Predictability of Simultaneous Implant Placement in the Severely Atrophic Posterior Maxilla: A 9-Year Longitudinal Experience Study of 2,132 Implants Placed into 731 Human Sinus Grafts

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Purpose: *One-stage implant placement in the grafted maxillary sinus has traditionally been limited to patients with at least 5 mm of residual bone to ensure complete implant stabilization. The aim of this prospective study was to determine the long-term survival rates of implants with roughened surfaces placed immediately into maxillary sinus grafts in patients with 1 to 5 mm of residual bone.* ***Materials and Methods:*** *A total of 2,132 microtextured screw-type (n = 1,374) or hydroxyapatite-coated cylinder-type (n = 758) implants were immediately placed into the grafted sinuses of 731 patients. The implants were restored and monitored for up to 9 years of clinical follow-up.* ***Results:*** *Cumulative survival at 9 years was 97.9% (n = 2,091 implants); 20.4% of the implants were placed in 1 to 2 mm of residual bone.* ***Discussion:*** *Initial implant stability and parallelism were achieved through a combination of meticulous condensation of the particulate bone graft material around the implants, the frictional interface of the roughened implant surfaces and the host tissues, and selection of an appropriate graft material.* ***Conclusions:*** *Simultaneous implant placement into sinus floor grafts can be a predictable treatment option for patients with at least 1 to 2 mm of vertical residual bone height when careful case planning and meticulous surgical techniques are used.* (More than 50 references) INT J ORAL MAXILLOFAC IMPLANTS 2006;21:94–102

Key words: *bone graft, implants, sinus lift, subantral augmentation*

Subantral augmentation, or the so-called sinus lift procedure, which was first introduced by Tatum[1] in 1975, used a series of malleted instruments to create an osteotomy through the residual maxillary ridge, followed by an upward fracture of the sinus floor and elevation of the schneiderian membrane.[1] Once access to the sinus cavity was achieved, additional particulate graft material could be inserted through the osteotomy and into the elevated sinus to further expand the volume of available bone. If sufficient residual bone was present, a dental implant that extended into the graft material was immediately placed; if not, the crestal access channel could be filled with graft material and allowed to heal for future implant site development.

Today, most clinicians use a modified Caldwell-Luc approach, which involves preparation of a buccal window to gain access to the sinus cavity and then elevation of the schneiderian membrane to create a secluded compartment for the augmentation material.[2,3] This technique has shown such favorable results that the posterior maxilla is often considered one of the most predictable regions for grafting prior to, or simultaneously with, implant placement.[2] Because it allows a direct view of the sinus, this technique enables a greater volume of augmentation material to be placed in the appropriate position and packed to maximum density. A minimum of 5 mm of residual alveolar bone height is traditionally recommended for the 1-stage surgical procedure to ensure

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Table 1	Criteria Used for Patient Selection
Parameter	**Criteria**
Inclusion	• Maxillary posterior sinus floor bone deficiency (ie, 1–7 mm in height, bi- or unilaterally) • Good periodontal health • Good general health; those with controlled medical conditions accepted with physician approval • Stable mental health condition • Ability to complete at least 24 months of clinical follow-up • Willingness to provide signed informed consent
Exclusion	• Use of immunosuppressive medication • Presence of immunodeficiency disease • Use of postirradiation therapy • Evidence of sinus pathology (eg, chronic or acute sinusitis, cysts, tumors)

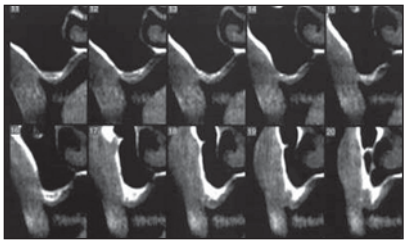


Fig 1 Alveolar bone height of 1 to 2 mm can be seen in the areas requiring augmentation grafting in this dental CT scan.

adequate implant stabilization and parallelism; when residual bone height is less than 4 mm, a 2-stage procedure with delayed implant placement is traditionally advocated.[4]

In recent years, some clinicians have adopted a 1-stage surgical technique that allows implant placement in as little as 1 to 2 mm of residual bone, provided microtextured or coated implants at least 13 mm in length are placed, and provided that the graft material is carefully controlled to allow for axial orientation and stability.[5–7] Implant designs and surfaces have evolved in recent years; turned (machined) titanium implant surfaces are being modified to increase their surface microtexture or "roughness." Reports in the dental literature indicate that the frictional resistance created by roughened implant surfaces, combined with surgical protocols that result in slight bone compression, can improve initial implant stabilization.[8–11] In short-term studies, implants with roughened surfaces have also been reported to achieve greater bone-to-implant apposition and interfacial strength than implants with machined surfaces.[12–25] Long-term results of implants placed immediately in patients with minimal (1 to 2 mm) residual alveolar bone, or of newer implants with microtextured surfaces placed in bone grafts, have not been well documented.

This article reports on the long-term results of a patient population in which dental implants with microtextured and coated surfaces were immediately placed into the grafted maxillary sinuses of patients with 1 to 7 mm of residual bone height using a modified Caldwell-Luc approach. The surgical techniques used and the biologic rationale for the results are discussed.

MATERIALS AND METHODS

Patient Selection and Evaluation

Consecutive patients who presented in the private practices of the authors and met the requirements of a strict selection protocol (Table 1) were included in this study. Each candidate underwent a meticulous evaluation of his or her medical history and dental examination, including panoramic and periapical radiographs and dental computed tomography (CT) scans. A prerequisite for inclusion was the presence of at least 1 mm of crestal bone height between the sinus floor and the alveolar ridge (Fig 1).

Preoperative and Postoperative Medication

Patients received 1.5 g oral clavulanate-potentiated amoxicillin (Augmentin, GlaxoSmithKline, London, United Kingdom) 1 hour before surgery. Penicillin-allergic patients received 450 mg clindamycin. Just before surgery, patients were instructed to brush their teeth for 5 minutes and then rinse their mouth for 3 minutes, both with 0.12% chlorhexidine gluconate (Peridex; Procter & Gamble, Cincinnati, OH). Clavulanate-potentiated amoxicillin 500 mg 3 times daily (clindamycin 150 mg 4 times daily for penicillin-allergic patients) was continued for 10 days postsurgery.

Augmentation Materials

A variety of grafting materials were used. In the majority of patients, autogenous bone was used, either as a single graft harvested from the iliac crest (21 sinuses) or as a composite graft harvested from intraoral sites (eg, the mandibular symphysis, ramus, zygoma, tuberosity). The composite grafts consisted of approximately 50% autogenous bone and 50% demineralized freeze-dried bone allograft (DFDBA) (Miami Tissue Bank, Miami, FL) or bovine-derived

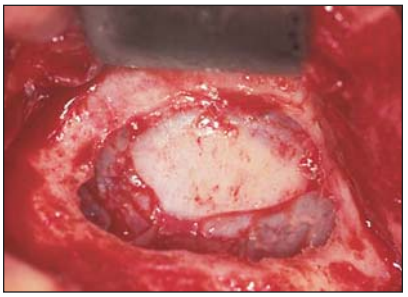


Fig 2 A large buccal window was created in the lateral wall of the maxillary sinus.

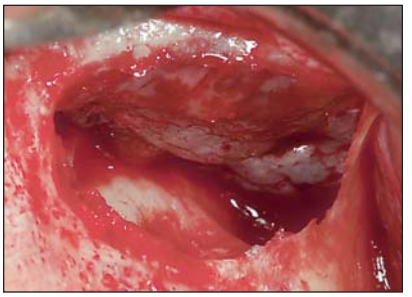


Fig 3 The osteotomy at the inferior aspect of the window was made at or as close to the level of the superior aspect of the residual alveolar bone height as possible.

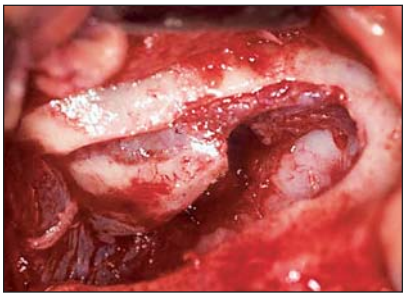


Fig 4 The osteotomy provided needed access to the lateral wall of the nasal cavity to ensure that graft material extended as far medially as possible. This is critical, as the implant apex is angled medially in many of these hyperpneumatized sinuses.

xenograft (Bio-Oss, Geistlich Pharma, Wolhusen, Switzerland). For 16 sinuses, bone cement[26] (BoneSource, Pfizer Howmedica, Parsippany, NJ) was used as a single graft material.

From 1993 to 1998, the harvested bone was prepared in a bone mill (BioComp Mini Mill, BioMedical Composites, Ventura, CA). After 1998, the bone was harvested with the MX Grafter (Maxillon Laboratories, Hollis, NH).

Implant Selection

The implants used were all 15 mm in length (Zimmer Dental, Carlsbad, CA); their diameters ranged from 3.25 to 4.7 mm. The implants were either hydroxyapatite (HA) cylinders (Spline MP-1) or titanium screws with microtextured surfaces created by blasting with HA particles.[27]

Barrier Membranes

Collagen membranes served 2 purposes. After the schneiderian membrane was elevated, small tears or dehiscences in the tissue were covered with a resorbable collagen membrane (CollaTape, Zimmer Dental) to facilitate graft containment.[28–30] A resorbable collagen membrane (BioMend or BioMend Extend, Zimmer Dental) was also placed over the grafted buccal window prior to closure.

Surgical Technique

Patients were treated in the dental office under local anesthesia and, when indicated, with intravenous sedation. The modified Caldwell-Luc surgical procedure, as described by Garg and Quinones,[3] was used to gain access to the sinus cavity.

A large buccal window was created in the lateral wall of the maxillary sinus (Fig 2) using a wide-diameter, round diamond bur (no. 6 or no. 8 Horico; Hopf Ringleb, Berlin, Germany) in a straight handpiece at 2,000 rpm under copious external irrigation.[3] The osteotomy at the inferior aspect of the window was made at or as close to the level of the superior aspect of the residual alveolar bone height as possible (Fig 3). Care was taken not to penetrate the sinus membrane. Cutting was applied in a light, staccato fashion to strip away the outer bony cortex without damaging the schneiderian membrane.[3] Once the schneiderian membrane was elevated and the compartment was created, an absorbable surgical pad (Johnson & Johnson/Codman, Somerville, NJ) (1 cm $\times$ 3 cm) soaked in lidocaine 2% with 1:100,000 epinephrine was applied to promote hemostasis.[31] If the schneiderian membrane was torn, a resorbable collagen membrane cut to double the diameter of the tear was placed over the area[3] to facilitate sinus membrane dissection and elevation.

When indicated, the creation of a large window offered 2 advantages. First, it allowed exposure and elevation of the sinus membrane from all sinus bony walls (the lateral wall of the nasal cavity, the maxillary tuberosity, and inferiorly to the floor and to the posterior wall of the maxillary sinus) to form a large host site, which is crucial for bone graft consolidation during phase I bone formation. Second, it provided needed access to the lateral wall of the nasal cavity (Fig 4). In clinical situations requiring implants to be placed in the area of the canines and premolars and where the buccopalatal dimension is very narrow, the appropriate degree of inclination cannot be achieved (implants tend to incline toward the palate). In such cases, a large buccal window improves access and allows just enough fracture of the lateral wall of the nasal cavity to allow it to be pushed inward in order to create room for the appropriate angulation of the implants.

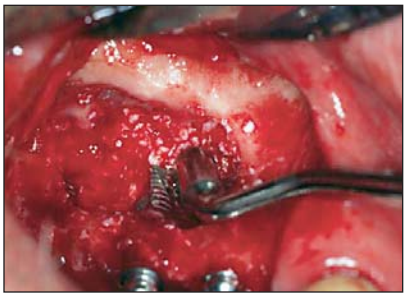


Fig 5 Graft material was placed. The dental implants were placed to half of their total length, and the graft was further condensed.

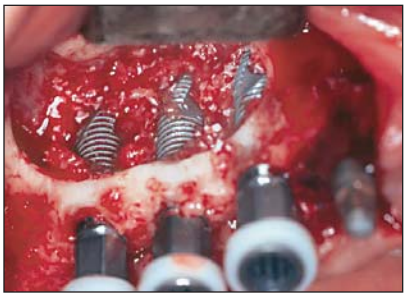


Fig 6 The implants were then seated in ther final positions. Further graft was placed and condensed.

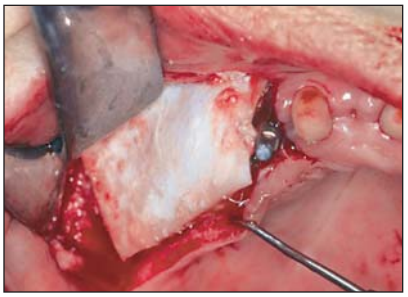


Fig 7 After completion of the sinus floor augmentation and implant placement procedures, the sinus buccal window was covered with a resorbable barrier membrane.

Implant sites were marked using a surgical template, and osteotomies were performed according to the manufacturer's recommendations. The graft material was placed at the superior aspect of the sinus and against the medial aspect of the grafted compartment created in the sinus cavity (the dissected sinus membrane). The graft material was meticulously condensed at each stage. The dental implants were then placed to half of their total length (Fig 5). Then, after further condensation of the graft, the implants were seated in their final positions (Fig 6). In severely atrophic alveolar ridges, where primary stabilization depended entirely on the condensed graft material, mesiodistal parallelism of the long-axis orientation of the implants was accomplished by matching the distance between the apices of the implants with that between the coronal ends of the implants. To ensure correct buccopalatal inclination, the distance between the buccal plate and the apical ends of the implants also was measured.[5] Any remaining graft material was placed over the exposed implant surfaces. Throughout the grafting process, care was taken to meticulously condense and adapt the graft material to the implants without dislodging their axial orientation. In cases of incomplete stabilization, additional graft material was condensed around the implants.

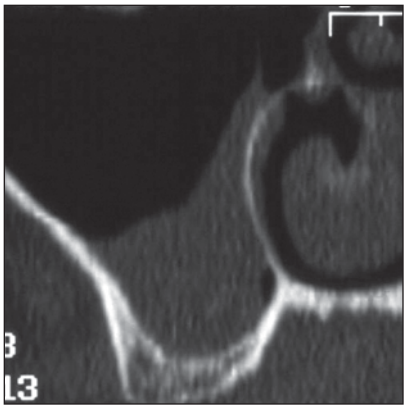
After completion of the sinus floor augmentation and implant placement procedures, the sinus buccal window was covered with 1 of the following resorbable barrier membranes: a DFDBA strip (Lambone; Pacific Coast Tissue Bank, Los Angeles, CA), collagen (BioMend Extend; Zimmer Dental), or freeze-dried dura mater (University of Miami Tissue Bank) (Fig 7). The membrane was placed over the graft in accordance with the principle of guided bone regeneration. No additional steps were taken to stabilize the membranes. The mucoperiosteal flap was closed over the graft, and implants using 3-0 Vicryl (Johnson & Johnson/Ethicon) vertical interrupted mattress sutures.

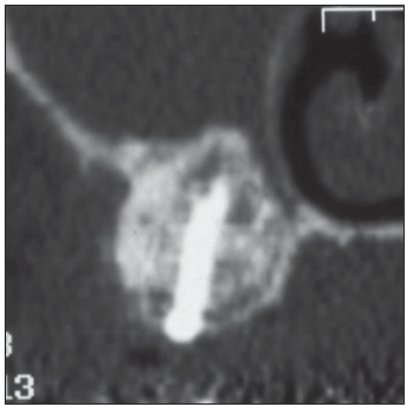
Patients were instructed to avoid blowing their noses for at least 7 days after surgery and to cough or sneeze with an open mouth to prevent increased pressure in the operated sinus. After surgery, whenever the clinical or the patient situation permitted, patients who were completely edentulous were fitted with interim implants and provisional prostheses. Patients who had > 5 mm of crestal bone and wore a removable prosthesis prior to surgery were permitted to resume wearing their prosthesis immediately after surgery. Patients who wore a removable prosthesis and had < 5 mm of residual crestal bone were instructed not to wear their prosthesis for 2 to 3 weeks after surgery. For the next 3 months, the prosthesis was worn for esthetic purposes only, and no mastication was permitted. All patients were required to follow a soft diet. Dentures were relined periodically with a soft tissue conditioner.

Second-stage surgery to expose the implants was performed 6 to 9 months after implant placement. In preparation for this procedure, panoramic and periapical radiographs and CT scans were obtained to assess the newly formed bone and its interface with the implants (Figs 8 to 10). Clinical evaluation criteria at the time of implant exposure included stability in all directions, crestal bone resorption, and any reported pain or discomfort. Assessment of new bone formation at the second-stage surgery was accomplished by means of a crestal incision rather than by a punch technique, which limits visualization of the implant cover screw. Patients were provided with a fixed implant-supported prosthesis or a fixed bar for retention of a removable prosthesis.

RESULTS

A total of 731 patients (278 men, 453 women) ranging in age from 42 to 81 years (mean, 53 years) met the criteria for inclusion in this study (Table 2). Of the





Figs 8a and 8b Views of the surgical site preoperatively and 6 months postoperatively.

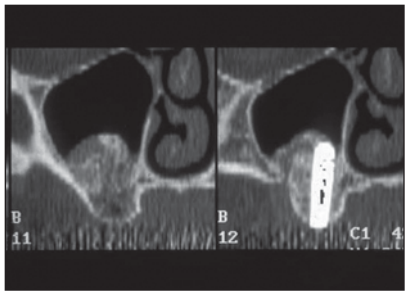
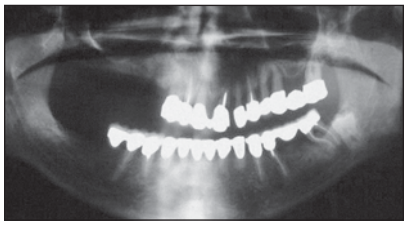
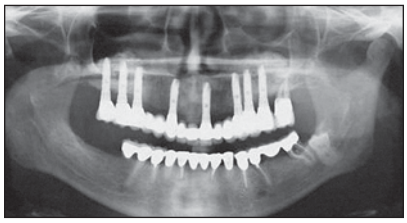


Fig 9 Mature graft anterior to and around the osseointegrated implant at 6 months postsurgery.





Figs 10a and 10b Preoperative and postoperative Panorex views of the patient.

Table 2 Patient Demographics

Characteristic	No. of patients (%)
Sex	
Male	278 (38)
Female	453 (62)
Health risk factors	
Hypertension	103 (14.1)
Diabetes, type 1	16 (2.2)
Diabetes, type 2	52 (7.1)
Ischemic cardiac disease	65 (8.9)
Post-myocardial infarction	35 (4.8)

Mean age was 53 y (range, 42 to 81 y).

2,132 implants placed, 64% (1,374) had microtextured surfaces and 36% (758) had coated surfaces (Table 3). Implant distribution by residual bone height and graft type is presented in Table 3. In this study, the residual sinus floor height was 1 to 2 mm for 20.4% of the implants placed, 3 to 5 mm for 48.0% of the implants placed, and > 5 mm for 31.6% of the implants placed (Table 3). Life table analysis of all implants placed revealed a 97.9% (n = 2,088) cumulative survival rate after 9 years of clinical loading (Table 4).

Distribution of the implant failures by residual bone height (Table 5) reveals that the cumulative failure rate for all implants placed was 2.1% (n = 44) through 9 years of clinical follow-up. Of these, 75% (n = 33) failed before the end of the first year of clinical loading, and the remaining 25% (n = 11) failed within 4 to 7 years of clinical loading (Table 5). The percentage of failures that occurred in patients with 1 to 2 mm of residual bone was 41% (n = 18), while 34% (n = 15) of the failures occurred in 3 to 5 mm of residual bone and 25% (n = 11) occurred in > 5 mm of residual bone (Table 5).

Infection was the leading cause of implant failure (61.4%, n = 27), followed by failure to integrate (13.6%, n = 6) and severe bone loss (25.0%, n = 11) (Table 5). Bone loss was also reported with some implants that failed to integrate (n = 2) or that were lost because of infection (n = 6) (Table 5). The percentage of failures that involved the HA-coated implants was 75% (n = 33), whereas 25% (n = 11) involved the microtextured implants (Table 5).

DISCUSSION

The sinus floor augmentation procedure has evolved over the last 25 years to become one of the most predictable grafting procedures available for placing dental implants in the severely atrophic posterior maxilla. However, 5 mm of alveolar bone has been arbitrarily established as the minimum bone height required for initial stability and parallelism. When alveolar bone height is less than 5 mm, a 2-stage procedure has been recommended.[5,6] A period of 4 to 12 months is allowed for healing of the graft material

Table 3 Distribution of Implant Type by Residual Maxillary Bone Height and Graft Type

	Implants				Grafts			Clinical procedures	
Residual bone height	Diameter (mm)	Surface	Design	No. placed	Type	Material	Source	Sinuses grafted	Implants placed
1–2 mm	3.25	HA	Cylinder	177	Individual	Autograft	Iliac crest	21	63
	3.75	MTX	Screw	224	Composite	Autograft + xenograft	Oral + bovine	79	229
	4.00	HA	Cylinder	34	Composite	Autograft + allograft	Cadaver + oral	49	143
3–5 mm	3.25	HA	Cylinder	294	Composite	Autograft + xenograft	Oral +bovine	201	578
	3.75	MTX	Screw	429	Individual	Bone cement	Synthetic	16	48
	4.00	HA	Cylinder	32	Composite	Autograft + allograft	Cadaver + oral	137	397
	4.70	MTX	Screw	268					
> 5 mm	3.25	HA	Cylinder	182	Composite	Autograft + xenograft	Oral + bovine	111	330
	3.75	MTX	Screw	254					
	4.00	HA	Cylinder	39	Composite	Autograft + allograft	Cadaver + oral	117	344
	4.70	MTX	Screw	199					

HA = hydroxyapatite; MTX = microtextured.

Table 4 Life Table Analysis of Implants Placed into Maxillary Sinus Grafts

Time interval (y)	No. of sinuses grafted	No. of implants			
		Placed	Lost	SR (%)‡	CSR (%)§
0*	731	2,132	15	99.3	99.3
0 to 1†	725	2,117	18	99.1	98.4
1 to 2	722	2,099	0	100.0	98.4
2 to 3	722	2,099	0	100.0	98.4
3 to 4	722	2,099	0	100.0	98.4
4 to 5	722	2,099	6	99.7	98.1
5 to 6	720	2,093	3	99.8	97.9
6 to 7	718	2,090	2	99.9	97.9
7 to 8	718	2,088	0	100.0	97.9
8 to 9	718	2,088	0	100.0	97.9

*0 y = placement to second-stage surgery.
†0 to 1 = second-stage surgery to 1 year.
‡SR = survival rate for time interval.
§CSR = cumulative survival rate.

Table 5 Implant Failure by Residual Bone Height

Residual bone height	Implant surface	Time of failure	Reason for failure	No. failed	% of all failures
1–2 mm	HA	BL	Infection with bone loss	6	13.6
	HA	BL	Failed to integrate with bone loss	2	4.5
	MTX	BL	Failed to integrate	2	4.5
	HA	LF	Bone loss	8	18.2
3–5 mm	HA	BL	Infection	5	11.4
	MTX	FYL	Infection	7	15.9
	HA	LF	Bone resorption	3	6.8
> 5 mm	HA	FYL	Infection	9	20.5
	MTX	BL	Failed to integrate	2	4.5

BL = before loading; LF = late failure after 4 to 7 years of functioning; FYL = first year of loading.

before the implants are placed. The 2-stage procedure allows for assessment of the amount of new bone formed prior to re-entry. The primary disadvantage associated with the 2-stage procedure is the amount of time it adds to the overall treatment. Another disadvantage relative to the 1-stage procedure is the difficulty of assessing the amount and position of graft material that will be required for a future implant.

A study published by the authors[5] in 1998 involving a limited number of patients demonstrated the validity of a treatment protocol that combined simultaneous implant placement with maxillary sinus augmentation in a 1-stage procedure when the alveolar bone height was 1 to 2 mm. To the authors' knowledge, a large-scale prospective study with long-term follow-up to evaluate simultaneous implant placement in different alveolar bone heights with the same surgical technique, implant types, graft material, and surgeons has not been reported.

The present study demonstrated a high survival rate for simultaneous implant placement with grafting of the maxillary sinus. The differences in implant failure rates for the 3 different heights of alveolar bone—4.1%, 1.5%, and 1.6% for implants placed in 1 to 2 mm, 3 to 5 mm, and > 5 mm of residual bone, respectively—were statistically significant ($P = .003$). Although the highest failure rate, 4.1%, was observed in the 1-to-2-mm group, it is nonetheless a very low rate of failure for any highly compromised clinical condition. The authors attribute this result to the surgical concepts that were used: creation of a large buccal window, allowing access to a large recipient site; use of composite grafts consisting of at least 50% autogenous bone; meticulous condensation of the bone graft material; placement of long implants; selection of HA-coated or microtextured implant surfaces; use of a membrane to cover the graft and implants; antibiotic use and strict oral hygiene; use of interim implants; and restricted denture use.

Together, these surgical techniques appear to compensate for the problems that have been observed in other studies associated with the failure of implants placed in sinus floor augmentations. Creation of a large window with the osteotomy level with the superior aspect of the residual alveolar bone height allows exposure and predictable elevation of the sinus membrane as well as formation of a large recipient host site. The proliferative capacity and health of the host site play a crucial role in early revascularization, maturation, and consolidation of the graft. In general, bone regeneration is more predictable when a defect is surrounded by host bone. The large buccal window also facilitates appropriate angulation of implants in the area of the canines and premolars and where the buccopalatal dimension is very narrow.

A well-documented correlation has been found between implant failure and bone quality. Because of its immunologic acceptability and various mechanisms for bone regeneration, autogenous bone is the so-called gold standard of graft material.[32–37] A 2-phase theory of osteogenesis during healing has been described.[38–40] However, the amount of autogenous bone available for harvesting in the oral cavity with moderate morbidity is limited.

Composite bone grafts consisting of 50% autogenous bone and 50% Bio-Oss or DFDBA promote predictable bone formation without exposing the patient to invasive bone harvesting procedures.[6] Allogeneic grafts and xenografts function strictly as a scaffold for osteoinduction. Using at least 50% autogenous bone and placing the graft directly adjacent to the large volume of host bone afforded by a wide surgical approach improves the predictability of the second phase of bone formation within this scaffold as the graft is gradually replaced. As it does in normal bone remodeling, bone morphogenetic protein acts as the coupling agent between bone resorption and new bone apposition. Stem cells found in the graft, the local tissues, and the circulatory system respond in the form of osteoblast differentiation and new bone formation. Essentially, the greater the surface area (ie, the larger the recipient site), the greater the number of stem cells and endosteal osteoblasts that will potentially be available.

Achieving initial implant stability and maintaining parallelism are major concerns in implant placement, especially when implants are placed in less than 5 mm of bone. Appropriate spacing and angulation are critical for prosthetic restorability, but achieving these goals can be particularly challenging when minimal residual crestal bone is available because mastication can cause the implants to move during the graft maturation period. In the present study, initial axial and lateral implant stability were achieved by meticulously condensing the particulate graft material around the implants, thus optimizing the direct bone-to-implant contacts and increasing cellular density. The greater the cellular density of the transplanted osteocompetent cells, the greater the potential for new bone formation. Meticulous condensation will eventually lead to the formation of type 2 or type 3 bone rather than the type 4 bone normally found in the posterior maxilla. Others have observed that increasing bone quantity and quality might reduce the failure rate of early implants, even in smokers.[41] Rotational movements by the implants, however, could not be controlled. In an animal study, implants that were rotation-mobile became com-

pletely osseointegrated.[42] This finding correlates with the present authors' clinical observations. Use of the bone mill initially and later the MX Grafter provided excellent harvested autogenous bone.

Another advantage of this surgical approach was the use of long implants (15 mm in length) that also had treated surfaces. Other investigators have previously noted the importance of longer implant length in implant success,[43] and numerous studies have shown that a surface-enhanced implant can achieve osseointegration better than a machined-surface (turned-surface) implant.[44–48]

The placement of a membrane barrier over the buccal window excludes the proliferation of epithelial cells and fibroblasts and favors proliferation of bone cells. In light of the relatively long healing process (6 to 8 months), this guided bone regeneration concept is essential.

A number of reports of dental implant procedures have highlighted the value of maintaining strict oral hygiene, particularly in smokers,[49–51] and using antibiotics perioperatively.[52,53] Subantral augmentation and implant placement procedures run the risk of introducing new bacteria into the sinus and nose and require the use of prophylactic antibiotics to prevent infection.[54] High-dose antibiotics administered before a surgical procedure have been demonstrated not only to minimize the incidence of postoperative infection[55] but also to significantly reduce the rate of implant failure through second-stage surgery.[54]

Using interim implants and restricting the use of dentures to avoid pressure on the soft tissues during the first 3 months after surgery are additional precautions to optimize conditions for implant survival. A stress-free environment may be important because movement of just 10 to 20 μm during the early stages of wound healing is enough to direct differentiation of mesenchymal cells into fibroblasts instead of osteoblasts.[56]

CONCLUSIONS

Subantral augmentation with simultaneous implant placement can be used to treat the atrophic maxilla in patients with at least 1 mm of vertical residual bone height when careful case planning and surgical techniques are used. Augmentation of the atrophic maxillary sinus using a modified Caldwell-Luc procedure has been successfully applied to extend the option of implant therapy to selected patients with pneumatized sinuses and resorbed ridges. Results of the 731 cases in the present study revealed that the 2,132 implants simultaneously placed into grafted sinuses with 1 to 7 mm of residual sinus floor bone height achieved 97.9% survival after 9 years of clinical follow-up in this patient population.

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