In the moderately to severely atrophic maxilla, trephined cores measuring 3 to 6 mm in height and 5 to 6 mm in diameter may be apically displaced to facilitate sinus augmentation and staged implant placement. The crestal core elevation (CCE) procedure incorporates specially designed core osteotomes to minimize membrane perforation and the mal-leting force associated with core intrusion. This report reviews the technique, instrumentation and indications for CCE and presents two clinical cases clearly demonstrating the efficacy of this less invasive alternative to the more commonly used lateral window osteotomy.

KEY WORDS: Maxillary sinus, bone graft, dental implant, platelet rich fibrin, PRF

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INTRODUCTION

A residual subantral deficiency of bone volume can be predictably augmented by a variety of sinus floor elevation (SFE) techniques incorporating a wide range of graft materials in a delayed or simultaneous approach to implant placement.\textsuperscript{1-9} The lateral window osteotomy (LWO) is certainly the most frequently reported technique, producing reliable long-term results in reconstruction of the atrophic posterior maxilla.\textsuperscript{6,10-11} 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.\textsuperscript{12} A staged lateral window osteotomy (LWO) is most often advised when less than 5 mm of residual subantral bone height (RSBH) is present\textsuperscript{8} although successful results have been reported in 2 to 3 mm of subantral bone.\textsuperscript{13} Sites with less than 5 mm of RSBH have also demonstrated an increased failure rate when treated with osteotome-mediated sinus floor elevation (OMSFE).\textsuperscript{14-16} Summers’\textsuperscript{3} bone-added osteotome sinus floor elevation (BAOSFE) procedure was originally recommended at sites with at least 5 to 6 mm of RSBH, limiting this treatment to patients with only a moderately atrophic posterior maxilla. Summers\textsuperscript{4} introduced the future site development (FSD) procedure as an alternative to the lateral window approach in the more severely resorbed posterior maxilla where there was inadequate crestal bone present for primary stabilization of implants. In the FSD procedure, the residual subantral bone is impled in the form of a “plug” with the aid of wide diameter (5 to 6 mm) osteotomes and trephines as needed. The attached “plug” or core of native bone and added graft materials are used to elevate the sinus floor (Figures 1-5). The reported advan-

with an osteotome. Core elevation requires significant malleting force unless the core has been prepared to within 1 mm of the sinus floor along its entire perimeter (Figure 6). Trephine preparation is most certainly complicated by variations in the topography of the residual alveolar ridge and sinus floor (Figure 7) that can lead to underpreparation at points along the core perimeter, preventing controlled intrusion of the core. Conversely, in an effort to more closely approach the sinus floor, additional trephine preparation can result in severe laceration of the sinus membrane and possible core removal or displacement into the sinus cavity. To further simplify core preparation and reduce the risk of membrane laceration, Toffler\textsuperscript{12,17} designed core osteotomes (H & H Co, Ontario, CA) which are used to prepare the apical 1 to 2 mm of the core as it approaches the sinus floor. These instruments are one-third round and 0.5 mm thick and fit precisely around the 5.0 or 6.0 mm core preparation (Figures 8-10).

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.\textsuperscript{12} The core osteotomes directly infracture the sinus floor along the core’s periphery significantly lessening the apical force required for core displacement. Toffler\textsuperscript{12} reported on 43 partially edentulous patients with a mean...
age of 56 (range 36 to 72 years). Staged sinus augmentation using CCE was performed at 73 sites where there was a minimum residual ridge width (RRW) of 6mm and a RSBH 5mm or less (mean 3.2 mm). Multiple sites were treated in 22 patients. The core osteotomies were grafted with a composite of 20% to 60% autogenous bone mixed with bovine bone and covered with either an e-PTFE membrane or a bioabsorbable collagen membrane. In all cases where implants were placed, the distance between the healed alveolar crest and sinus floor was at least 8 to 9 mm. Radiographic analysis of the areas treated with CCE showed a 6 mm to 12 mm increase in available bone height for implant placement. The resistance of the regenerated tissues was typical of type III to IV bone. In areas where 8 to 9 mm of subantral bone height was present, additional OMSFE was performed to allow for placement of an implant 10 to 11.5 mm in length. At the time of clinical review, adequate healing (5 to 7 months) had allowed for placement of 57 threaded implants in 33 of 43 patients. Implant length ranged from 10 mm to 13 mm (mean: 11.3mm) and the diameter 3.75 to 5.5mm (mean:
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4.6mm). Thirty-seven of the 57 implants placed had been loaded for 3 to 35 months (mean 15.5 months) with no failures during the study period. This report will review and update the technique, demonstrating the efficacy of the procedure in two clinical cases.

MATERIALS AND METHODS

Staged sinus grafting using CCE is traditionally performed at maxillary premolar and molar implant sites with a RSBH of 3 to 6 mm and a residual ridge width (RRW) ≥ 7mm to retain at least 0.5 to 1.0 mm of crestal bone facial and palatal to a 5 mm or 6mm core prep which have external diameters of 6 mm and 7 mm respectively (Figures 11-12). If multiple sites are treated, then sites with as little as 2 mm RSBH may be successfully augmented as well, but the author prefers performing a LWO with less than 3 mm of RSBH. All patients undergoing CCE receive a 1 to 2 hour preoperative dose of an antibiotic and 8 mg dexamethasone sulfate which is tapered to 4 mg the following 2 days and 2 mg on the third postoperative day. The majority of patients are sedated with midazolam and their blood pressure, pulse and pO2 are closely monitored throughout the procedure. After obtaining adequate local anesthesia, a crestal incision is made throughout the entire edentulous area. An anterior releasing incision is made on the mesial aspect of the adjacent tooth. The posterior releasing incision is placed distal to the tuberosity in those patients where autogenous bone will be obtained. A surgical guide and 2mm round drill may be used to locate the center of the crestal core at the site of future implant placement (Figure 13). Core diameter is based on the RRW and ideally, there should be at least 1.0 mm of palatal and facial bone outside the core preparation. Core preparation into the facial and palatal plates of bone will not only jeopardize their survival but also make core elevation more difficult (Figure 14). Core preparation is initiated with a trephine with an internal diameter of 5.0 or 6.0mm and markings at 2.0, 4.0, 6.0, and 8.0mm (H and H Co. Ontario, CA) (Figure 15). The initial “bite” of the trephine is created by operating the trephine in reverse at 500 RPM with external irrigation. The core is then prepared with the trephine (forward at 850RPM) to the desired “working depth” of 1 to 2 mm from the sinus floor in the area of most limited bone height. The one-third round #5 or #6 core osteotome (H & H Co, Ontario, CA) has a 0.5mm thick tip and fits around the 5.0 or 6.0mm core (Figure 16-17). While gently malleting and rotating the core osteotome, the clinician retains the tactile sensation lost when using a trephine in close approximation to the sinus floor. The sinus floor can now be directly infracted along the perimeter of the core to facilitate
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apical displacement. Using a 5mm or 6mm diameter concave-tipped osteotome with 2mm markings up to 8mm (H & H Co, Ontario, CA), the core is displaced to the original level of the sinus floor (Figure 18). The integrity of the sinus membrane must then be confirmed by visual inspection. At this point you have technically doubled the amount of subantral bone by apically displacing the full length of the bone cylinder. If this RSBH is sufficient (at least 8.0 to 9.0 mm) then the osteotomy may be grafted with a particulate material (Figure 19) or platelet-rich fibrin (PRF) (Figures 20-22). If the estimated bone augmentation has created less than 8.0mm of subantral bone then PRF is placed in the osteotomy in advance of 2 to 3 loads bovine bone mineral or mineralized freeze-dried bone allograft (FDBA) and similar to the BAOSFE procedure, the graft materials are displaced to the original level of the sinus floor to achieve an additional 2.0 to 3.0mm of SFE. The grafted osteotomy is then covered with a bioabsorbable porcine type I collagen membrane (OSSIX-PLUS, OraPharma, Warminster, PA), (Figure 23). This collagen membrane has recently demonstrated fully submerged barrier function for up to 29 weeks as well as ossification of its cross-linked collagen.19 To stabilize the membrane and facilitate primary closure, a combination of horizontal mattress and interrupted sutures are placed using PTFE monofilament suture (Osteogenics Biomedical Inc, Lubbock, TX). Tension-free closure of the flap is obtained with the aid of vertical releasing incisions at the mesial and distal extremes and/or periosteal releasing incisions, if necessary. Sutures are removed 10 to 14 days later. An immediate postoperative radiograph is taken to confirm graft containment and to determine the extent of sinus floor elevation (Figure 24). Postoperative care consists of an antibiotic (amoxicillin 500mg three times daily for 7 days), a decongestant (pseudoephedrine 120mg two times daily for 3 days), and rinsing with 0.12% chlorhexidine mouthwash twice daily until the patient returns 10 day later for suture removal. Additionally, the patient is instructed not to blow their nose and to sneeze with an open mouth. Patients are also advised to refrain from using any removable prostheses until the sutures are removed. After a healing

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Figure 18: Apical preparation with the core osteotome simplifies core intrusion to a depth of 6 mm, effectively doubling the height of the subantral bone.

Figure 19: The core osteotomy has been grafted with mineralized freeze-dried bone allograft (MFDBA) in advance of collagen membrane coverage.

Figure 20: An autologous “plug” of platelet-rich fibrin (PRF) may be used to fill the osteotomy or inserted as membrane protection prior to additional sinus elevation with particulate materia

Figure 21: A 6 mm core displaced 4 to 5 mm at site #3.

Figure 22: A PRF plug has been inserted to fill the osteotomy prior to membrane placement.

Figure 23: The grafted osteotomy has been covered with a bioabsorbable porcine type I collagen membrane (OSSIX-PLUS, OraPharma, Warminster, PA).

Figure 24: An immediate postoperative radiograph taken to confirm successful core intrusion at site #s 3 & 4. Overlying membrane was stabilized by 3 tacks to aid in ridge augmentation site #5.
period of 4 to 5 months, a periapical radiograph is taken to estimate the available bone height prior to implant placement. A crestal incision is used to expose the healed ridge. The implant sites are marked with a 2mm round drill using a surgical guide. The augmented site generally demonstrates type III or IV bone quality and presents minimal resistance to drilling. Most often, drills are utilized to prepare the osteotomy to its final diameter (0.7 mm to 1mm less than the implant diameter) at a depth of 5 to 6mm then osteotomes are used to further consolidate the bone apically. They may also provide for additional sinus elevation, if needed, to allow for the placement of a 10mm to 11mm long implant. If excellent primary stability is achieved (30 Ncm of insertion torque or a favorable ISQ reading), then healing caps are immediately placed or the submerged implants are uncovered and healing caps placed.

**CASE PRESENTATIONS**

**Case 1**

A 61 year-old male recently lost tooth #3 due to mesiobuccal root fracture and extensive furcal bone loss. He sought a second opinion after a lateral window osteotomy (LWO) and staged implant placement had been recommended. The periapical radiograph reveals 3 to 5 mm of RSBH as well as a sinus septum which certainly increases the risk for membrane perforation using a lateral approach (Figure 25). In addition, a thick lateral sinus wall and membrane dissection around the roots of #2 also increased the degree of difficulty in performing a LWO. As a less invasive and less costly alternative, CCE was recommended in combination with staged implant placement. Flap elevation revealed a residual buccal defect and a 10 to 11 mm wide ridge which permitted preparation of a 6 mm diameter core (Figure 26). The core was prepared with a trephine to a depth of 3 mm, and then the #6 core osteotome was used to advance the preparation an addi-
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Infracture the sinus floor around the core perimeter. This facilitated simple core intrusion to a depth of 4 to 5 mm using a 6 mm diameter concave-tipped osteotome (Figure 27). The osteotomy was packed with bovine bone mineral (BBM) and apically displaced 3 to 4 mm to achieve some additional sinus floor elevation (SFE). At present, PRF is always placed in advance of any graft material, but this autologous product was not available at the time this patient was treated. The osteotomy was then back-filled with BBM (Figure 28), covered with a bioresorbable collagen membrane and the tissues primarily closed. An immediate postoperative radiograph revealed graft containment and 7 to 8 mm of SFE (Figure 29). Five months later the ridge had completely healed and the implant osteotomy was prepared with a combination of drills and osteotomes (Figure 30) to allow for the placement of a 6 x 11.5 mm tapered implant (Figure 31). The implant supported restoration has now been in function for 7 years (Figures 32-33).

Case 2
A 57 year-old female had recently lost tooth #5 contributing to failure of a fixed prosthesis incorporating tooth #s 3 and 6, replacing missing #4. Replacement of the fixed prosthesis was not considered as #3 demonstrated a moderate degree of bone loss and furcation involvement. The panoramic view from the dental scan revealed a sinus septa at site #4 and a residual defect and thickened sinus membrane at site #5 (Figure 34). A radiographic cross-section at site #4 shows the septa clearly with 3 to 4 mm of RSBH (Figure 35). A lateral approach at this site would most likely result in significant membrane perforation. Flap elevation allowed for the preparation and 4 to 5 mm apical displacement of a 5 mm core at site #4 and a residual defect and thickened sinus membrane at site #5 (Figure 34). A radiographic cross-section at site #4 shows the septa clearly with 3 to 4 mm of RSBH (Figure 35). A lateral approach at this site would most likely result in significant membrane perforation. Flap elevation allowed for the preparation and 4 to 5 mm apical displacement of a 5 mm core at site #4 and a residual defect and thickened sinus membrane at site #5 (Figure 36). The core osteotomy at #4 and the buccal defect at site #5 were grafted with MFDB (Figure 37) and covered with PRF and a bioresorbable

Figure 31: Single stage implant placement of a 6 x 11.5 mm tapered implant.

Figure 32: Implant-supported restoration site #3 after 5 years in function

Figure 33: Periapical radiograph of implant after 5 years of loading.

Figure 34: Dental scan, panoramic view of URQ reveals missing teeth #s 4 & 5, a sinus septa and membrane thickening.

Figure 35: Dental scan, cross section site #4 shows septa, which certainly makes a lateral approach difficult

Figure 36: Core elevation site #4 and OMSFE site #5.

Figure 37: Grafting site #s 4 & 5 with mineralized freeze-dried bone allograft (MFDBA).

Figure 38: Immediate postoperative radiograph shows core intrusion #4 and OMSFE #5

Figure 39: 6 months later, 4 mm diameter implants placed into the healed ridge.
collagen membrane. The immediate postoperatively radiograph clearly demonstrated apical core disimpaction at #4 and localized OMSFE at #5 (Figure 38). Five months later, 4 mm diameter implants were placed into the healed ridge with excellent primary stability (Figure 39). Four months later SFE and successful integration was demonstrated radiographically around the 9mm and 13 mm long implants (Figure 40).

**DISCUSSION**

The author has nearly completed analyzing the data on sites treated using the CCE procedure with implants in function from 1 to 10 years. As of September 2009, 125 patients have been treated with CCE performed at a total of 152 sites. Implant survival with up to 10 years of loading is approximately 94%, certain that equaling that reported for sinus floor elevation using a lateral approach.

A full clinical report on implants placed using CCE is in press and should be published shortly. This report updates the technique the author introduced in 2001 and reviewed in 2002 and 2004. The CCE procedure incorporates modifications to Summers’ (1998) original FSD procedure designed to reduce potential complications and provide more predictable, rapid healing while using the more conservative crestal approach to staged sinus augmentation surgery. SFE using the CCE procedure requires significantly less flap elevation and graft materials resulting in reduced postoperative pain, bruising and swelling.

The LWO is easiest to perform in the totally edentulous posterior maxilla, but it is technically more difficult at single molar sites where a membrane perforation rate of 40% to 58% has been reported. The introduction of piezossurgical instrumentation has reduced the incidence of membrane perforation during window preparation, but a higher incidence of intraoperative complications would still be expected at single tooth sites due to restricted access, limited size of the antrostomy, increased thickness of the lateral sinus wall (Figure 41) and the presence of adjacent teeth. CCE has proven to be a most effective alternative to the LWO at these sites where quite often patients can provide only limited access to successfully utilize a lateral approach.