# Sinus Lift Augmentation To Facilitate Placement Of Nonsubmerged Implants:

## A Clinical and Histological Report

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*The anatomical restrictions for rehabilitation of the atrophic posterior maxilla limit treatment options for many patients. The learning objective of this article is the discussion of these limitations and presentation of a clinical report of the surgical technique and histologic findings of a sinus lift procedure which facilitates the placement of nonsubmerged endosseous oral implants.*

The success of endosseous oral implants has offered expanded versatility for the dental rehabilitation of patients that in the past had been fraught with restorative limitations. Although overcoming these limitations has offered patients the advantage of implant-supported prosthetics, there often remain areas in the oral cavity severely compromised for the placement of dental implants. The edentulous atrophic posterior maxilla is considered such an area and has been described as the most difficult for placement of implants.[1]

The problematic nature of this area stems from its lack of adequate quality and quantity of bone. The posterior maxilla has a very thin cortical plate, and the underlying bone is spongy, finely trabecular, and lacks the osseous density found in the premaxilla and mandible. Besides these inherent defi-

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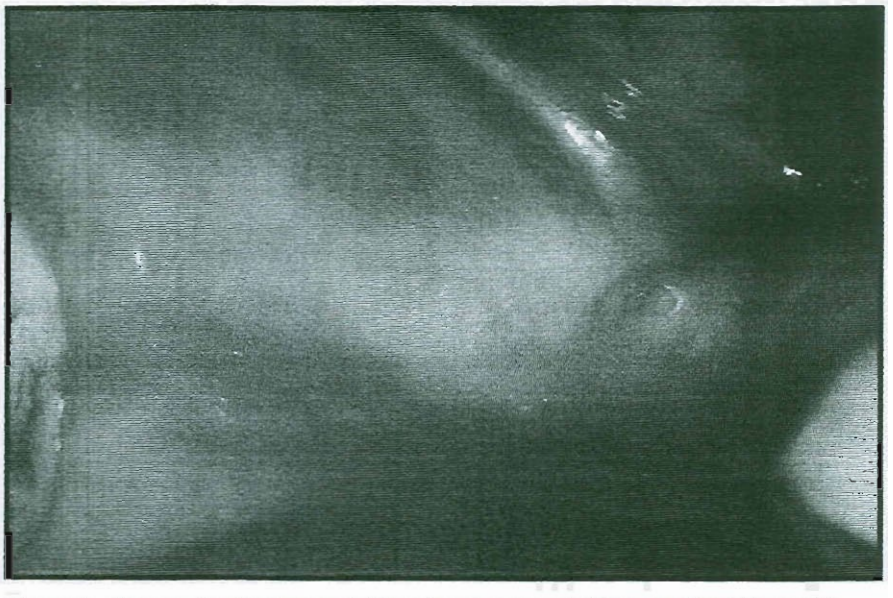

**Figure 1.** Preoperative appearence of the edentulous area in the posterior right maxilla.

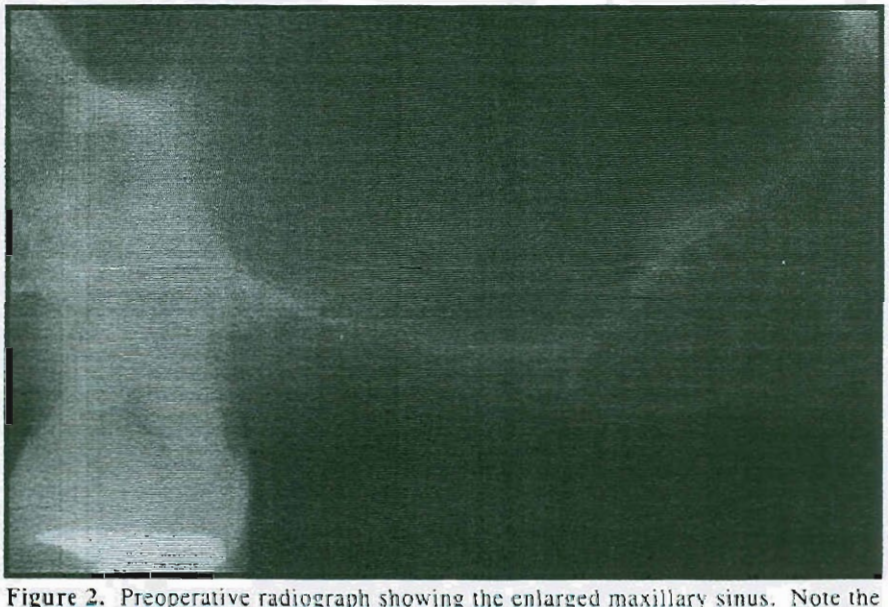

**Figure 2.** Preoperative radiograph showing the enlarged maxillary sinus. Note the partition of bone remaining following alveolar resorption of the edentulous space.

ciencies in bone quality, the posterior maxilla undergoes significant atrophic changes following tooth extraction. In addition to the usual crestal resorption following tooth loss, the degree of atrophy is exacerbated by a concomitant enlargement of the maxillary sinus. This process is referred to as sinus or antral pneumatization,[2] and is perpetuated by an increase in osteoclastic activity from the periosteum of the Schneiderian membrane following tooth loss.[3] This results in resorption of the sinus floor which further diminishes the amount of bone. These anatomic limitations and atrophic changes can reduce the predictability of implant success in this region as suggested by Adell et al in a 15-year follow-up study, where the highest proportion of fixture loss occurred in the posterior maxilla.[4]

Various techniques have been developed to augment this compromised region of the oral cavity. These include the use of iliac crest cancellous grafts,[5] cortico-cancellous grafts,[6] rib grafts,[7] allograft alveolar augmentation grafts,[8] LeFort I osteotomy with interpositional bone grafts,[9] or alloplast, composite alloplast-autograft combinations.[10] These augmentation procedures have met with varying success and are indicated in cases of severe maxillary atrophy where the interarch distance is extremely increased. Often, however, and specifically in partially edentulous cases, the interarch distance is insufficient for the use of such augmentation procedures, since they would reduce the intermaxillary space to unrestorable dimensions.

In these instances, where the interarch distance is normal or reduced, a transalveolar augmentation procedure, such as grafting of the maxillary sinus, is indicated. The sinus lift augmentation technique was first described by Tatum using a crestal approach for the placement of ceramic implants in the posterior maxilla.[11] The purpose of this technique was to increase the available bone in the posterior maxilla without infringing upon the freeway space required to restore the dentition. This increase in available bone can then be used for stabilization and osseointegration of dental implants. Boyne and James later de-

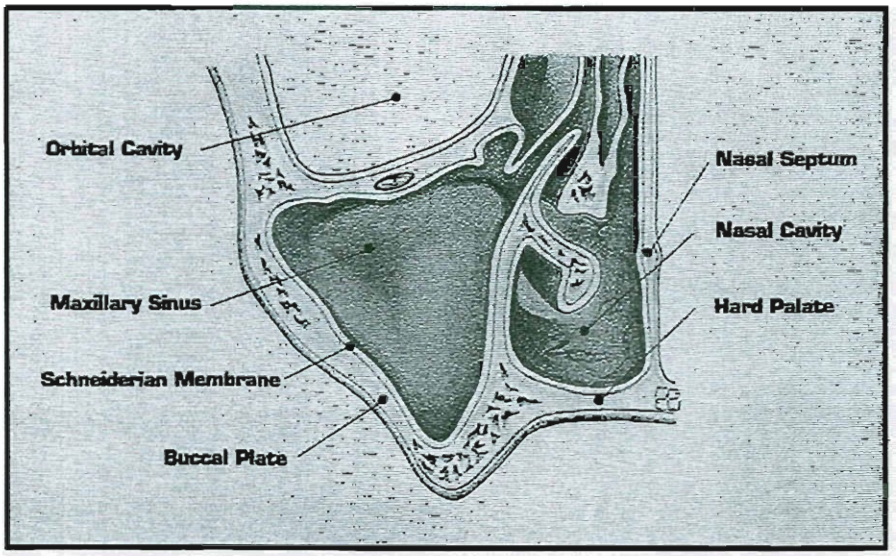


**Figure 3.** Cross-sectional drawing of the maxillary sinus demonstrating inadequate width of remaining bone for primary stabilization of dental implants.

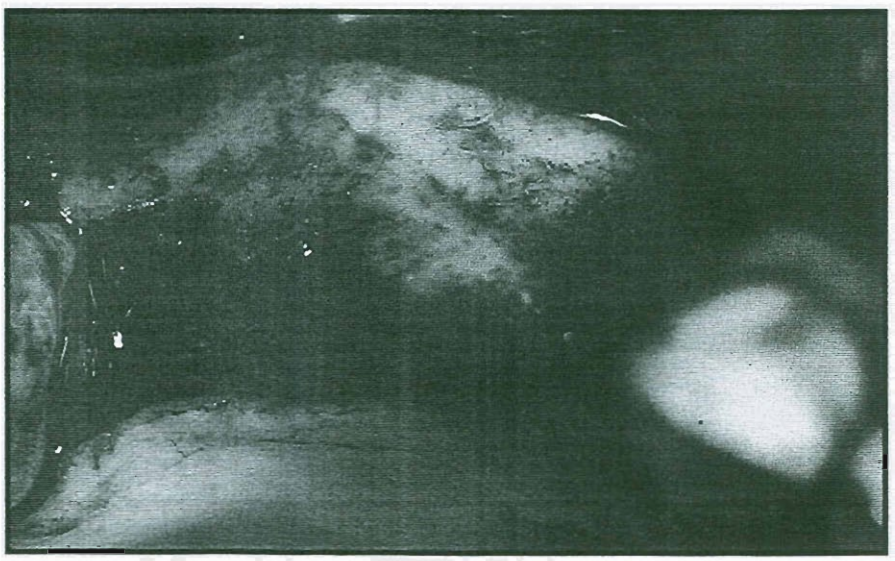

**Figure 4.** Crestal incision with full thickness flap reflection exposing the buccal plate of the maxilla to the inferior border of the zygomatic bone.

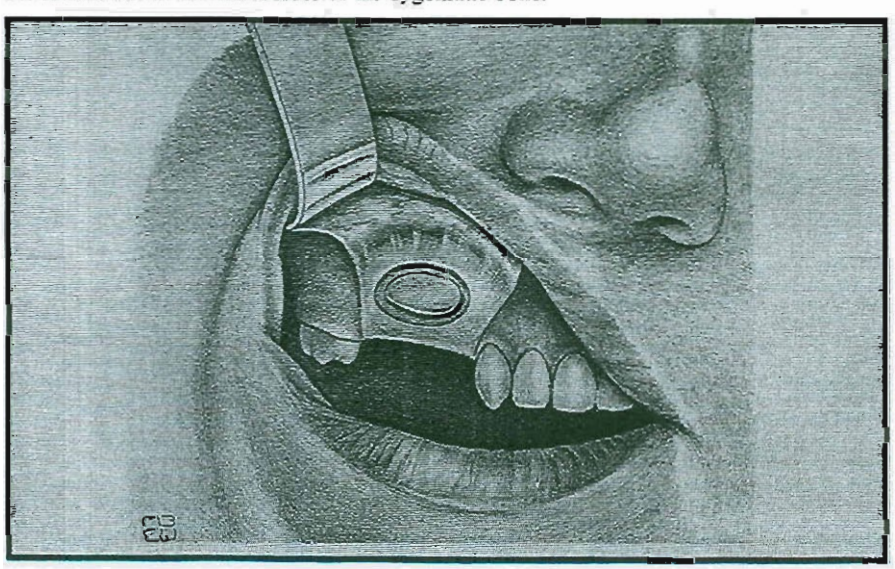

**Figure 5.** Drawing illustrating the osteotomy design.

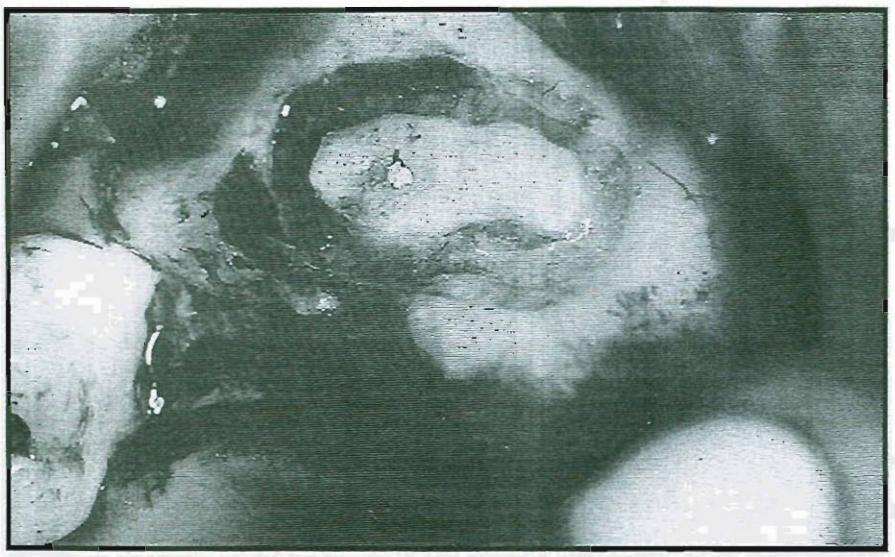

**Figure 6.** Initial preparation of the osteotomy elucidating the blue hue of the Schneiderian membrane as it is approached using rotary instruments.

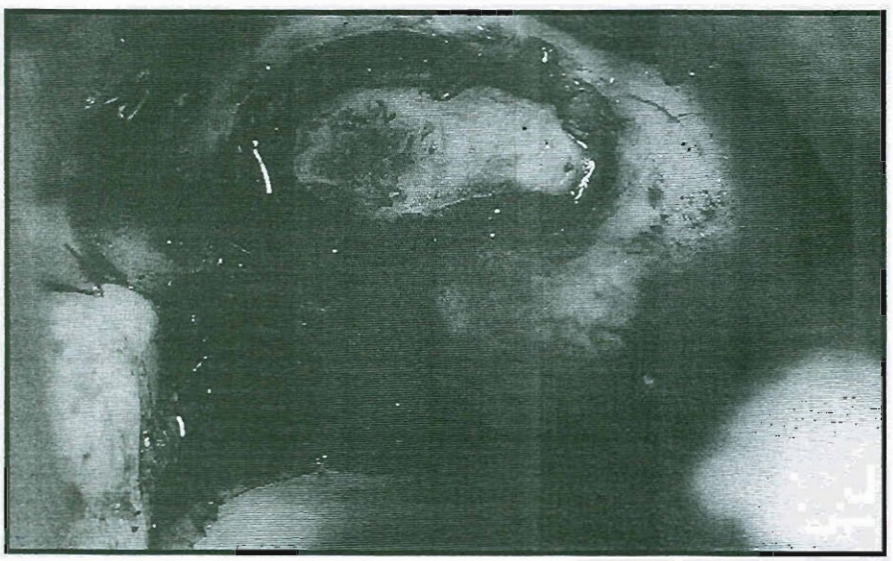

**Figure 7.** Completion of the osteotomy following release of the "access window" from the surrounding bone. Slight movement is noted upon inspiration and expiration confirming adequate removal of bone.

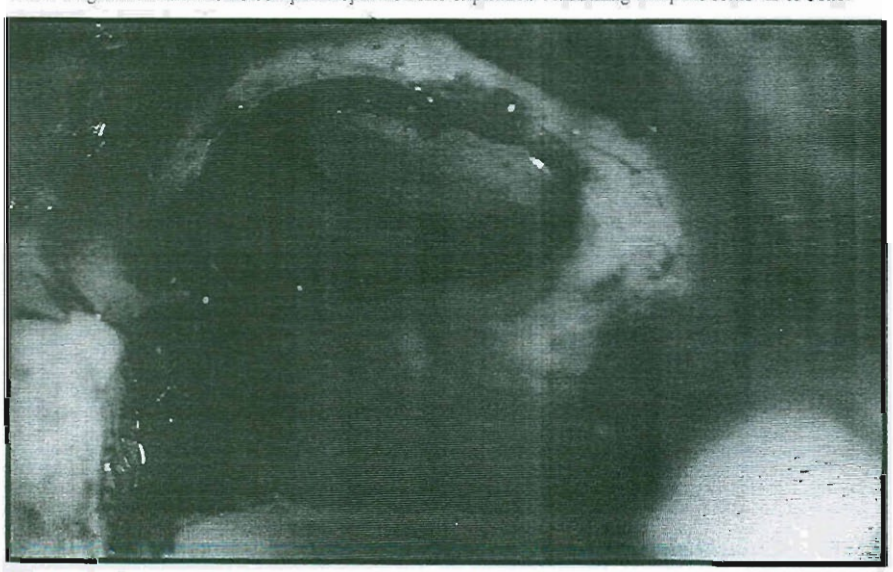

**Figure 8.** Elevation of the membrane to establish adequate release for the rotation of the window inward and superiorly creating the new floor of the sinus.

scribed grafting of the sinus with autogenous cancellous bone using a lateral maxillary osteotomy.[12] In 1986 Tatum introduced a modified Caldwell-Luc procedure for augmentation of the sinus.[13] In this report, a lateral osteotomy was fractured inward and the sinus membrane elevated prior to grafting with autogenous bone. This procedure formed the basis for the development of a more predictable method of altering the morphology of the posterior maxilla.

## *CASE REPORT*

### *Preoperative Evaluation*

A 40-year old female presented for consultation concerning the prospect of implant placement in the maxillary right posterior quadrant. Examination of the area, which had been edentulous for approximately 2 years, revealed a long edentulous span between the canine and the second molar (Figure 1). It was decided that due to the length of this span it would not support a conventional fixed bridge.

Analysis of the radiographs showed that the partition of bone remaining, following the enlargement of the maxillary sinus and resorption of the alveolar bone, would not be adequate to establish primary stabilization of implants in a one-stage sinus lift procedure (Figures 2 and 3). There appeared to be approximately 2 mm of bone remaining, and in agreement with subantral treatment options described by Misch[14] this would require a second stage placement of the implants. Therefore, it was decided to augment the sinus first, followed by implant placement six months later.

### *Sinus Lift Procedure*

1. When appropriate, prescribe preoperative nasal decongestants, antihistamines, and antibiotics. The patient under discussion had no history of sinus problems or infection. Therefore, preoperative medications were not given.
2. Ask the patient to rinse with an antimicrobial mouth rinse and perform an intra and extra-oral scrub prior to the patient being surgically draped.

3. Anesthetize the surgical area with local anesthetic. Administer a posterior superior alveolar and greater palatine nerve block along with local infiltration.

4. Make a supracrestal incision with two long vertical releasing incisions that extend beyond the mucogingival junction.

5 Reflect a full thickness flap to gain access to the underlying bone (Figure 4). The reflection of the flap should expose the lateral aspect of the maxilla and the inferior border of the zygomatic bone. Care should be taken not to perforate the periosteum during the reflection of the flap as the periosteum will be in intimate contact with the graft material upon final closure. If laceration of the periosteum occurs, placement of an expanded polytetrafluoroethylene augmentation material (Gore-Tex, W.L.Gore & Assoc., Flagstaff, Arizona) prior to flap closure may be considered as a barrier to fibrous connective tissue invasion.

6. Use sounding of the buccal bone to locate the maxillary sinus. Map out the design of the osteotomy in the buccal plate (Figure 5). The design should allow an unrestricted manipulation of the osteotomy medio-superiorly to be positioned as the new floor of the sinus. Preparing the osteotomy with a rounded configuration will contribute to safe manipulation as no sharp edges must be allowed to puncture the Schneiderian membrane. This design allows adequate access to the sinus so that atraumatic elevation of the membrane can be accomplished.

7. Perform preparation of the osteotomy, using a high speed hand piece with copious sterile irrigation. The first bur used is a #6 round carbide bur, cutting in a counterclockwise direction, so that the flutes do not engage the bone but rather paint it away. This will help to avoid or minimize any traumatic encounters with the membrane while releasing the window from the surrounding bone. The blue hue of the membrane becomes in-

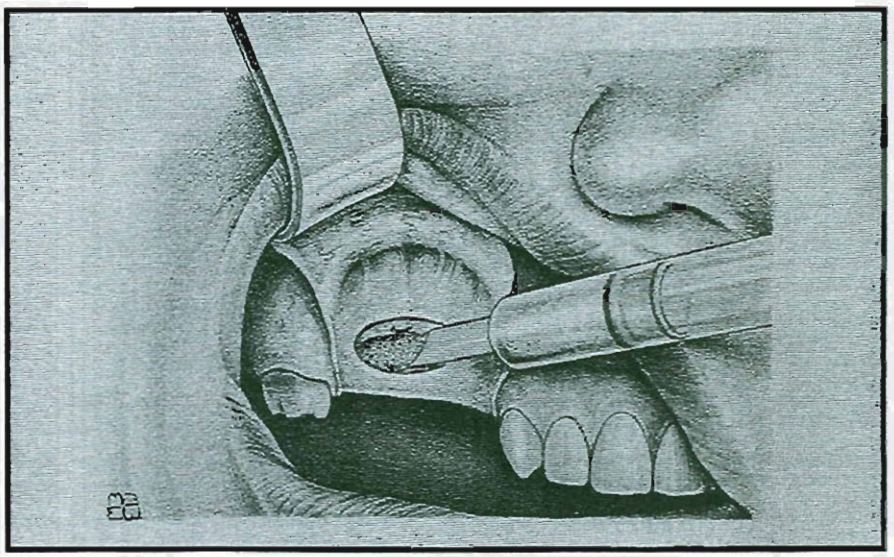

**Figure 9.** Drawing illustrates the use of a 3cc syringe for placement of the bone grafting material into the sinus.

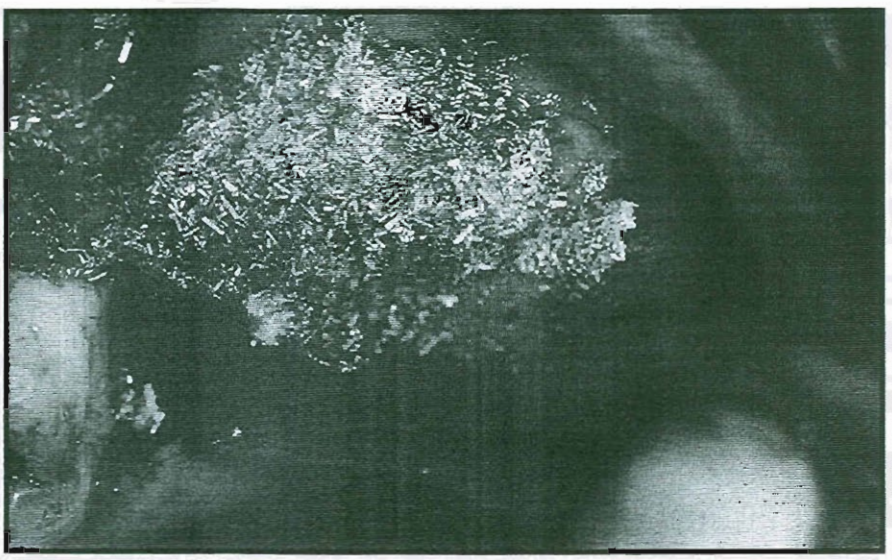

**Figure 10.** View of the sinus cavity completely filled and condensed to ensure no voids within the graft.

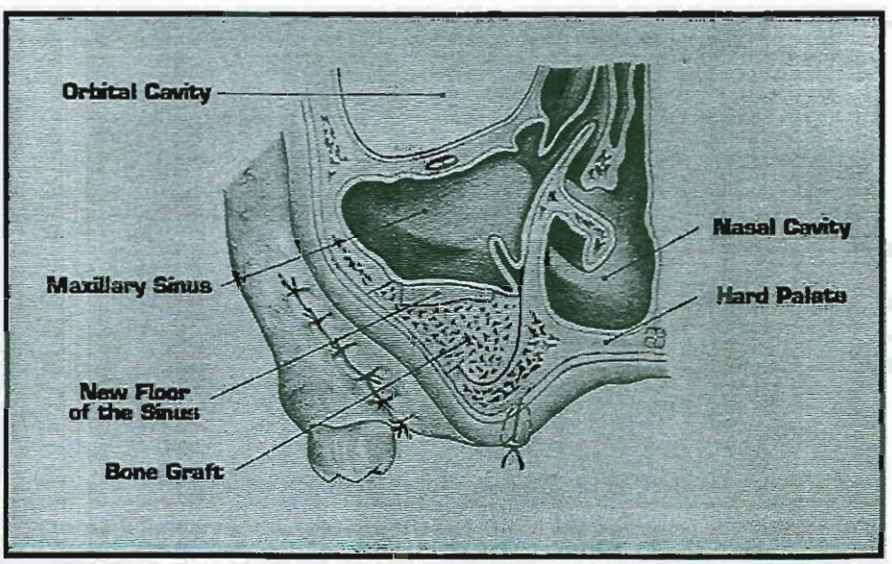


**Figure 11.** Cross-sectional drawing illustrating the graft material in place and the new location of the sinus floor.

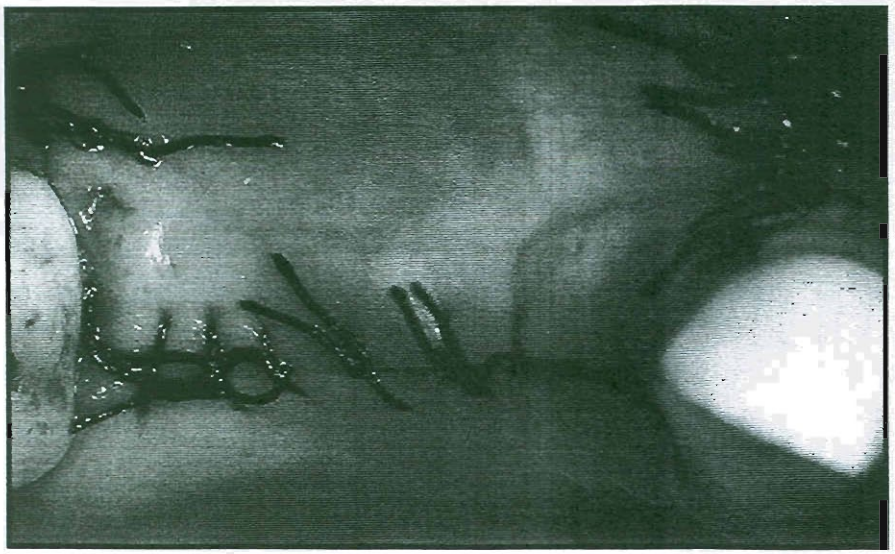

**Figure 12.** Clinical appearence of the area after repositioning and suturing of the flap.

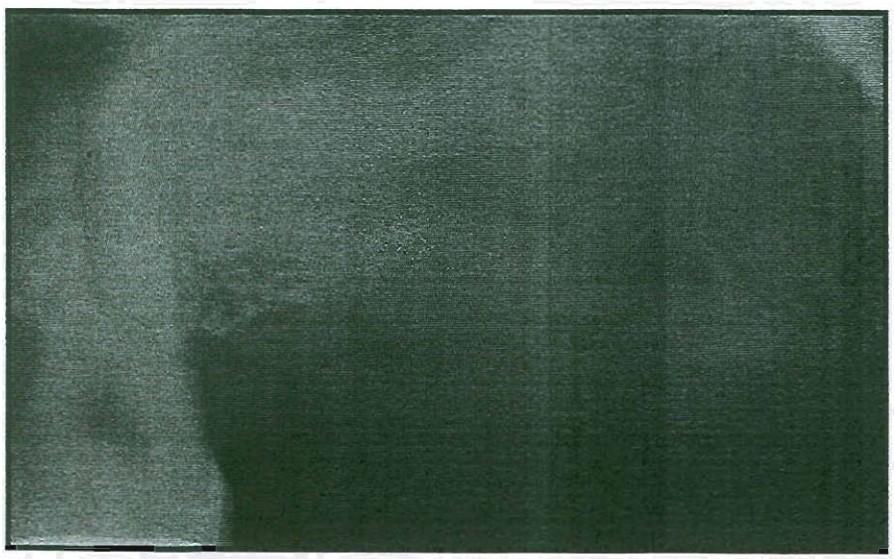

**Figure 13.** Six-month postoperative radiograph revealing the augmented sinus and demonstrating an increase in available bone for the placement of dental implants.

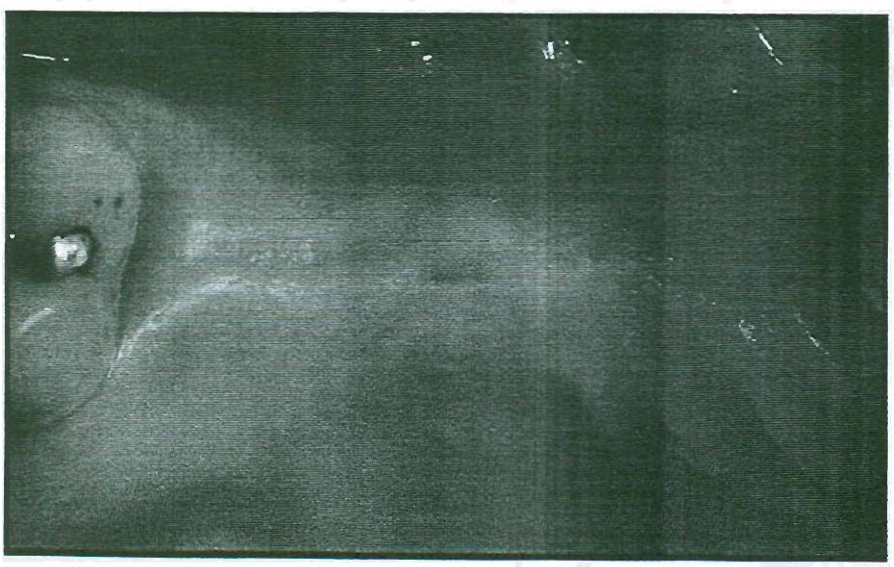

**Figure 14.** Second stage presurgical occlusal view of the edentulous area.

creasingly apparent as the bone is delicately removed (Figure 6). Once the membrane is seen around the entire outline of the osteotomy, substitute the carbide bur with a fine #6 round diamond bur. This bur is used to reduce the remaining bone to a thin shell until the membrane exhibits slight movement upon inspiration and expiration (Figure 7). Careful tapping of the osteotomy with a mirror handle can further release the window of bone from the surrounding area. Perform the removal of bone on the superior aspect of the "access window" to minimize any pinching of the membrane during its movement medially.

8. Elevators specially designed for sinus lifts are now used to elevate the membrane. The elevation should begin by releasing the membrane at the edge of the osteotomy and systematically working deeper into the sinus. Care should be taken when reflecting the membrane in the hinge joint area since this is the most frequent site of perforation.[15] Any buttresses that impair elevation of the membrane, such as elevated bone septa in the floor of the sinus, should be identified and removed with sharp chisels or burs. Continue elevation of the membrane to the far wall of the sinus until adequate height is attained (Figure 8). Measurements should be taken from the previous floor of the sinus to the new floor to ensure adequate bone height will be achieved for the placement of implants. If a small perforation of the membrane occurs, it can be repaired with resorbable hemostatic agents such as oxidized regenerated cellulose (Surgicel, Johnson & Johnson, New Brunswick, NJ), collagen tape (Collatape, The Kendall Co., Boston, MA), and gelatin sponges (Gelfoam, The Upjohn Co., Kalamazoo, MI), or with surgical wound support materials like Polyglactin 910 woven mesh (Vicryl Woven Mesh, Ethicon, Sommerville, NJ). Larger defects must be evaluated on the ability to

obtain closure of the defect and stabilization of the graft material. If this is not possible, the flap should be repositioned and sutured, and the augmentation procedure reattempted 2 to 3 months later.

9. Initiate grafting the floor of the sinus at the far wall (ie, lateral wall of the nasal cavity) and condense in small increments. The graft used for augmentation in this case was a 1:1 mixture of resorbable hydroxylapatite (Osteogen, Stryker, Inc., Kalamazoo, MI) and demineralized allogenic bone matrix in a flowable gel (Grafton, Musculoskeletal Transplant Foundation, Little Silver, NJ). Introduce the gel into the sinus cavity with a 3cc syringe and condense from the medial to the lateral wall and then superiorly until a complete fill is achieved (Figures 9 and 10). The osteotomy of the buccal plate is now the new floor of the sinus, and the Schneiderian membrane is elevated into the superior aspects of the sinus.
10. The flap, with its periosteum intact, is approximated over the bone graft and repositioned with interrupted sutures (Figures 11 and 12).

## *Postoperative Treatment*

The postoperative use of systemic antibiotics is discretionary and analgesics should be taken as required. In this case, only a nonsteroidal antiinflammatory analgesic was prescribed. Sutures were removed after 10 days, and the patient was instructed not to wear a removable appliance for the first two postoperative weeks.

After a healing period of 6 months, radiographs were taken to assist in the treatment planning of the second stage, implant placement surgery. Examination of these revealed that the grafted sinus had a homogenous radiographic density, similar to that of the adjacent host bone (Figure 13). Furthermore, the quantity of bone in the area was increased to dimensions which now permitted the placement of three implants (ie, one mesial and two into the augmented sinus).

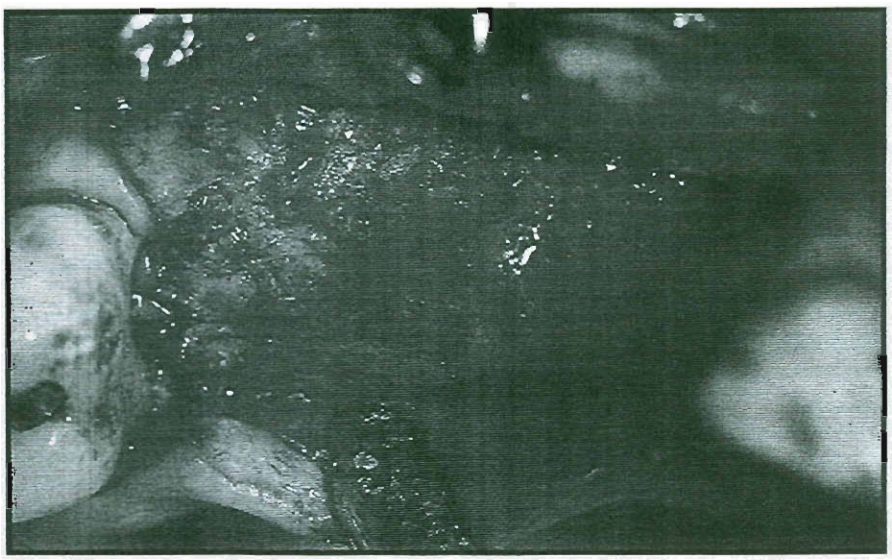

**Figure 15.** Lateral view of original entry site to sinus cavity. Complete fill of the sinus with incorporation of graft material is evident. The texture and density of the fill is consistent with that of normal bone.

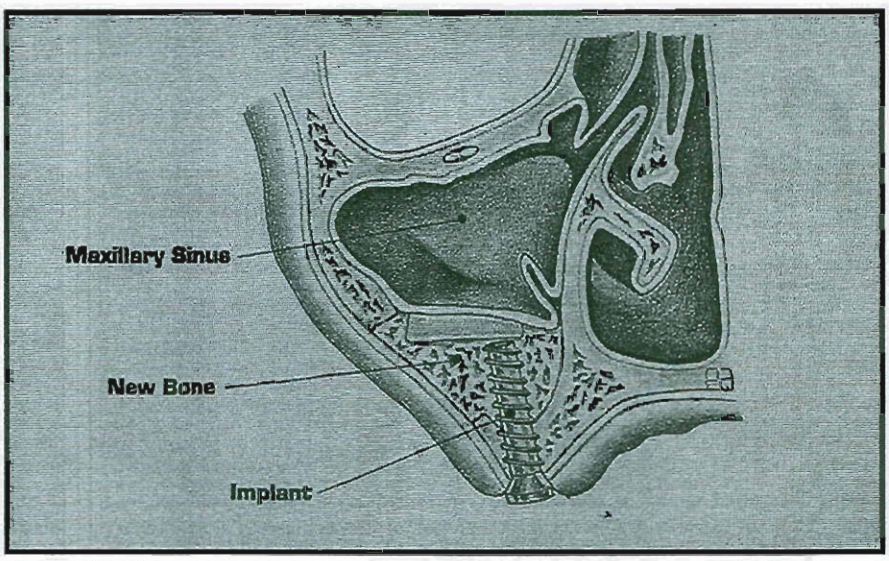


**Figure 16.** Cross-sectional drawing through the sinus showing placement of an implant into the grafted sinus.

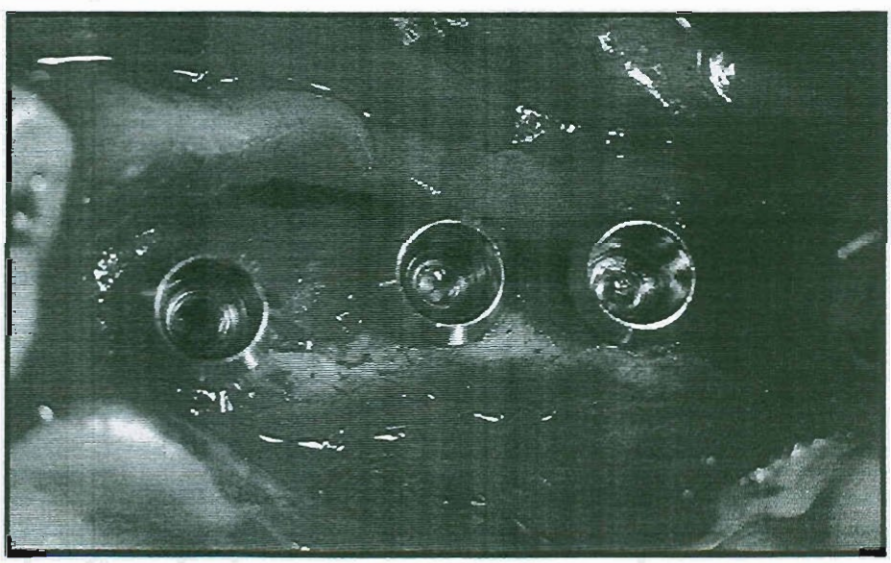

**Figure 17.** Location of the nonsubmerged implants as dictated by the surgical stent.

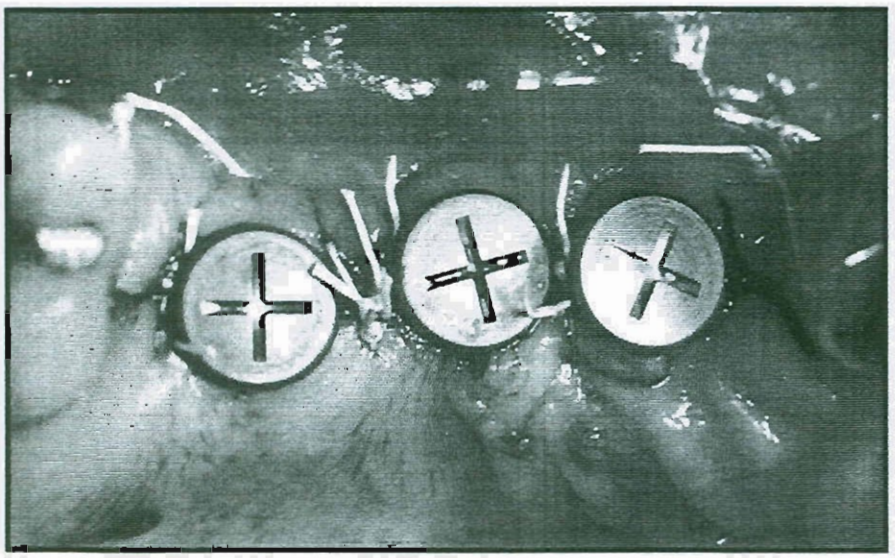

**Figure 18.** Appearence of the soft tissues after repositioning and suturing of the flap around the nonsubmerged implants. Note the intimate adaptation of soft tissues to the implants.

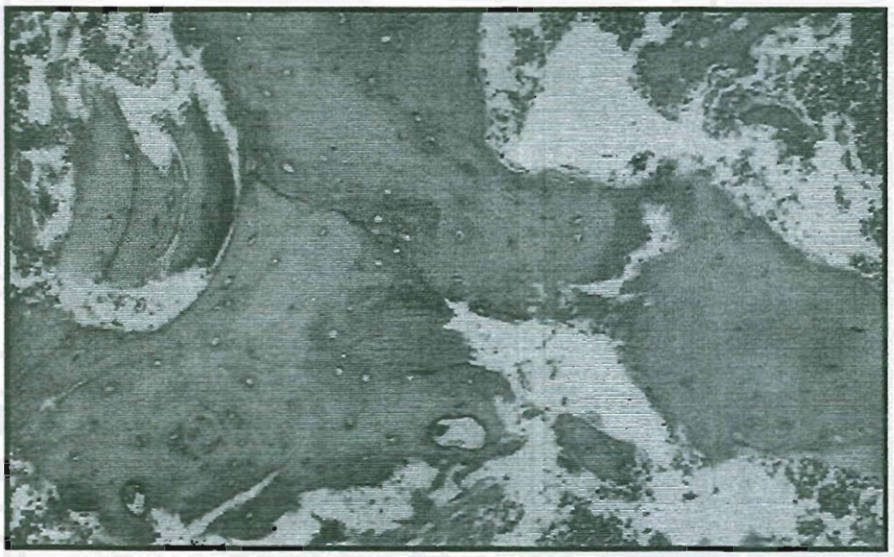

**Figure 19.** Photomicrograph of a core biopsy specimen from the augmented sinus. New bone is present in the margins of the grafted sinus. The new bone is lamellar and compact in nature. (H&E stain.)

**Figure 20.** Photomicrograph of a core biopsy specimen from the middle portion of the sinus showing evidence of new bone in growth without fibrous encapsulation of graft particles. (Trichrome stain.)

## *Implant Surgery*

The patient was prepared for surgery as previosly described. Presurgical photographs show the integrity of soft tissues prior to surgery (Figure 14). Local anesthetic was administered and a crestal incision was performed. A full thickness flap was elevated revealing a complete fill of the previous entry into the sinus (Figure 15). Three implant osteotomies were prepared using a trephine bur and a surgical stent as a guide. Hard tissue core biopsies from the area of the grafted sinus were obtained for histologic examination.

Two nonsubmerged 12 mm hollow screw implants (ITI - Straumann AG, Waldenburg, Switzerland) were placed in the grafted area. Solid primary stabilization of these implants into the augmented sinus suggested a highly favorable environment for osseointegration (Figure 16). A 10 mm hollow cylinder nonsubmerged implant was placed into the bone mesial to the sinus (Figure 17). Healing cover screws were placed and, prior to suturing, the soft tissues were contoured to establish an ideal adaptation of the flap around the implants (Figure 18). The patient was instructed to rinse with chlorhexidine 0.12% twice daily for the next two weeks. Suture removal and sounding of the implants was done one week post-operatively. At this time, all clinical evidence demonstrated healthy periimplantal gingiva with solid implant stabilization. The patient was seen every two months for recall maintenance and oral hygiene reinforcement.

## *Histologic Evaluation*

The hard tissue core biopsies obtained at the time of implant placement (ie, six months after the sinus augmentation procedure) were fixed, decalcified, and paraffin embedded, using standard histologic methods. Specimens were thin-sectioned, mounted on glass slides, and stained with either a hematoxylin and eosin or trichrome stain.

Histologic examination of the specimens indicated a significant amount of new bone growth in the augmented sinus. The new bone in the margins of the grafted sinus was lamellar and compact (Figure 19).

Osteocytes were present in their lacunae and there were numerous resting lines. Towards the middle of the sinus there was evidence of new bone ingrowth without fibrous encapsulation of graft particles (Figure 20). The bone was more immature, contained randomly oriented osteocytes, and was surrounded by a highly vascularized connective tissue. Osseous apposition was observed around remaining particles of resorbable hydroxylapatite.

### *Six-Month Follow-Up*

The implants were allowed an osseointegration (ie, healing) period of 6 months prior to initiation of the restorative phase. Clinical examination revealed healthy periimplantal tissues with no signs of plaque or inflammation, and the maintenance of implant stability (Figure 21). Radiographs support the clinical findings and indicate osseointegration of the fixtures as well as the absence of pathology around the implants and sinus (Figures 22 and 23). The implants are currently awaiting final restoration.

## *DISCUSSION*

The surgical technique for augmentation of the maxillary sinus as presented in this case report is an adequate method for the reconstruction of the atrophic posterior maxilla. This procedure can be performed in one or two stages, depending on the amount of available bone. The one-stage procedure is indicated when there is enough remaining bone to achieve primary stabilization of the dental implants. A bony partition of 3 to 4 mm is considered adequate for the placement of implants as long as primary stabilization is achieved. A two-stage procedure is indicated when there is less than 3 mm of bone or when primary stabilization is not possible. In this case, the augmentation procedure was performed in two stages since only 2 mm of bone were originally present.

The type of graft material used to augment the sinus appears to be one of the most important variables for the success of this procedure. Grafting materials utilize properties described as osteoinductive or osteoconductive to facilitate

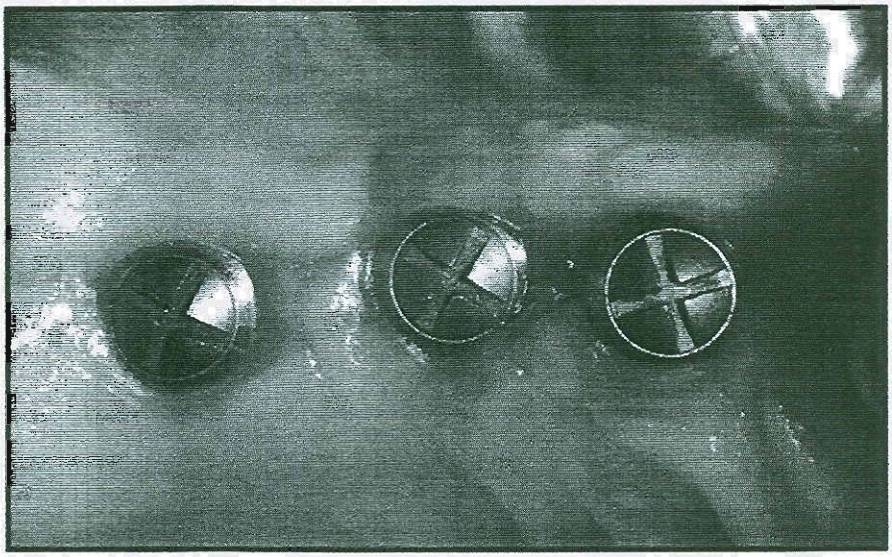

**Figure 21.** Occlusal view of implants six months after placement revealing healthy periimplantal tissues, with no signs of plaque or inflammation, and the maintenance of implant stability.

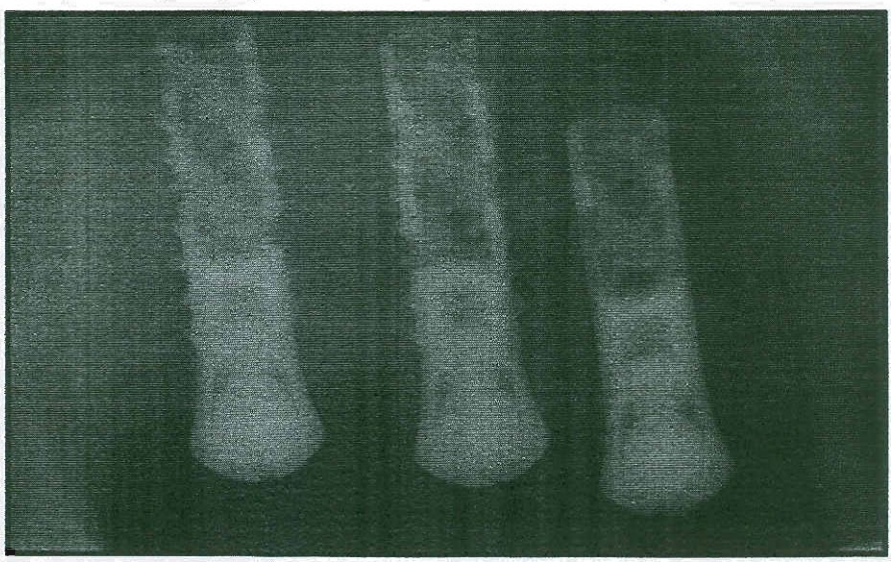

**Figure 22.** Six months post-operative radiographs support the clinical findings and indicate osseointegration of the fixtures as well as the absence of pathology around the implants and sinus.

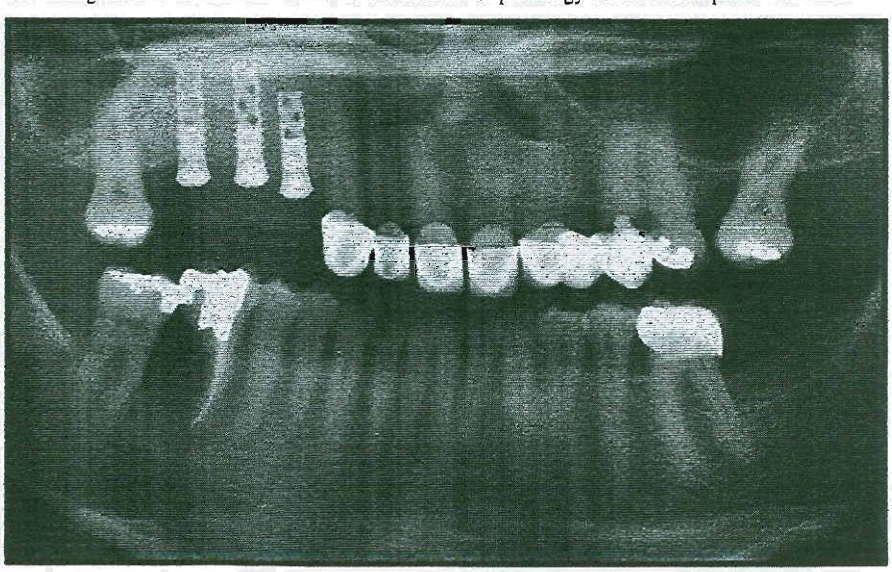

**Figure 23.** Panoramic view of dentition with implants placed into augmented sinus.

new bone deposition. The principle of osteoinduction is facilitated by osteogenic substances that induce progenitor cells of the surrounding recipient bed to form new bone. These substances are contained in demineralized allogenic bone matrix and other autogenic and allogenic grafting materials. Osteoconduction refers to the process where the grafting material provides an architectural matrix or scaffold for bone deposition. This property is seen in such grafting materials as resorbable hydroxylapatite.

To date, however, no significant study has determined which graft material is superior, although numerous authors have described clinical evidence supporting the combined use of resorbable hydroxylapatite and demineralized allogenic bone matrix.[2,15,16,17] In the present case report, these two materials were combined to augment the sinus. This combination appeared to have provided significant ossification necessary for integration of the implants. Histologic examination of biopsies from the augmented sinus suggested the osteoconductive capability of resorbable hydroxylapatite as manifested by the formation of new bone of high density without the typical fibrous encapsulation seen with other alloplastic materials. The combination of resorbable hydroxylapatite with demineralized allogenic bone matrix shows promise due to the possible synergism between their osteoinductive and osteoconductive properties. The resorbable hydroxylapatite is also physiochemically and crystallographically equivalent to the mineral portion of human bone[18,19] and may contribute to the ossification process by acting as a slow-release mineral reservoir.[20,21]

The endosseous dental implants placed in the augmented sinus of this case report were nonsubmerged, single-stage implants. Placement of these into the augmented sinus cavity resulted in healing with a favorable soft and hard tissue response. Clinical parameters demonstrated sound osseointegration and healthy gingiva surrounding the implants. This is the first application of this type of dental implant in conjunction with a sinus lift procedure that has been reported in the literature. This implant system has more than 18 years of clinical experience and is characterized as requiring only a single surgical procedure for the placement of implants. The differences between one- and two-stage implants date back to studies by Brånemark and colleagues, where they postulated that submersion of the implant during the osseointegration period was a prerequisite to successful integration.[22,23] Since the early 1970s, however, Schroeder and co-investigators began a series of experimental studies and clinical trials which have clearly shown that osseointegration can be achieved utilizing a one-stage titanium implant.[24,25,26,27] Gotfredsen et al demonstrated clinically, radiographically, and histologically that nonsubmerged, single-stage implants achieve the same level of osseointegration as two-stage implants.[28] Buser and colleagues described a perpendicular arrangement of connective tissue fibers that were firmly attached to the transmucosal portion of nonsubmerged implants.[27] The establishment of this fiber arrangement appears to be an important biological barrier that ensures the success of this type of implant.[29]

The use of nonsubmerged implants in conjunction with sinus augmentation procedures may be advantageous via transference of occlusal stimuli through the implants to the host bone and adjacent graft. Enneking et al showed that in canine fibulae, treated with autograft, physiologic stress led to more complete graft incorporation and repair.[30] The extrapolation of these findings suggests that passive, nonfunctional loading of the implants during the osseointegrating phase may favor a more efficient and complete graft incorporation as well as implant osseointegration. This statement is unproven but warrants further investigation. The inquiry could address the question of whether nonsubmerged implants would better exploit this property of a remodeling stimulus.

In conclusion, the sinus augmentation procedure has demonstrated great potential in the rehabilitation of patients with posterior maxillary atrophy. Further controlled histologic investigations and clinical trials evaluating the use of different grafting materials and implant types are needed. These studies are currently underway.

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