Staged Sinus Augmentation Using a Crestal Core Elevation Procedure and Modified Osteotomes to Minimize Membrane Perforation

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Staged sinus floor elevation allows predictable implant placement in the severely deficient posterior maxilla. An alternative to the most commonly used lateral window approach involves the apical displacement of cortical bone(s) using osteotomes and a composite graft. Crestal core elevation (CCE) incorporates specially designed osteotomes to minimize the incidence of membrane perforation and placement of a barrier membrane over the core osteotomy. This article presents the technique and instrumentation, as well as documentation of 43 patients demonstrating the efficacy of this modality.

Key Words: crestal core elevation, sinus, bone, augmentation, future site development

Various techniques have been reported to augment the sinus utilizing different graft materials in delayed or simultaneous approaches.1-4 While the quantity of preexisting bone required for successful simultaneous implant placement has not yet been determined, adequate bone should be available to provide primary implant stability. A lateral approach osteotomy without simultaneous implant placement has been advised when less than 5 mm of residual alveolar bone is present between the inferior border of the sinus and the crest of the alveolar ridge.5,6,10,11 Less than 5 mm of preexisting bone height and smoking have been shown to reduce the likelihood of implant survival using the bone-added osteotome sinus floor elevation (BAOSFE) technique.7 Previous investigators have indicated a 96% or higher survival rate when pretreatment bone height was a minimum of 5 mm.9 This success rate was reduced to 85.7% when the pretreatment bone height was 4 mm or less. The minimum residual alveolar bone height treated with the highly predictable localized management of the sinus floor (LSF) technique was 5 mm to 7 mm.10 This stresses the importance of the quality and quantity of the remaining native bone in simultaneous implant placement using internal (crestal) sinus elevation or the lateral window technique.

Staged Sinus Elevation

The future site development (FSD) technique has been developed as an alternative to the lateral window approach when inadequate crestal bone is present for primary stabilization of implants.8 In this procedure, trephined crestal bone cores are implanted with osteotomes to raise the sinus floor prior to graft augmentation. The cores and added graft material are used to...

Figure 1. Illustration demonstrates crestal core preparation using trephina. Core is prepared to within 1 mm of the sinus floor.
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elevate the sinus floor, and care is taken to avoid direct contact with the membrane. Since its introduction in 1995,
there have been no published reports on the success, predictability, or complications experienced with this procedure.

Crestal core elevation (CCE) is a modification of the FSD procedure for staged sinus elevation that incorporates procedural modifications that include specially designed core ostotomes, crestal core elevators, and barrier membranes placed over the core preparations. These modifications, applied to the original FSD technique, have simplified the procedure, minimized membrane perforation, and improved bone quality and healing. Using only a trephine for core preparation as described in the FSD technique, it is difficult to uniformly prepare the core close enough to the sinus floor to ease core elevation. Core elevation requires significant malleting force unless the core has been prepared to within 1 mm of the sinus floor (Figure 1). Trephine preparation is complicated by variations in the topography of both the residual alveolar ridge and the sinus floor that can lead to underpreparation at points along the core's perimeter (Figure 2). Conversely, small areas are easily over-prepared with the trephine and can result in a large perforation or macrocortication of the mucosal lining of the sinus (Figure 3). The incidence of membrane tears during trephination can be reduced by the use of #5 or #6 core ostotomes (H & H Co, Ontario, CA) and 5- or 6-series core elevators (H & H Co, Ontario, CA) to facilitate elevation of the core boundaries. These instruments are equipped with 0.5-mm-thick curved tips designed to fit within the borders of core preparations that are created with a 5-mm or 6-mm trephine (Figure 4). While gently malleting these instruments, the clinician retains the tactile sensation lost when using a trephine to complete the most delicate aspect of the core preparation. In the severely deficient posterior maxilla, this technique allows for sinus floor elevation using a less traumatic approach in an easier and more predictable manner.

**Materials and Methods**

Fifty-three partially edentulous patients were included in this study (20 female and 23 male patients, 36 to 72 years old; mean age = 56). Staged sinus grafting using CCE was performed at 73 sites where there was a minimum ridge width of 6 mm, and 5 mm or less (mean: 3.2 mm) of residual alveolar bone available beneath the sinus floor. Multiple sites were treated in 22 patients. The procedure was performed bilaterally on two patients. Five to 7 months later, 57 threaded implants were placed in 33 of the 43 patients. The remaining 10 patients were scheduled to have implants placed within the next 4 months.

Figure 2. Panoramic view of the maxillary left quadrant demonstrates variations in residual alveolar ridge height along the edentulous area. Uniform core preparations to within 1 mm of sinus floor were not possible.

Figure 3. During initial core preparation at site #14(26), the trephine has contacted the sinus membrane and resulted in core removal and a large perforation. Repair was attempted after further membrane dissection.

Figure 4. The 6-mm trephine and #5 core osteotome with a 0.5-mm-thick curved tip was designed to fit around the crestal core prepared by the trephine. The #5 core osteotome was to be used around the crestal core prepared with a 5-mm trephine.
Patients were also instructed to rinse with 0.12% chlorhexidine twice a day for one minute beginning 3 days prior to surgery. A crestal incision positioned toward the palatal aspect was made throughout the entire edentulous area. An anterior releasing incision was made at the mesial aspect of the most anterior tooth bordering the edentulous area. The posterior releasing incision was placed distal to the tuberosity in those patients where an autogenous graft was obtained (37 patients). In those patients where inadequate bone was available for grafting in the immediate surgical site, access was gained to the symphysis (4 patients) or the retromolar area (2 patients) in order to obtain bone cores to be added to the graft mix or placed directly into the core preparations. Core preparation was initiated with a trephine equipped with a 5-mm or 6-mm internal diameter and 2-mm markings. Selection of the trephine diameter was based on the width of the residual alveolar ridge. Core was taken to leave 1 mm of buccal and palatal bone outside the core preparation.

The core was prepared to the desired "working" depth of 1 mm to 2 mm from the sinus floor in the area of most limited bone height (Figure 5). After trephine preparation to the working depth, the #5 or #6 core osteotome was malleted while the instrument was rotated around the core boundary to achieve an additional 1 mm to 2 mm of apical core preparation. The preparation was completed as close to the sinus floor as possible using the #5 or #6 core osteotomes with 2-mm markings to gauge the depth of penetration and to avoid insertion of the instrument into the sinus. Once circumferential preparation was completed with the core osteotome, the 5- or 6-series hollow-tipped core elevators were firmly positioned around the core to finalize core preparation and initiate apical displacement of the core (Figure 6). The tips of the core elevators were hollowed to depths of 2 mm, 4 mm, and 6 mm. Selection of the proper core elevators was based on both the core diameter and available alveolar bone beneath the sinus at each site where a core had been prepared.

At this point, a standard 5-mm-diameter or 6-mm-diameter osteotome was gently inserted or malleted to apically displace the core to the original sinus boundary while the apex of the core remained attached to the mucosal lining of the sinus (Figure 7). Membrane integrity was verified prior to grafting by having the patient hold his or her nose and blow out onto a mirror. If neither fogging nor expectoration was observed on the mirror, the grafting procedure was completed. A composite graft
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mixture was then prepared using autogenous bone combined with particulate bovine bone (Bio-Oss, Osteohealth, Shirley, NY) or alloplastic bovine bone material impregnated with a synthetic 15 amino acid sequence (PepGen P-15, CoraMed Dental, Lakewood, CO) (18 sites). The author used approximately 20% to 60% of autogenous graft material harvested directly from the surgical site when possible. The graft mixture was then added to the core osteotomy and the 5-mm- or 6-mm-diameter osteotomes were gently pushed or milled to the original level of the sinus floor to further compress the graft and achieve additional lateral and vertical sinus elevation (Figures 8 and 9). Four to five loads of the graft mixture were placed prior to taking a periapical radiograph to confirm graft containment and estimate the extent of augmentation.

Once grafting was completed and adequate sinus elevation of 7 mm to 12 mm was achieved, an epiflue membrane (Nobel Biocare, Yorba Linda, CA) was placed in 68 sites, and an absorbable collagen barrier material (Ossix, Implant Innovations, Palm Beach Gardens, FL) was placed in 5 sites to cover the core preparation(s). The epiflue membranes were secured with 2 to 4 titanium screws (Nobel Biocare, Yorba Linda, CA) (Figure 10). The flap was then released at the base from the periosteum to facilitate increased coronal displacement and ensure membrane coverage. Every effort was made to achieve a relaxed closure with a combination of horizontal mattress and interrupted sutures using 3-0 vicryl (Ethicon Inc., Somerville, NJ) or 4-0 e-PFTE sutures (Nobel Biocare, Yorba Linda, CA).

An immediate postoperative radiograph was taken to evaluate graft containment and the extent of sinus floor elevation (Figures 11 and 12). Antibiotics were prescribed for an additional 7 days. Patients were instructed to rinse with 0.12% chlorhexidine during the first 3 to 4 weeks postoperatively. A nonsteroidal anti-inflammatory (500 mg ibuprofen qd) was also prescribed as well as a nasal decongestant, used as needed. In those patients in whom multiple cores were elevated (22 patients) or vertical ridge augmentation was performed in combination with CCE (6 patients), a tapering dose of prednisone (Medrol Dose-Pak, Pharmacia & Upjohn, Peapack, NJ) was started the night prior to surgery to minimize postoperative swelling. Suture removal was scheduled 11 to 14 days postoperatively, and the patients were reevaluated every two weeks for the first month and then every 3 weeks until implant placement surgery, which was performed 5 to 7 months following grafting.

Implant Placement

The healing period for CCE was based on the amount of preexisting bone and the average percentage of autogenous bone in the graft mix. Periapical and panoramic radiographs were taken and compared to baseline observations to confirm graft healing and determine available bone height prior to implant placement. A similar mucoperiosteal flap was elevated. If the e-PFTE membrane remained submerged during the healing period, it was removed with the stabilizing screws.

Osteotomes were prepared with a combination of drills and osteotomes according to the bone quality in the grafted sinus. The regenerated tissue was generally comparable to type III or IV bone and presented minimal resistance to drilling. Using osteotomes, the local bone was further consolidated to improve its density and primary implant stability. Osteotomes were also used to provide additional sinus elevation if necessary (6 sites) to allow for the placement of threaded, etched, or titanium oxide (TiO2)-blasted implants 10 mm to 13 mm in length.
The flaps were then closed primarily, and postoperative instructions were provided. The implants were uncovered 6 months later and healing abutments were placed. The patients were scheduled to begin impression procedures 4 weeks following implant uncovering. Multiple implants placed in the grafted sinus were restored with a splinted metal-ceramic prosthesis.

Case Presentations

Case 1

A 60-year-old female patient presented for replacement of teeth #14(26) and #15(27). A periapical radiograph revealed 1 mm to 4 mm of bone height beneath the sinus floor (Figure 13). Two 6 mm crestal cores were prepared and apically displaced to the level of the sinus floor (Figure 14). The prepared sites were grafted with a combination of 50% particulate bovine bone and 50% autogenous bone. The site was covered with an e-PTFE membrane and stabilized with titanium tacks. Five and one-half months later, two implants measuring 5 mm × 11.5 mm were placed. The implants were uncovered 6 months later and restored with a splinted, cement-retained prosthesis (Figure 15).

Case 2

A 65-year-old female patient presented with a hopeless tooth #2(17) and missing teeth #3(16), #4(15), and #5(14). The CT panoramic view revealed 1 mm to 3 mm of residual alveolar bone beneath the sinus (Figure 16). A 5-mm core was elevated at site #5 and a 6-mm core was elevated at site #3 (Figure 17). Six months later, three 4 mm × 11.5 mm implants were placed. Once the implant stability was confirmed, a splinted, cement-retained prosthesis was positioned (Figures 18 and 19).

Results

At the time of clinical review, 73 sites had been treated using the CCE procedure, and adequate healing (5 to 7 months) had occurred to allow for the placement of 57 implants in 33 patients. Implant length ranged from 10 mm to 13 mm (mean: 11.3 mm), and diameter ranged from 3.75 mm to 5.5 mm (mean: 4.6 mm). The first 4 implants placed (2 patients) were smooth-surfaced. The remainder had an etched (35 implants) or TiO2-blasted (16 implants) surface. Thirty-seven of these implants have been loaded for 3 to 35 months (mean: 15.5 months) with no failure during the study period. Four membrane tears were recorded during core preparation with the trephines. The three smaller tears (2 mm to 4 mm) were repaired with a collagen membrane through the crestal access following additional membrane dissection from the sinus floor. The membrane was freed from the sinus floor to repair the larger laceration, and a synthetic resorbable membrane (Resolut XT, 3i Implant Innovations Inc, Palm Beach Gardens, FL) was attached to a suture needle threaded through an adjacent core osteotomy. Once the membrane repairs were completed, graft material was placed in the core osteotomy and gently compressed to maintain membrane elevation. The membrane dissection minimized the compression required to apically displace the graft. Although there was no increased incidence of postoperative infection in this group, one patient with a smaller laceration experienced mild postoperative nasal bleeding the evening of the procedure. Four of the remaining 39 patients also experienced nasal bleeding. Implant placement was performed 7 months later in all cases of membrane violation and no difference in bone quality was
noted during osteotomy preparation. No membrane lacerations have occurred since the incorporation of the modified core elevating instruments into the procedure.

Early exposure (4 to 6 weeks) of the ePTFE membrane occurred in 4 patients (9.3%), involving 6 sites. These barrier membranes were removed 1 to 2 weeks following exposure and were replaced with a collagen membrane (BioGuide, Osteohealth Co., Shirley, NY). Three of the 4 patients with early exposure have had implants successfully placed and restored; the fourth patient has since been scheduled for implant placement. Late ePTFE membrane exposure (14 to 20 weeks) occurred in 2 patients (4.7%) involving 3 sites. These late exposures were related to mucosal perforation created by pressure from a removable prosthesis. In these cases, the membranes were immediately removed, with no absorbable replacement. Although implant placement has been performed for both of these cases, only one patient has had the definitive restorations positioned. The remaining patient is scheduled for implant uncovering.

Radiographs obtained just prior to implant placement demonstrated apical displacement of the sinus floor and replacement of the sinus space by radiopaque materials of varying densities. In all cases, the distance between the alveolar crest and sinus floor was at least 8 mm to 9 mm. Crestal core preparations were no longer visible at the reentry surgery for implant placement and membrane removal. The resistance of the regenerated tissue to drills and osteotomes was typical of type III to IV bone. The bone was softer as implant site preparation progressed apically. In areas where 8 mm to 9 mm of bone was available, additional osteotomy sinus floor elevation was performed to allow for placement of an implant 10 mm to 11.5 mm in length.

Fifty-seven implants have been placed in 33 CCE patients. Thirty-seven have been loaded for 3 to 35 months (mean: 15.5 months). Implant restorations include 2 single-unit, 8 two-unit, and 12 three-unit prostheses. To date, there have been no implant failures detected during the study period as assessed by radiographic examination and clinical stability.
Discussion

Use of the CCE procedure has been successfully incorporated to elevate the sinus floor and allow implant rehabilitation of the deficient posterior maxilla. Contemporary instrumentation for this procedure (ie, core osteotomes and elevators) has simplified the technique and minimized the incidence of membrane perforation. Membrane perforation was clinically detectable at 4 of 73 sites (5.5%). This compares favorably with perforation rates as described in the literature (ie, 18.2%, 35%, and 10%) using a lateral window approach.13,14

The healing time for CCE was 5 to 7 months, based on the relative percentage of autogenous bone in the graft mix, the preoperative amount of native bone, and the number of cores elevated. The rationale for combining particulate bovine bone or an impregnated anorganic bovine bone mineral with autogenous bone is to increase the bone density in the areas of regenerated bone, particularly around implants. In addition, the slower reabsorption process associated with particulate bovine bone facilitates maintenance of the graft volume during the rapid remodeling and reabsorption process of the implanted autogenous bone.15

Using the original FSD procedure, crestal cores were elevated, the osteotomy sites were grafted, and the surgical sites were allowed to heal without membrane coverage.4 The author has experienced improved bone quality using a barrier membrane over the crestal preparation(s). Similar results have been reported with the use of a nonresorbable membrane over the lateral window.4,16 In patients receiving bilateral sinus elevation, a significant difference in vital bone production was found when a membrane was used, as compared to the contralateral side without a membrane (25% and 11.9%, respectively).17 Although membrane coverage of the crestal core preparations should provide similar benefits and may explain the author’s improved results, healing without exposure of the membrane remains a crucial factor in maximizing regenerative success.18
In this study, premature membrane exposure occurred in 6 patients (14%) and was associated with significant inflammation necessitating early removal with an additional surgical procedure. Poorer bone quality and less consolidation of the grafted materials were evident in patients with exposures that progressed to implant placement. To minimize postoperative complications associated with exposure and subsequent contamination of the e-PFPE membrane, a collagen barrier membrane (Osstem, 3i Implant Innovations, Palm Beach Gardens, FL) that is resistant to animal and bacterial collagenase when prematurely exposed was incorporated with the CCE procedure. Several CCE sites that were covered by the collagen barrier membrane have recently been reentered for implant placement. Primary stability was achieved with no noticeable difference in bone quality in comparison to sites treated with an e-PFPE membrane.

Radiographic analysis of the areas treated with CCE showed a 6-mm to 12-mm increase of available bone for implant placement. This result indicates that it is possible to obtain sufficient bone to support dental implants in the deficient posterior maxilla in combination with autogenous bone, bovine bone mineral, and a barrier membrane. The author is hopeful that similar success, along with fewer postoperative complications, can be achieved using the collagen barrier membrane to replace the more technique-sensitive e-PFPE barrier, and sinus membrane perforations will be minimized or eliminated using the newly designed core osteotomes and elevators.

Conclusion

The modifications introduced with the CCE procedures offer the potential for reduced complications and more predictable, rapid healing while using a more conservative approach to sinus augmentation surgery. The CCE procedure results in adequate alveolar bone height for the placement of mini-implants, 10 mm to 13 mm in length, in patients with less than 5 mm of preoperative alveolar bone height in the posterior maxilla. All the implants placed by the author in the grafted sites have demonstrated acceptable primary stability in primarily type IV bone and have achieved osseointegration at uncovering. Additional investigations will follow on the survival of these implants under long-term functional load to determine if success is comparable to those implants placed in sinuses grafted with the more traditional lateral approach.

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References