The majority of the implant failures were found with the MP surface; this is in agreement with the literature.^{24,25} A machined surface has a reduced surface area and less bone-to-implant contact

when compared to a rough surface.^{24,25} In our observation, MP implants demonstrated rotation of 1 to 2 mm before the torque required for restorative abutment connection reached 20 N. This may suggest that, even after the healing period has elapsed, the alveolar bone still undergoes remodeling, and implants with increased surface area (eg, TPS, SLA, HAC) may play an important role in implant survival by assuring that stability will be maintained over the long term.^{26,27}

Interestingly, all failures occurred when implants were placed simultaneously with sinus grafting, regardless of their implant surface or the bone graft regimen applied. The increased failure rate of simultaneously placed implants was probably caused by the following factors: (1) poor primary stability of the implants at the time of placement²⁸⁻³⁰; (2) premature non-functional load during mastication; and/or (3) poor bone quality (type IV bone).³¹ Because no failures occurred when implants were placed in a delayed approach, it can be assumed that a staged approach may not only increase the implant success rate but may also overcome the deficiencies of severely atrophic ridges, since these implants were placed in areas where minimal bone volume was present before grafting (≤ 4 mm).¹⁹ The simultaneous approach may decrease the healing time since the graft and implants heal concomitantly, but an increased failure rate can be expected.

Within the limitations of this study, the following conclusions can be drawn.

- The combination of DFDBA + absorbable HA + nonabsorbable HA significantly improved stability of the augmented bone and implant survival rates in these areas.
- Implant surface texture in augmented sinus areas seems to play an important role in overall survival rates. Implants with rough surfaces may be a preferable choice.
- An increased failure rate should be expected when implants are placed simultaneously with sinus augmentation.

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