Chapter 16

Sinus elevation: Osteotome-mediated approach

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Introduction

The reduced subantral bone volume as a consequence of postextraction ridge resorption and secondary pneumatization of the maxillary sinus may 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 (Boyne and James, 1980; Garg and Quinones, 1997; Jensen et al., 1998; Smiler, 1997; Summers, 1994a,c, 1995; Tatum, 1986; ten Bruggenkate and van der Bergh, 1998; Thor et al., 2007). The lateral window osteotomy (LWO) has been the most frequently reported technique, producing reliable long-term results in oral implant rehabilitation (Del Fabbro et al., 2004; Jensen et al., 1998; Wallace and Froum, 2003). The LWO bone augmentation procedure (Fig. 16.1) is most often utilized presumably because it seems simpler to perform and provides the surgeon with more visual control; it is, however, considered to be invasive, time-consuming, and expensive (Jensen et al., 1998). As a less invasive alternative to the LWO, osteotome techniques (Cavicchia et al., 2001; Davarpanah et al., 2001; Fugazzotto, 2003; Rosen et al., 1999; Summers, 1994a,c, 1995; Toffler, 2001, 2004a) can obtain a localized elevation of the sinus floor through a crestal osteotomy, minimizing the degree of flap elevation and eliminating the need for preparation of a larger bony window in the lateral aspect of the alveolus (Figs. 16.2 and 16.3).

An osteotome-mediated approach offers the advantages of a more conservative surgical entry, more localized augmentation of the sinus, a lesser degree of postoperative morbidity, and an ability to load the implants in a shorter time period (Fugazzotto, 2003). When there is adequate subantral bone for primary stabilization of implants, osteotome-mediated sinus floor elevation (OMSFE) procedures attain 2–5 mm of localized SFE, usually permitting the simultaneous placement of implants ≥10 mm in length (Cavicchia et al., 2001; Leblebicioglu et al., 2005; Nkenke et al., 2002; Rosen et al., 1999; Toffler, 2004a) (Figs. 16.4–16.6).

Literature review: OMSFE and simultaneous implant placement

Clinical studies on OMSFE with simultaneous implant placement show a success rate between 88.6% and 100% (Cavicchia et al., 2001; Coatoam and Krieger, 1997; Deporter et al., 2000; Emmerich et al., 2005; Fermorgård and Åstrand, 2008; Ferrigno et al., 2006; Horowitz, 1997; Komarnyckyj and London, 1998; Rosen et al., 1999; Schleier et al., 2008; Summers, 1994c; Toffler, 2004a; Zitzmann and Schärer, 1998). The primary determinant in implant survival with OMSFE procedures is the height of the residual alveolar ridge (Cavicchia et al., 2001; Nkenke et al., 2002; Rosen et al., 1999; Schleier et al., 2008; Toffler, 2004a). A review of the literature indicates that implant type, the choice of graft material, the absence of graft material, and the method of sinus floor infracture (direct or bone-cushioned) exerted minimal influence on survival outcome; however, factors such as edentulism, osteoporosis, and an overdenture prosthesis have been shown to influence postloading survival of implants placed in areas of limited residual subantral bone height (RSBH) (Toffler, 2004a). Summers (1994c) claimed that a preoperative RSBH of at least 5–6 mm was needed for implant success with the bone-added osteotome sinus floor elevation (BAOSFE) procedure. Other reports have
Fig. 16.1 Lateral window osteotomy (LWO) at single tooth site #14 with 2 mm of residual subantral bone height (RSBH).

Fig. 16.2 Osteotome-mediated sinus floor elevation (OMSFE) site #14 immediately after sinus floor infracture.

Fig. 16.3 Crestal core elevation (CCE) sites #3 (6-mm core) and #4 (5-mm core) for delayed implant placement.

Fig. 16.4 Site #14 with an RSBH of 4–6 mm.

Fig. 16.5 Placement of a 4.8 × 10-mm implant with 4–5 mm of OMSFE using collagen and anorganic bovine bone mineral (ABBM).

Fig. 16.6 Five months later. Note the apical relocation of the sinus floor.
demonstrated similar findings (Cavicchia et al., 2001; Fermengård and Åstrand, 2008; Nkenke et al., 2002; Rosen et al., 1999; Toffler, 2004a). A multicenter study on the BAOSFE procedure showed that the survival rate was 96% when the RSBH was at least 5 mm and 85.7% when the RSBH was 4 mm or less (Rosen et al., 1999).

It does not seem to be relevant as to what kind of graft material is used with regard to the success rate of implants in augmented sinuses (Browaeys et al., 2007). It has been recommended that grafting material be used in combination with OMSFE to create more bone volume in support of the implant; however, there is no conclusive data in the literature reporting on the possible advantage and maturation of a bone graft at the apical portion of the implant (Artzi et al., 2003; Reiser et al., 2001). In fact, recent reports have demonstrated the clinical success of OMSFE using no grafting materials (Fermengård and Åstrand, 2008; Lai et al., 2008; Leblebicioglu et al., 2005; Nedir et al., 2006; Schleier et al., 2008; Schmidlin et al., 2008), suggesting that the mere tenting of the Schneiderian membrane by the implant apex could stimulate subantral bone formation.

Most authors report an average bone height gain of 3–4 mm using traditional osteotome procedures (Ferrigno et al., 2006; Komarneyckj and London, 1998; Toffler, 2004a,b; Zitzmann and Schärer, 1998). The extent of SFE possible by crestal approach is unknown, considering that the greater the number of adjacent sites to be elevated, the greater the extent of the elevation possible. The possible apical extension of the newly formed subantral space created by the distension of the Schneiderian membrane via a crestal approach is correlated with the interimplant distance, sinus membrane elastic properties, and the quality of membrane attachment to the underlying sinus floor (Berengo et al., 2004).

After reviewing the available literature, it appears that short-term clinical survival/success of implants in the posterior maxilla placed using OMSFE at sites with at least 5 mm of RSBH is similar to that of implants placed in more native bone using conventional methods. In cases of severely resorbed maxillae (<5 mm of RSBH) requiring >4 mm of SFE, minimally invasive SFE with simultaneous implant placement using osteotomes does not seem to be the method of choice. A two-stage procedure using a lateral window technique, or a crestal core approach (Fugazzotto, 2001; Toffler, 2001, 2002, 2004b), would be preferred.

**Clinical indications**

The clinical considerations for selecting when and what type of OMSFE procedure will be used include (i) RSBH; (ii) degree of SFE required; (iii) residual ridge width (RRW), ideally providing ≥1 mm of bone buccal and palatal to implant; (iv) vertical ridge resorption (VRR) and anticipated crown-to-implant (C/I) ratio; (v) the desired implant length; and (vi) the number of adjacent implants to be placed in the elevated area.

The following guidelines were chosen to maximize clinical success based on the author’s clinical experience and personal implant failures.

**OMSFE and simultaneous implant placement**

1. **RSBH**—Ideally ≥6 mm (Fig. 16.7), although an RSBH of 5 mm is adequate if a wider diameter implant (2.5 mm) can be placed at a single tooth site with minimal VRR (Fig. 16.8). Also, if multiple sites are...
treated in anticipation of a splinted restoration, sites with 4–5 mm of RSBH and a mild to moderate degree of VRR can be considered for OMSFE and simultaneous placement (Fig. 16.9).

2. Degree of SFE—2–5 mm.

3. RRW—≥5.5 mm at premolar sites and ≥6.5 mm at molar sites to provide 1 mm of bone thickness facial and palatal to implants that are 3.5–5.5 mm in diameter at premolar sites and 4.5–5.5 mm in diameter at molar sites.

4. VRR—Ideally mild to moderate, although sites with severe VRR can be considered as part of a splinted restoration attached to longer implants.

5. Implant length—7–11 mm. Implants that are 7–8 mm in length should be at least 4.5 mm in diameter and splinted to implants of greater dimension.

6. Implant diameter—4.5–5.5 mm for implants 7–9 mm in length; 3.5–5.5 mm for implants 10–11 mm long.

OMSFE for delayed implant placement using a CCE procedure

1. RSBH—4–6 mm for single tooth sites (Fig. 16.10), 3–5 mm for multiple tooth sites in anticipation of a splinted restoration supported by longer anterior implants and the greater degree of SFE possible with apical displacement of multiple cores.

2. Degree of SFE—4–7 mm.

3. RRW—≥8 mm to retain at least 1 mm of crestal bone facial and palatal to a 5–6 mm core preps, which have external diameters of 6 and 7 mm, respectively.

4. VRR—Mild to moderate for single sites; mild to severe for multiple sites.

5. Implant length—9–11 mm for single-tooth restorations and 8–11 mm for multiple implants.

6. Implant diameter—4.5–5.5 mm for implants 8–9 mm in length; 4.0–5.5 mm for implants 10–11 mm long.

OMSFE for delayed implant placement using a CCRR procedure

1. RSBH—6–8 mm at sites where there is no clinical advantage to performing simultaneous implant placement with OMSFE. These sites are usually located anterior to sites with inadequate RSBH to perform simultaneous implant placement (Fig. 16.11).

2. Degree of SFE—2–5 mm.
Implant site development

Table 16.1 Review of clinical indications

<table>
<thead>
<tr>
<th>Sinus floor elevation (SFE) technique</th>
<th>Number of sites</th>
<th>Residual subantral bone height (RSBH)a</th>
<th>Amount of SFE</th>
<th>Vertical ridge resorption (VRR)</th>
<th>Residual ridge width (RRW)b</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Staged lateral window osteotomy (LWO)c</td>
<td>Single or multiple molar/ premolar</td>
<td>4 mm or less</td>
<td>≥7 mm</td>
<td>Moderate to severe</td>
<td>N/A</td>
</tr>
<tr>
<td>2. LWO simultaneous implant placement</td>
<td>Single molar</td>
<td>5–6 mm</td>
<td>≥6 mm</td>
<td>Moderate to severe</td>
<td>≥7 mm</td>
</tr>
<tr>
<td>3. Crestal core elevation (CCE)</td>
<td>Multiple molar/premolar</td>
<td>3–6 mm</td>
<td>4–6 mm</td>
<td>Mild to severe</td>
<td>≥8 mm</td>
</tr>
<tr>
<td>4. Osteotome-mediated sinus floor elevation (OMSFE) with simultaneous implant placement</td>
<td>Single molar/premolar</td>
<td>≥6 mm</td>
<td>2–5 mm</td>
<td>Mild to severe</td>
<td>≥5 mm</td>
</tr>
<tr>
<td></td>
<td>Single molar or premolar</td>
<td>5 mm</td>
<td>3–4 mm</td>
<td>Minimal</td>
<td>≥6.5 mm (implant body ≥4.5 mm)</td>
</tr>
<tr>
<td>5. Crestal core removal/replacement (CCRR)e</td>
<td>Multiple tooth sites</td>
<td>4–5 mmf</td>
<td>2–5 mm</td>
<td>Minimal to moderate</td>
<td>≥6 mm</td>
</tr>
<tr>
<td></td>
<td>Single molar/premolar sites</td>
<td>6–8 mm</td>
<td>2–5 mm</td>
<td>Mild to severe</td>
<td>≥6 mm</td>
</tr>
</tbody>
</table>

a This amount must be confirmed clinically as a preoperative panoramic or periapical radiograph does not precisely determine the slope of the alveolar ridge or the possibility of less bone being present in the center of the ridge than buccally or palatally.
b Ideally, residual ridge width allows for 1 mm of crestal bone buccal and palatal to the implant.
c At single tooth sites with severe VRR, vertical ridge augmentation may be required in combination with an LWO.
d A 7–9-mm implant will be placed in 4–5 mm of RSBH only when it will be splinted to one or more additional implants of greater length.
e CCRR is only performed when delayed implant placement is the preferred method due to reduced RSBH at adjacent or distal sites where CCE or an LWO is required.

3. RRW—≥6 mm to allow for 1 mm of facial and palatal bone after preparing a 3-mm core with an external diameter of 4 mm.
4. Implant length—11–13 mm.
5. Implant diameter—3.5–5.5 mm depending on location and RRW (Table 16.1).

Surgical technique

The procedures described will include (i) OMSFE and simultaneous implant placement, (ii) OMSFE and delayed implant placement using a crestal core elevation (CCE) procedure, and (iii) OMSFE and delayed implant placement using a crestal core removal/replacement (CCRR) procedure.

Preoperative assessment

For all OMSFE procedures, patients are excluded if they present with a medical condition that would contraindicate dental surgery or interfere with the wound healing process (e.g., uncontrolled diabetes, uncontrolled hypertension, active chemotherapy). Increased failure rates should be expected in patients exhibiting risk factors such as systemic diseases causing wound healing problems, heavy smoking, increased periodontal susceptibility, poor bone density, and extreme atrophy (Bornstein et al., 2008; van Steenberghe et al., 2002). Patients with a history of dizziness syndrome (Menière or Menière-like), easily susceptible to become acute due to the percussion on the osteotomes during surgery, are not candidates for OMSFE (Peñarrocha et al., 2001). Patients are also excluded if they report a history of frequent sinusitis, previous surgical interventions in the sinus, and detection of any pathological changes on the presurgical radiographic exam. In the presence of untreated or undiagnosed pathologies of the sinus (infectious-inflammatory, acute, and chronic), treatment is delayed until the appropriate referral to an otolaryngologist has been made and the necessary treatment performed.

A complete examination of hard and soft oral tissues is conducted for each patient to exclude uncontrolled periodontal and dysfunctional disease. A panoramic or periapical radiographic assessment permits approximation of the RSBH. The panoramic radiograph will reveal the general topography (flat/oblique) of the sinus floor and the presence of transverse septa. A presurgical periapical digital radiograph that has been calibrated is helpful in assessing the RSBH and the prospective implant axis in relation to the topography of the sinus floor and adjacent teeth. Should the height of the available subantral bone at the implant site be uncertain, thus raising doubts on the method for SFE, crestal or lateral, staged or simultaneous, then computed tomography (CT) scans or cone beam volume technology (CBVT) showing the sinus in section are indicated (Corrente...
et al., 2009). CT or CBVT imaging will accurately reveal RSBH, septa presence and morphology, the buccopalatal slope, and the proximity of the lateral nasal wall, as well as RKW and sinus pathology. Radiographic and clinical analysis, along with the number of sites to be treated, will determine whether OMSFE will be performed with simultaneous or delayed implant placement (for more precise treatment planning, see the “Clinical Indications” section).

**Flap design/OMSFE procedures**

The surgical steps preceding OMSFE procedures do not differ from those for standard implant insertion. The patient is premedicated with 2.0 g of amoxicillin or 500 mg of azithromycin 1 hour prior to surgery. Just prior to anesthesia, the patient is asked to rinse with 0.12% chlorhexidine gluconate for 1 minute, and the surgical site is cleaned thoroughly with the same solution or betadine on a cotton swab. The area is anesthetized with articaine hydrochloride 4.0% with epinephrine 1:100,000 buccally and palatally to obtain a deep anesthesia including the sinus floor. Full-thickness flaps are elevated following a midcrestal incision. Modifications to the standard linear incision are incorporated if OMSFE and simultaneous implant placement using a single-stage protocol is anticipated. At single-tooth sites, intrasulcular incisions are preferred. Flap reflection is usually minimized but must provide adequate access and visualization to the entire ridge crest. Mesial and distal vertical releasing incisions are often required with simultaneous lateral ridge augmentation or to facilitate coronal flap advancement. After flap reflection, OMSFE is performed with simultaneous or delayed implant placement based on the RSBH, ridge morphology, and implant primary stability.

**Site preparation for OMSFE and simultaneous implant placement**

The osteotomes used for this procedure may be generic, implant-specific, or the surgeon’s preferential design. Since February 2002, the author has used personally designed rapid-expansion limited-bone (RELB) osteotomes (H&H Co., Ontario, CA) for localized SFE and simultaneous implant placement in areas of limited bone height (4.0–8.0 mm). The RELB osteotomes are marked at 4, 5, 6, 8, and 10 mm, are 2.0–5.5 mm in diameter, and have either a 0.5-mm tapered tip or are parallel-sided (Fig. 16.12). The osteotomes of choice must be available in straight or offset design because access to first and second molar sites is very often limited with straight osteotomes and can result in less-than-ideal axial inclination of the implant as well as trauma to the lower lip (Fig. 16.13). Osteotomes designed with a 30° offset provide adequate access without sacrificing tactile sensitivity or instrument stability (Fig. 16.14). A surgical mallet is used to advance the osteotomes. Stops may be attached to the osteotomes to limit apical preparation and avoid rapid infracture, overinsertion, and concurrent membrane perforation (Fig. 16.15).

The technique favored by the author most closely resembles a modification of Summers’ BAOSFE technique (Summers, 1994c), termed localized sinus lift (LSL), first reported by Cavicchia et al. (2001) and further refined by Toffler (2004a). The technique is performed in four steps: (i) crestal bone site preparation with...
Implant site development

Once the working depth has been established, the site is then completely prepared with the conventional sequence of drills needed for the placement of an implant of the selected diameter, carefully avoiding direct contact between the drills and the floor of the sinus. As the diameter of the osteotomy is widened, the surgeon ascertains the residual bone quality based on resistance and “drill-bone” collection (Fig. 16.17). This will assist in determining the degree to which the osteo-

calibrated drills; (ii) direct sinus floor fracture with an osteotome; (iii) sinus membrane elevation with grafting materials; and (iv) implant placement.

Using a surgical template to aid in implant positioning, an osteotomy is initiated at the future implant site with a 2.0-mm round bur. A 2.0-mm twist drill is then advanced to a depth that is 0.5–1 mm from the sinus floor (working depth) as measured from the preoperative radiograph. A 2-mm calibrated guide pin is then inserted into the osteotomy and this ideal subsinus position is confirmed radiographically prior to proceeding (Fig. 16.16). If there is no resistance to the apical progression of the 2-mm guide pin, the surgeon must be suspicious of a membrane perforation. Once the working depth has been established, the site is then completely prepared with the conventional sequence of drills needed for the placement of an implant of the selected diameter, carefully avoiding direct contact between the drills and the floor of the sinus. As the diameter of the osteotomy is widened, the surgeon ascertains the residual bone quality based on resistance and “drill-bone” collection (Fig. 16.17). This will assist in determining the degree to which the osteo-

Fig. 16.14 The 80° (left) and 90° (right) offset osteotomes improve posterior access but sacrifice control in comparison with the 30° offset osteotome (center).

Fig. 16.15 Osteotome with stop positioned to limit excessive apical intrusion and concurrent membrane perforation.

Fig. 16.16 Two-millimeter depth gauge (Neoss Inc., Woodland Hills, CA) inserted to a depth of 7 mm confirms ideal working depth for OMSFE.

Fig. 16.17 Implant drill collects large volume of bone indicating good bone density requiring only slight underpreparation of the osteotomy to achieve good primary stability.
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Osteotomy will be underprepared relative to the final implant diameter (range 0.5–1.2 mm) to improve primary implant stability. As an alternative in softer bone, the osteotomy may be widened with osteotomes to increase local bone density and primary stabilization of the implant (Summers, 1994a,b,c). As a matter of patient comfort, the author widens the osteotomy using drills only, remaining 0.5–1 mm below the floor of the sinus. The final diameter of the osteotomy is 0.5–1.2 mm smaller than the implant diameter to maximize primary stability. Consistently maintaining the working depth and drilling to within 1 mm or less of the sinus floor minimizes the malleting force required to displace residual bone beneath the sinus floor, thereby reducing the possibility of membrane perforation due to uncontrolled apical penetration of the osteotome. The malleting force applied to the osteotome must always be proportioned to the bone resistance. Hard malleting is avoided with the surgeon exerting restraining pressure to prevent uncontrolled advancement and membrane perforation. The osteotome should not advance more than 1 mm with each impact. The patient’s head is stabilized while malleting the osteotomes by placing firm pressure on the forehead (Fig. 16.18). As previously stated, at first and second molar sites, it is frequently necessary to use osteotomes with a 30° offset to improve access and perpetuate ideal restorative positioning of the implant (Figs. 16.13 and 16.18). The surgeon must focus on maintaining the position of the instrument while allowing the assistant to mallet. Each strike of the mallet must maintain the same path of insertion. Off-angled malleting creates an elliptical osteotomy, compromising implant fixation. The force applied should be sufficient to fracture the sinus cortical floor but restrained enough to prevent the osteotome tip from traumatizing the Schneiderian membrane. If the surgeon prefers a more controlled approach, an appropriate osteotome with a stop that can be regulated can be used to allow the instrument to progress only 1 mm at a time (Cavicchia et al., 2001) (see Fig. 16.15). A calibrated straight or offset osteotome consistent with the diameter of the last drill used for implant site preparation is used to achieve the initial sinus floor infracture, but the osteotome itself does not enter the sinus. If the osteotome is not easily advanced, a slightly narrower (−1.0 mm) osteotome may be used or additional apical preparation with drills may be considered to pierce a dense spot in the bone. Please be advised that the narrower the osteotome, the greater the risk of uncontrolled up-fracture and membrane perforation. The moment of induced greenstick fracture of the sinus floor is easily recognized. The layer of cortical bone forming the floor is displaced apically carrying the membrane up with it (Figs. 16.19 and 16.20). Immediately after infracture, the implant site is

Fig. 16.18 Patient positioning and head stabilization during malleting. Note that the neck is not hyperextended, which increases the risk for benign positional paroxysmal vertigo (BPPV).

Fig. 16.19 Osteotome-mediated sinus floor infracture. Apical displacement of the sinus floor with the attached membrane is evident.

Fig. 16.20 Periapical radiograph with 3-mm guide pin immediately after sinus floor infracture with a 3.0-mm osteotome. Note the “bowing” of the sinus floor at site of infracture.
Implant site development

Graft material can be placed into the osteotomy and apically displaced to the working depth (Figs. 16.25 and 16.26). The graft material may be autogenous bone chips or any biocompatible and osteoconductive allograft or xenograft. Anorganic bovine bone mineral (ABBM) is often the preferred bone substitute due to its reported success in either direct or indirect sinus elevation procedures (Deporter et al., 2000, 2005; Piattelli et al., 1999; Rosen et al., 1999). While being only very slowly absorbed, the material is highly biocompatible and osteoconductive (Piattelli et al., 1999) when used as a sinus graft. This graft material is deproteinized and radiopaque, and the state of the grafted area can be seen easily on radiographs. Each 4.0–5.0-mm column of bone

tested for perforation of the sinus membrane by three methods: (i) direct inspection; (ii) the Valsalva maneuver, which is performed by asking the patient to blow through the nose (after pinching the nostrils) while holding a mirror directly underneath the osteotomy site; mist formation, which may include blood, would indicate a positive response suggesting a perforation; and (iii) manual insertion of a depth gauge to verify that the elasticity of the sinus membrane has been maintained. When a perforation of the Schneiderian membrane is detected, three treatment options are available: (i) abort and repeat procedure after at least 3 months; (ii) localized repair and implant insertion (see “Complications” section); or (iii) revert to an LWO to repair perforation, graft the sinus, and place an implant. Once membrane integrity has been verified, a collagen sponge (Collatap, Zimmer, Carlsbad, CA) (Fig. 16.21), or more recently, a membrane made of platelet-rich fibrin (PRF), is added to the osteotomy (Figs. 16.22 and 16.23) and compressed apically into the developing subantral space. These materials act as “membrane insurance” to possibly seal any undetected perforation in advance of particulate materials. The PRF membrane can provide protection for the sinus membrane during the use of an osteotome, and in case of perforation, the fibrin matrix can aid in wound closure (Diss et al., 2008). PRF may also be used in lieu of particulate grafting to predictably elevate the sinus floor (Fig. 16.24) using a crestal approach (Diss et al., 2008). The author uses PRF whenever possible in his OMSFE procedures based on its reported efficacy in membrane repair (Choi et al., 2006) and its ability to reduce sinus graft healing time (Choukrour et al., 2006).

After direct sinus floor infracture and apical displacement of a collagen sheet or PRF membrane, columns of graft material can be placed into the osteotomy and apically displaced to the working depth (Figs. 16.25 and 16.26). The graft material may be autogenous bone chips or any biocompatible and osteoconductive allograft or xenograft. Anorganic bovine bone mineral (ABBM) is often the preferred bone substitute due to its reported success in either direct or indirect sinus elevation procedures (Deporter et al., 2000, 2005; Piattelli et al., 1999; Rosen et al., 1999). While being only very slowly absorbed, the material is highly biocompatible and osteoconductive (Piattelli et al., 1999) when used as a sinus graft. This graft material is deproteinized and radiopaque, and the state of the grafted area can be seen easily on radiographs. Each 4.0–5.0-mm column of bone
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is used to create 1.0 mm of localized SFE. This procedure is repeated until adequate elevation is attained to accommodate the selected implant length. Graft material is progressively added to encourage membrane doming without perforation. Implants are placed in the prepared osteotomy site without tapping. In denser crestal cortical bone, the coronal 2–4 mm may be expanded with a pilot drill so that the diameter of this part of the osteotomy is 0.3 mm less than the implant diameter. This will prevent wobble on insertion, which will compromise the implant’s primary stability. Partially filling the osteotomy immediately in advance of placing the implant allows the implant to push additional bone into the sub sinus space, providing an additional cushioning and doming effect. As previously stated, the choice of graft material is not as important as adherence to technique and maintenance of membrane integrity. In fact, it has been shown that grafting is not necessary to achieve procedural success (Fermergård and Åstrand, 2008; Lai et al., 2008; Leblebiciglu et al., 2005; Nedir et al., 2006; Schleier et al., 2008; Schmidlin et al., 2008). The sole disadvantage of not using a graft material is the necessity to insert the osteotomes beyond the level of the sinus floor to directly elevate the membrane, although these reports do not suggest an elevated perforation rate when elevation is confined to 2.0–4.0 mm.

The initial stability of the implant and RSBH will determine whether a one-stage or two-stage surgery is performed. If an insertion torque of 30 Ncm is not achieved or the RSBH is 5 mm or less, the implants are submerged to prevent inadvertent early loading. If primary stability is not achieved, consider a wider implant, or the osteotomy site can be grafted, covered with a bioabsorbable membrane, and the implant placed in a delayed fashion. In the event of single-stage surgery, a precise adaptation of the wound margins to the implant healing cap is achieved, with tension-free, interrupted sutures. For submerged healing, a combination of horizontal mattress and interrupted sutures are used to maintain primary wound closure.

Postoperative radiograph

An immediate postsurgical radiograph will demonstrate a variable topography and visibility of the graft material. This has been described by means of three parameters (Diserens et al., 2005): (i) no graft material visible; (ii) graft material visible on one or two sides of the implant; and (iii) graft material visible all around the apex of the implant. Nonvisibility or very weak visibility of the grafted material is mostly noted if implants are placed without graft, PRF, or autogenous bone chips, whereas bovine bone mineral (Bio-Oss®, Geistlich Pharma AG, Wolhusen, Switzerland) fill can always be detected. A successful elevation using a radiopaque graft material will appear rounded and uniform in density. When

Fig. 16.24 A 4 × 11-mm implant placed with OMSFE using only PRF as the grafting material. Note the localized inflammatory response in the membrane to elevation.

Fig. 16.25 At site #14, Bio-Oss collagen fills the 4.0-mm-wide, 5-mm-deep osteotomy.

Fig. 16.26 The bone graft has been apically displaced with a 4.0-mm osteotome to the working depth of 4 mm. For each grafted column of bone, 1 mm of SFE will be achieved.
Implant site development

matizing the surgical site. Removable prostheses are relined and replaced 2–3 weeks postoperatively. Sutures are removed 8–15 days after surgery. Implants are allowed to heal for a minimum of 3 months prior to second-stage surgery. Healing abutments are placed if this additional surgery is required, and the implants are restored 2–4 weeks later.

**CCE operative protocol**

**Preoperation and incision**

The preoperative protocol is identical to that used for patients undergoing OMSFE with simultaneous implant placement except that these patients receive a preoperative dose of 8 mg dexamethasone sulfate, which is tapered to 4 mg the following 2 days and to 2 mg on the third day. 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 or 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 of those patients where autogenous bone will be obtained. A surgical guide and 2-mm round drill may be used to locate the center of the crestal core at the site of future implant placement. Core diameter is based on RRW. Ideally, there should be 1.0–1.5 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. For example, if the RRW is 9 mm, a 5-mm core could be prepared with a trephine that has a 5-mm internal diameter but a 6-mm external diameter, leaving 1.5 mm of facial and palatal bone (Fig. 16.29). Core prepa-
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Sonick—Implant Site Development

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Implant site development

with polytetrafluoroethylene (PTFE) monofilament suture (Osteogenics Biomedical Inc., Lubbock, TX) to stabilize the membrane and approximate the wound edges (Fig. 16.41). Interrupted PTFE sutures complete the closure. 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 10–14 days later. An
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Fig. 16.37 A collagen sponge is impregnated with recombinant platelet-derived growth factor (rhPDGF-BB) to be placed into the core osteotomies.

Fig. 16.38 The impregnated sponge in the osteotomies will be apically displaced to the working depth in advance of the grafting material.

Fig. 16.39 A combination of mineralized freeze-dried bone and autogenous bone added to the osteotomies to achieve 1–3 mm of additional SFE.

Fig. 16.40 The core preparations and graft materials are covered by a slowly resorbing collagen membrane (Ossix-Plus).

Fig. 16.41 Primary soft tissue closure is initiated with a horizontal mattress PTFE monofilament suture (Osteogenics Inc.) to stabilize the membrane and approximate the wound edges.

immediate postoperative radiograph is taken to confirm graft containment and to determine the extent of SFE (Fig. 16.42). Postoperative care consists of an antibiotic (amoxicillin 500 mg three times daily for 7 days), a decongestant (pseudoephedrine 120 mg two times daily for 3 days), and rinsing with 0.12% chlorhexidine mouthwash twice daily until the patient returns 10 days 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. A healing period of 4–6 months is necessary at CCE sites to allow vascularization and incorporation of the grafts along with formation of new bone (Figs. 16.43–16.46). 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 2-mm 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 (1 mm less than the implant diameter) at a depth of 5–6 mm then osteotomes are used to further consolidate the bone apically. They may also provide for additional sinus elevation, if
Fig. 16.42 The immediate postoperative radiograph clearly demonstrates the controlled apical core displacement and SFE of 4–6 mm at sites #14 and #15. (a) Completely healed ridge 5 months after CCE sites #14 and #15. (b and c) Placement of 5-mm-diameter implants at sites #14 and #15. (d) Immediate postoperative radiograph of the $5 \times 9$-mm implant at site #14 and the $5 \times 11$-mm implant at site #15.

Fig. 16.43 At site #3, there is 3–4 mm of RSBH and a mild to moderate degree of vertical ridge resorption (VRR).

Fig. 16.44 A 6-mm core has been intruded to a depth of 4 mm.
Sinus elevation: Osteotome-mediated approach

Complications: OMSFE for simultaneous implant placement

Lack of Primary Stability

In areas of limited subantral bone, primary stability of the implant is clearly critical to implant success as the added graft material used to displace the sinus floor does little to improve initial implant fixation. A clear association exists between a minimum RSBH of 5 mm and implant success in OMSFE and simultaneous implant placement (Cavicchia et al., 2001; Nkenke et al., 2002; Rosen et al., 1999; Toffler, 2004a). This may be a function of reduced stabilization at insertion as implant placement in an RSBH of less than 4 mm is associated with reduced primary stability (Hirsch and Ericsson, 1991; ten Bruggenkate and van der Bergh, 1998). In areas of minimal RSBH, any inadvertent surgical trauma or widening of the osteotomy will have a much greater effect than when the implants are placed in a greater volume of bone (Fugazzotto, 2003). The author traditionally underprepares the osteotomy by 0.5–1.2 mm based on the thickness of the remaining cortical bone, localized bone density, as well as the RSBH. Failure to achieve a nonrotational stability may increase risk for failure, and delayed placement should be considered is such cases or one may consider the placement of a wider diameter implant if there is sufficient RRW. In the author’s clinical practice, implants that do not achieve an insertion torque of at least 30 Ncm or are placed in 5 mm or less of RSBH are allowed to heal in a two-stage protocol to protect them from inadvertent early loading.

Perforation of the Schneiderian membrane

The incidence of perforation during OMSFE and simultaneous implant placement has been reported between 0% and 25% (Berengo et al., 2004; Ferrigno et al., 2006; Leblebicioglu et al., 2005; Reiser et al., 2001; Schleier et al., 2008; Tilotta et al., 2008; Toffler, 2004a; Vitkov et al., 2005), although some tears (in vivo studies) may not...
have been detected due to limited visualization and the unreliability of the Valsalva maneuver or nose-blow test. It is therefore recommended during OMSFE that membrane integrity be tested with not only a Valsalva maneuver but also with direct inspection and blunt probing. Membrane lacerations during OMSFE can be attributed to the presence of a thin sinus membrane, sinus septa, aggressive use of osteotomes, drills, or trephines, or hasty addition of large increments of grafting material. OMSFE can be effective in the presence of transversal bony septa (Figs. 16.48 and 16.49) or in proximity to the lateral nasal wall, but the risk of membrane laceration is elevated (Reiser et al., 2001) (Figs. 16.50 and 16.51). The incidence of sinus septa has been reported at 24–41%, with high variability in size and location (Ulm et al., 1995; Velásquez-Plata et al., 2002).

The inexperienced clinician may have difficulty controlling the depth of osteotome insertion, creating a high risk of sudden membrane puncture and penetration into the sinus cavity with the instrument. Stops may be attached directly to the osteotome to limit the extent of apical displacement (Fig. 16.15). Although there are reports of successful OMSFE inserting osteotomes well beyond the level of the sinus floor (Deporter et al., 2000; Kang, 2008; Schleier et al., 2008), this must be done in a very controlled, progressive manner to counteract the elevated risk of membrane perforation.

It has been hypothesized that in cases where the elastic properties of the sinus membrane allow only for a restricted pattern of membrane elevation, perforations...
are more likely to occur, especially when membrane lifting exceeds certain limits (Berengo et al., 2004). Microlacerations (≤2 mm) during OMSFE are likely to be clinically inconsequential in the short- and long-term postoperative periods (Aimetti et al., 2001; Baumann and Ewers, 1999; Berengo et al., 2004; Nkenke et al., 2002; Toffler, 2004a). Once a perforation has occurred, the addition of graft material will perpetuate the vertical pattern of augmentation at the implant apices and not allow a lateral distension circumferentially to the implant tips as membrane damage will hinder the sealing of the submembranous space and reduce the pressure applied to the sinus mucosa (Berengo et al., 2004).

Early postoperative indications of a tear can include epistaxis, exfoliation of graft particles out of the nose, and the development of sinusitis. A small tear in the sinus membrane can lead to sinus invasion of oral microorganisms and a direct communication between the graft material and the contaminated sinus cavity. Displacement of graft material through the sinus membrane is a great concern, as it can lead to transient or chronic sinusitis in 10–20% of sinus elevation cases, prompting the need for additional treatment (Block and Kent, 1997; Doud Galli et al., 2001; Tidwell et al., 1992). Dislocated bone chips may initiate local inflammation and subsequent severe absorption of the bone graft (Raghoebar et al., 1999). Due to the limited drainage from the sinus cavity, even small amounts of foreign material in the sinus cavity may cause inflammation and sinusitis (Kahnberg and Vannas-Löfqvist, 2008). Postoperative sinus infection, even if treated early with antibiotics and saline rinsing, can potentially destroy the graft material and jeopardize implant success. This would make a clear argument for avoiding placement of graft materials at OMSFE sites where a perforation is confirmed or suspected as there is no way to verify membrane integrity once the graft material has been added. In the author’s clinical practice, if a perforation is detected through direct vision, Valsalva maneuver, or probing (Figs. 16.52 and 16.53), no graft material is added, and a collagen sponge impregnated with platelet-derived growth factor (rhPDGF-BB, Gem 21), or more recently, a PRF membrane, is introduced into the osteotomy and gently advanced apically. The infused collagen sponge is not easily displaced and may act as a barrier between the sinus and the implant site (Cavicchia et al., 2001). Alternatively, it is possible that the insertion of PRF could facilitate membrane repair (Choi et al., 2006). At the perforated OMSFE site, implant length should be no longer than 2–3 mm more than the original RSBH (Fig. 16.54). If this does not allow for the placement of an implant at least 8–9 mm in length, the site is abandoned, and implant placement is delayed for 3 months. This perforation protocol would seem justified in light of the fact that in the majority of cases, small rifts of the Schneiderian membrane will not disturb the healing process (Fermergård et al., 2008) and protrusion of an implant 2–3 mm into the sinus without grafting material does not adversely affect apical bone formation or implant success (Boyne, 1993; Jung et al., 2006; Nedir et al., 2004; Rohrer et al., 1995; Schmidlin et al., 2008).

**Nasal bleeding**

The incidence of membrane perforation has been previously discussed and may play a role in postoperative...
nasal bleeding. If postoperative nasal bleeding occurs, advise the patient to sit up straight and pinch the nostrils together with the thumb and index finger for 10 minutes. Once the bleeding has stopped, try to prevent any further irritation to the nose, such as sneezing, nose blowing, or straining for 24 hours. More persistent, uncontrolled bleeding should be managed medically using packing or cauterization.

It has also been suggested that during the healing phase, the increased vascularity in the area of the maturing graft may cause seeping of the pooled blood into the ostium of the maxillary sinus and out through the nose (Katranji et al., 2008).

**Displacement of implant into sinus**

The risk for implant displacement is elevated at sites with a membrane perforation and poor primary stability. Aggressive insertion, especially with press-fit implants (Fig. 16.55), or firm pressure from an overlying prosthesis may displace the implant into the sinus cavity. The implant must then be retrieved using the Caldwell–Luc technique or through endoscopy. Although both treatments have proven to be effective, certainly endoscopic removal would result in less postsurgical morbidity (Nakamura et al., 2004).

**Conclusion**

The BAOSFE technique (Summers, 1994c) and its reported modifications (Cavicchia et al., 2001; Davarpanah et al., 2001; Fugazzotto, 2002; Toffler, 2004a) represent substantially less invasive and less costly alternatives for predictable implant installation in moderately deficient posterior maxilla with 5–7 mm of RSBH. For maxillary sites with adequate ridge width and only 3–5 mm of RSBH, modifications to Summers’s original future site development (FSD) procedure (Summers, 1995) reported by Fugazzotto (2001) and Toffler (2001, 2002) are less traumatic and less costly alternatives to LWO. In the severely deficient posterior maxilla, with less than 3 mm of RSBH, crestal procedures become more challenging, time-consuming, and less predictable. At these sites, an LWO would remain the best method to achieve adequate SFE for future implant placement. One must also consider the recently reported success with short implants with a variety of roughened surfaces (Domingues das Neves et al., 2006; Fugazzotto, 2008; Griffin and Cheung, 2004; Nedir et al., 2004; Renouard and Nisand, 2005) and how they may alter the RSBH requirements as well as minimize the extent of SFE. The long-term success of short implants in the posterior maxilla will be dependent on preservation of the remaining bone in the crestal cortical passage, as well as an improved bone-to-implant contact in the residual subantral bone, which allows the implant to successfully function with a significantly increased C/I ratio (Toffler, 2006). OMSFE procedures will be at the forefront of a dedicated movement toward less invasive and more affordable implant-supported rehabilitation of the posterior maxilla. The incorporation of shorter implants, as well as easily obtained patient-derived growth factors such as PRF, can beautifully compliment OMSFE, shortening treatment...
time, expanding the indications, and broadening the appeal of this minimally invasive approach to treating the atrophic posterior maxilla.

References


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