

# The Sinus Bone Graft

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Edited by

Chapter 18

**Ole T. Jensen, DDS, MS**

Private Practice

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Denver, Colorado



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# chapter 18

## Effect of Surface Morphology on Implant Survival in the Grafted Maxillary Sinus

*Dennis P. Tarnow, DDS*

*Sang-Choon Cho, DDS, BDS, MS*

*Stephen S. Wallace, DDS*

*Stuart J. Froum, DDS*

The design of an implant affects its success in the grafted bone at the maxillary sinus floor. Among other design characteristics, the surface texture of implants has been shown to have a significant effect on the amount of bone-implant contact; this effect may be even more significant in the bone graft situation. Early landmark studies, such as those by Buser et al<sup>1</sup> and by Wennerberg et al,<sup>2-4</sup> and a more recent study by Lazzara et al,<sup>5</sup> show that rough-surfaced implants achieve greater bone-implant contact than machine-surfaced implants. This now well-established principle has led implant manufacturers away from the production of smooth, untextured surfaces toward more macroscopically and microscopically textured surfaces.

Whereas blood clot contact is maintained by a textured surface, it contracts from a machined surface during early wound healing. This phenomenon helps the endosteum maintain contact with the foreign body implant, which leads to faster bone formation directly on the surface by the process known as *osteogenesis*. Once a clot detaches from the surface of smooth or machined implants, the clot must regrow contact back to the implant surface, a process that Davies calls *distance osteogenesis*.<sup>6</sup> Direct apposition of the clot to the implant surface during the initial stages of healing speeds implant integration and modeling for earlier and more complete osseointegration, resulting in a higher rate of implant

survival in grafted bone and allowing the adoption of earlier loading protocols.<sup>7-10</sup> In a study that compared machine-surfaced implants with acid-etched implants, the machined side achieved a lower-than-expected amount of implant-bone interface based on the receptor site bone quality, while the acid-etched side achieved a greater-than-expected interface.<sup>11</sup>

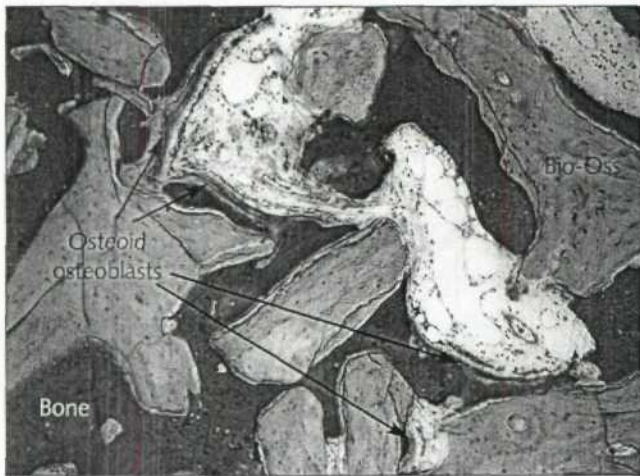
This phenomenon is extremely important clinically, particularly in softer bone such as that found in the posterior maxilla or healed sinus floor grafts. The formation of a stable bone-implant interface in type 3 or 4 bone such as that normally resulting from sinus augmentation surgery is a key factor in the success rate of implants placed in these grafts and loaded after integration. Histologic studies have confirmed the superiority of textured implants as compared to machined implants in the posterior maxillae of humans.<sup>5</sup>

When the floor of the sinus is grafted, the membrane is elevated from the lateral, anterior, and medial walls of the lower third of the sinus cavity. After the graft is placed, a clot forms within and around the graft particles, with vascularization from the vessels in the surrounding bony walls from which the sinus membrane has been elevated. The manner in which new bone forms in the grafted site may be compared to the manner in which bone forms in an extraction socket. The bone quality ultimately

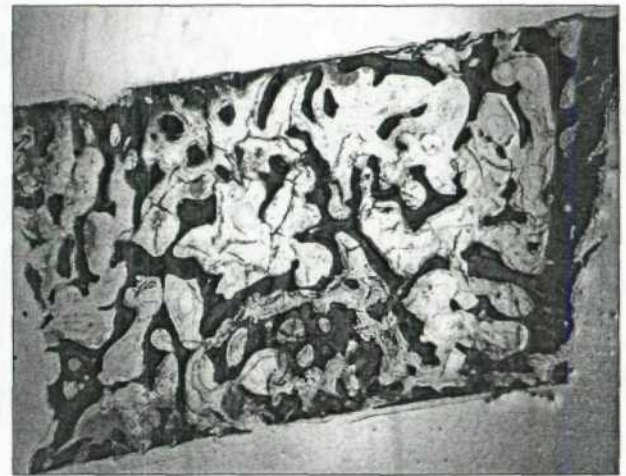
**Table 18-1** Vital bone formation in sinuses grafted with Bio-Oss alone and combined with autogenous bone (AB) or blood

Author	Graft material	Time (mos)	Bone (%)	Bio-Oss (%)	CT* (%)
Valentini, 2000 <sup>16</sup>	Bio-Oss alone	6.0	21.0	39.0	40.0
Valentini, 2000 <sup>16</sup>	Bio-Oss alone	12.0	28.0	27.0	45.0
Yilderim, 2001 <sup>17</sup>	Bio-Oss + AB	7.1	18.9	29.6	51.5
Yilderim, 2000 <sup>18</sup>	Bio-Oss + blood	6.8	14.7	29.7	55.6
John, 2004 <sup>19</sup>	Bio-Oss alone	3.0–8.0	29.5	14.9	55.6
John, 2004 <sup>19</sup>	Bio-Oss + AB	3.0–8.0	32.2	17.8	50.0
NYU (unpub)	Bio-Oss alone	6.0–12.0	18.5	28.0	53.5
NYU (unpub)	Bio-Oss + AB	6.0–12.0	15.7	29.6	54.7
<b>Average</b>			<b>23.0</b>	<b>27.0</b>	<b>50.0</b>

\*CT = connective tissue.



**Fig 18-1** Sinus grafted with 100% Bio-Oss, 6 months after surgery, demonstrating 30% vital bone (red) and 24% residual Bio-Oss (yellow). High-power view shows new vital bone formation directly on the residual Bio-Oss particles. (Stevenel blue and picric acid fuchsin; original magnification  $\times 20$ .)



**Fig 18-2** Sinus grafted with 100% Puros (Zimmer Dental) mineralized allograft at 6 months, demonstrating 25% vital bone (red). Medium-power view shows vital bone formation and residual Puros particles (brown). (Stevenel blue and picric acid fuchsin; original magnification  $\times 10$ .)

achieved after sinus graft healing is genetically and biomechanically predetermined by the density of the natural bone in that anatomic location. In a study by Moy et al<sup>12</sup> in which particulated bone harvested from the chin was grafted into the sinus, the matured graft did not exhibit the same density as the grafted chin bone, but had a lower density such as that normally found in the posterior maxilla. Histologically, native bone in the posterior maxilla is composed of approximately 30% calcified bone and 70% marrow.<sup>13</sup> An anatomic study by Ulm et

al<sup>14</sup> showed that bone in the maxillary molar region has an average density of 17.1% in females and 23.4% in males. The quality of the bone that migrates into and around a sinus graft appears to be determined initially by the density of the bone at the crest below the sinus.<sup>15</sup> Density of the bone then increases with implant function. Histologic reports in the literature show a wide range of bone graft densities; however, the prevailing average is close to 25% (Table 18-1; Figs 18-1 and 18-2).

**TABLE 18-2** Implant survival classified by surface texture and type of graft (block or particulate)

Implant surface/graft type	SE	Mean (%)	Least square mean* (%)
Machined/iliac block	2.5	78.8	78.8
Machined/particulate	3.3	89.5	90.0
Rough/iliac block	6.1	90.9	89.5
Rough/particulate	1.2	94.5	94.6

\*Least square mean includes adjustments for other variables.

This explanation corresponds with our knowledge of the healing of tooth extraction sites. When a mandibular canine and a maxillary second molar are extracted and all the bony walls are present, the mandibular canine socket fills with dense bone (type 1 or 2) after 6 months of healing, while the posterior maxillary socket fills with type 3 or 4 bone. This epigenetic and biomechanic phenomenon is a consistent biologic principle. Bone regeneration is consistent within each host location. The same phenomenon has been observed in the bone graft situation, where modeling and remodeling substantially replace the bone graft with natively bone. Thus, sinus bone grafts generally heal with type 3 or 4 bone. The significance of the choice of implant increases as bone density decreases, such as in grafted areas where primary stabilization is reduced and the capacity for osseointegration is relatively compromised.

Two systematic literature reviews on sinus grafting revealed consensus regarding the poorer rate of survival of machine-surfaced implants compared to textured implants placed in the augmented sinuses.<sup>20-22</sup>

Wallace and Froum<sup>20</sup> reported the survival of machine-surfaced implants and rough-surfaced implants as 82.4% and 95.2%, respectively. Del Fabbro et al<sup>21</sup> found survival rates for machine- and rough-surfaced implants of 85.6% and 95.9%, respectively. These reviews conclude that the surface texture of an implant is clinically significant.

Furthermore, rough-surfaced implants were more successful than machine-surfaced implants regardless of graft material used (Table 18-2). Del Fabbro et al<sup>21</sup> reported that 69.5% of all implants placed in 100% autogenous bone grafts had machined surfaces, accounting for 87.8% of the failures. The large disparity is probably owing at least in part to the fact that a majority of implants placed had machined surfaces.

## Clinical Experience

At New York University, a total of 400 patients had 1,134 implants placed in grafted sinuses. Implants were classified according to their surface morphology: acid etched (724), hydroxyapatite-coated (20), machined (104), sandblasted, large grit, acid-etched (SLA [Straumann]) (105), titanium oxide-blasted (TiOblast [Nobel Biocare]) (28), or titanium plasma-sprayed (TPS) (153) (Fig 18-3). Of the 1,134 implants placed, 1,030 had some type of roughened surface and the remaining 104 were machine turned. Minimum loading time for inclusion in this retrospective study was 6 months.

Seventy-six of the 1,134 implants placed in this study group failed, yielding an overall survival rate of 93.3%. However, a clear and significant difference was noted when the data for the rough-surfaced and machined implants were separated. A survival rate of only 70.2% was found for the machined implants versus 95.6% for all rough-surfaced implants combined. Table 18-3 presents a breakdown of implant survival by surface type.

The overall survival rate observed in this clinical investigation (93.3%) is comparable to that reported in previous studies for implants placed in grafted maxillary sinuses. The report of the Sinus Consensus Conference of 1996<sup>23</sup> analyzed retrospective data from 1,007 sinus floor augmentation bone grafts collected from 38 surgeons, involving the placement of 2,997 implants over a 10-year period. The complete data demonstrated a 90.0% success rate and revealed reduced success with machined implants, comparable in both regards to the NYU data.



**Fig 18-3** Five different implant surfaces. *From left:* machined, acid-etched, SLA, TiOblasted, TPS.

**Table 18-3** Survival rates of implants classified by surface texture

Implant surface	Acid-etched	HA	SLA	TiOblasted	TPS	Machined
Survival rate	95.8%	90.0%	96.1%	96.4%	94.8%	70.2%
	(694/724)	(18/20)	(101/105)	(27/28)	(145/153)	(73/104)

## Conclusions

Implants can be placed and subsequently loaded in augmented maxillary sinuses. A high survival rate depends on the surface texture of the implant. The machined implants have a relatively poor survival rate as compared to that of rough-surfaced implants.

Future research will isolate the many confounding variables in sinus augmentation surgery for the purpose of verifying the results and conclusions reported here.

## References

1. Buser D, Schenk RK, Steinemann S, Fiorellini JP, Fox CH, Stich H. Influence of surface characteristics on bone integration of titanium implants. A histomorphometric study in miniature pigs. *J Biomed Mater Res* 1991;25:889-902.
2. Wennerberg A, Albrektsson T, Andersson B, Kroll JJ. A histomorphometric and removal torque study of screw-shaped titanium implants with three different surface topographies. *Clin Oral Implants Res* 1995;6:24-30.
3. Wennerberg A, Albrektsson T, Lausmaa J. Torque and histomorphometric evaluation of commercially pure titanium screws blasted with 25- and 75- $\mu$ m-sized particles of  $Al_2O_3$ . *J Biomed Mater Res* 1996;30:251-260.
4. Wennerberg A, Albrektsson T, Andersson B. Bone tissue response to commercially pure titanium implants blasted with fine and coarse particles of aluminum oxide. *Int J Oral Maxillofac Implants* 1996;11:38-45.
5. Lazzara RJ, Testori T, Trisi P, Porter S, Weinstein RL. A human histologic analysis of Osseotite and machined surfaces using implants with 2 opposing surfaces. *Int J Periodontics Restorative Dent* 1999;19:117-129.
6. Davies JE. Mechanisms of endosseous integration. *Int J Prosthodont* 1998;11:391-401.
7. Testori T, Del Fabbro M, Feldman S, et al. A multicenter prospective evaluation of 2-months loaded Osseotite implants placed in the posterior jaws: Three-year follow-up results. *Clin Oral Implants Res* 2002;13:154-161.
8. Cochran DL, Buser D, ten Bruggenkate CM, et al. The use of reduced healing times on ITI implants with a sandblasted and acid-etched (SLA) surface: Early results from clinical trials on ITI SLA implants. *Clin Oral Implants Res* 2002;13:144-153.
9. Cooper L, Felton DA, Kugelberg CF, et al. A multicenter 12-month evaluation of single-tooth implants restored 3 weeks after one-stage surgery. *Int J Oral Maxillofac Implants* 2001;16:182-192.

10. Rocuzzo M, Bunino M, Prioglio F, Silvio D, Bianchi F. Early loading of sandblasted and acid-etched (SLA) implants: A prospective split-mouth comparative study. *Clin Oral Implants Res* 2001;12:572-578.
11. Trisi P, Lazzara RJ, Rao W, Rebaudi A. Bone-implant contact and bone quality: Evaluation of expected and actual bone contact on machined and Osseotite implants. *Int J Periodontics Restorative Dent* 2003;23:535-546.
12. Moy PK, Lundgren S, Holmes RE. Maxillary sinus augmentation: Histomorphometric analysis of graft materials for sinus floor augmentation. *J Oral Maxillofac Surg* 1993;51:857-862.
13. Trisi P, Rao W. Bone classification: Clinical-histomorphometric comparison. *Clin Oral Implants Res* 1999;10:1-7.
14. Ulm C, Kneissel M, Schedie A, et al. Characteristic features of trabecular bone in edentulous maxillae. *Clin Oral Implants Res* 1999;10:459-467.
15. Valentini P, Abensur D, Densari D, Graziani JN, Hammerle C. Histological evaluation of Bio-Oss in a sinus floor elevation and implantation procedure. A human case report. *Clin Oral Implants Res* 1998;9:59-64.
16. Valentini P, Abensur D, Wenz B, Peetz B, Schenk R. Sinus grafting with porous bone mineral (Bio-Oss) for implant placement: A 5-year study on 15 patients. *Int J Periodontics Restorative Dent* 2000;20:245-253.
17. Yildirim M, Spiekermann H, Handt S, Edelhoff D. Maxillary sinus augmentation with the xenograft Bio-Oss and autogenous intraoral bone for qualitative improvement of the implant site: A histologic and histomorphometric clinical study in humans. *Int J Oral Maxillofac Implants* 2001;16:23-33.
18. Yildirim M, Spiekermann H, Biesterfeld S, Edelhoff D. Maxillary sinus augmentation using xenogenic bone substitute material Bio-Oss in combination with venous blood. A histologic and histomorphometric study in humans. *Clin Oral Implants Res* 2000;11:217-229.
19. John HD, Wenz B. Histomorphometric analysis of natural bone mineral for maxillary sinus augmentation. *Int J Oral Maxillofac Implants* 2004;19:199-207.
20. Wallace SS, Froum SJ. Effect of maxillary sinus augmentation on the survival of endosseous dental implants: An evidence-based literature review. *Ann Periodontol* 2003;8:328-343.
21. Del Fabbro M, Testori T, Francetti L, Weinstein R. Systematic review of survival rates for implants placed in the grafted maxillary sinus. *Int J Periodontics Restorative Dent* 2004;24:565-577.
22. Cho S-C, Yang HS, Elian N, Wallace S, Froum S, Tarnow DP. Survival rates of implants with different surface morphologies in grafted sinuses: Six-month loading data. *Int J Periodontics Restorative Dent* 2005;(Submitted for publication).
23. Jensen OT, Shulman LB, Block MS, Iacono VJ. Report of the Sinus Consensus Conference of 1996. *Int J Oral Maxillofac Implants* 1998;13:11-45.