

CLINICAL USES OF OSTEOTOMES

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KEY WORDS

Bone compression
Bone density
Cortical floor elevation
Osteotomes
Ridge expansion
Trabecular compaction

Osteotomes can offer several significant advantages over the traditional graded series of drills. Osteotomes take advantage of the fact that bone is visco-elastic and can be compressed and manipulated. Compression creates a denser area for implant placement. Heat is a major detriment to osseointegration, but the osteotome technique does not generate heat. This technique also allows for greater tactile sensitivity. Three procedures are used: compaction, cortical floor elevation, and ridge expansion; these can be combined to facilitate implantation. If the practitioner recognized the properties of bone and understands how bone responds to manipulation, the techniques described here can aid in the preparation for the placement of dental implants with greater success.

INTRODUCTION

The word osteotome is derived from the Latin words "osteo," meaning bone, and "tome," to incise or cut. In the field of implant dentistry, Dr Hilt Tatum coined the word in the early 1970s to describe a special set of hand instruments developed to form or shape bone in preparation for the placement of dental implants (Fig 1).^{1,2}

In certain clinical situations, osteotomes offer several significant advantages over the traditional graded series of drills. Drilling removes bone. When adequate quantities of dense bone are available, this is not a problem. But when the alveolar bone is soft or when the ridge has resorbed enough to compromise implant placement, the ability to preserve existing bone, improve its quality, and manipulate its shape becomes desirable. Osteotomes take advantage of the fact that bone is visco-elastic; it can often be compressed and manipulated. Pushed rather than drilled into soft bone, osteotomes com-

press the bone laterally and thus create a denser interface for the implant to be placed. The osteotome technique also generates no heat, an advantage because heat is a major detriment to osseointegration. In the posterior maxilla, osteotomes offer much more visibility than do a rotating drill and irrigation stream. Furthermore, osteotomes allow for greater tactile sensitivity, making them more appropriate than drills for probing.³

The osteotome procedure is indicated in three general situations.⁴ (1) Where the bone at the implant site is soft and trabecular. Osteotomes change the density of the bone around the osteotomy site. Figure 2 is a color visoradiography x-ray showing osteotome in the compacting bone. Osteotomes expand the ridge buccolingually in a less invasive manner than traditional bone-spreading techniques. (2) Where the ridge is too narrow to adequately accommodate an implant.⁵ Osteotomes expand the ridge buccolingually in a less invasive manner than traditional

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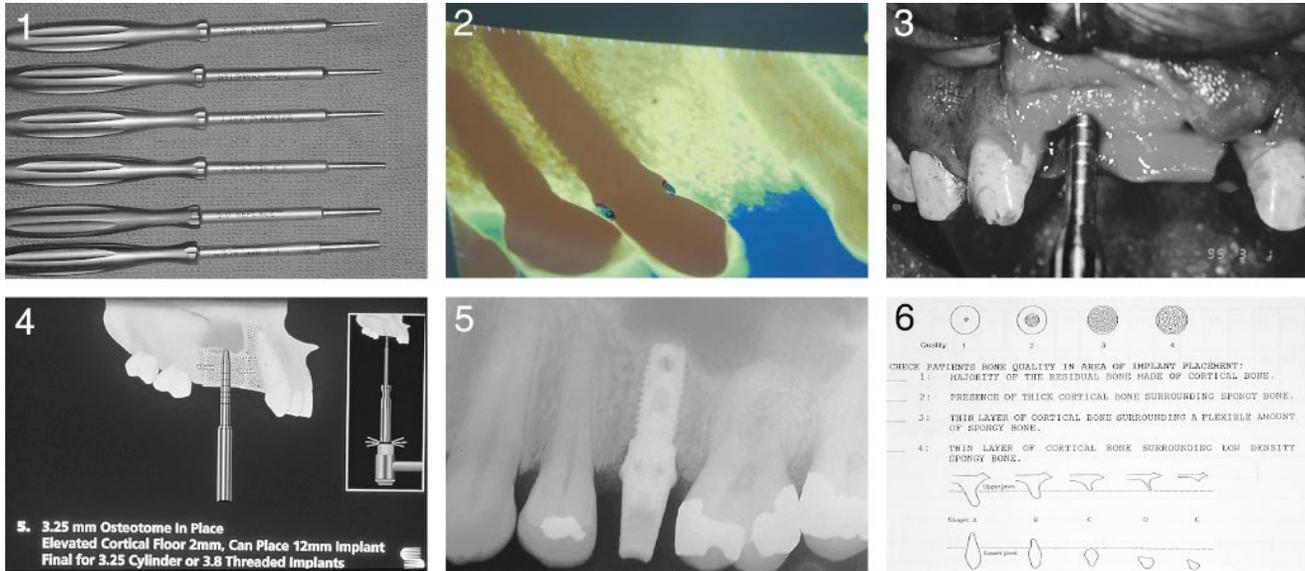


FIGURE 1. Osteotomes graduating from 2 mm diameter to 6 mm diameter (Steri-Oss Replace, Yorba Linda, Calif). FIGURE 2. Color visio-radiograph of two 4.3-mm-diameter, 16-mm-length root form implants in bone where the osteotomy was prepared with osteotomes. The brown color of the bone surrounding the implant indicates compaction and density. FIGURE 3. A 2.7-mm osteotome malleted into place, expanding the width of the bone. FIGURE 4. A 3.25-osteotome placed against the cortical maxillary sinus floor and then malleted into the infracture antral floor. FIGURE 5. Radiograph of 12-mm-diameter hydroxyapatite-coated threaded implant showing bone remodeling over the apex. FIGURE 6. Bone quality description.

bone-spreading techniques. Figures 3 and 4 show before and after tomograms of implants placed in central incisors. (3) When there is less than 10 mm of bone between the maxillary crest and the sinus. In such instances, osteotomes can be utilized to elevate the nasosinus cortical floor, typically by 1–3 mm. This elevation can enable placement of a longer implant than would otherwise be usable.^{6,7} Figure 5 is a radiograph of an implant placed after the floor has been infractured.

Manipulation of bone with osteotomes requires the practitioner to be acutely aware of bone quality. The Branemark classification system is an aid in this. According to that schema, bone falls into one of four categories, with Type I the densest and Type IV the least dense. Type 1 bone generally consists entirely of cortical bone. It is often described as having the consistency of oak or marble. Type II bone consists of 2.5–4 mm of cortical bone underlain by dense trabecular bone. Its consistency has been compared to plywood. Type III, reminiscent of soft pine, consists of 1.5–2 mm of cortical bone encasing

spongy trabecular bone. Figure 4 graphically illustrates bone quality. Type IV bone has 1 mm or less of cortical bone over sparse trabecular bone. It resembles balsa wood or Styrofoam.

Type I bone is too dense for ready manipulation, hence osteotomes are not indicated for use in it. If bone expansion is desirable, sites containing Type II through Type IV bone may be candidates. Types III and IV are best suited for trabecular compaction. In the maxilla, the author has utilized osteotomes as far posterior as the mesial aspect of the second molar. In the anterior mandible, osteotomes are most often used from the second premolar to the opposite second premolar.

Bone density may be assessed before surgery by the use of computerized tomography (CT) scans, site-selected cross-sectional tomograms, radio visography, and lateral cephalometric radiographs. In general, practitioners can assume that the bone in atrophic areas will be very dense.

Clinical determination of bone density is best diagnosed when the surgeon penetrates the bone with a pilot

bur or a 1.5-mm twist drill. The degree of resistance of the bone to the entering drill can transmit to the surgeon an indication of the bone type. If the bone is extremely resistant to the entrance of the drill and a dense white bone coagulum collects on the drill flutes, then the operator can conclude that clinical Type I bone is present, and osteotome use is not indicated. The less the resistance, the more indication there is for consideration of the use of osteotomes to compact the bone.

CLINICAL PROCEDURES

Bone compaction

With osteotomes, Type IV bone can be changed into Type III or Type II bone. Type III bone can generally be compacted to resemble Type II. The following steps are involved when condensing bone with the osteotome technique. After appropriate sedation, an incision is made from the tuberosity mesial to the distal of the most anterior tooth on the crest of the ridge.³ From that point, an oblique, mesially inclined incision is

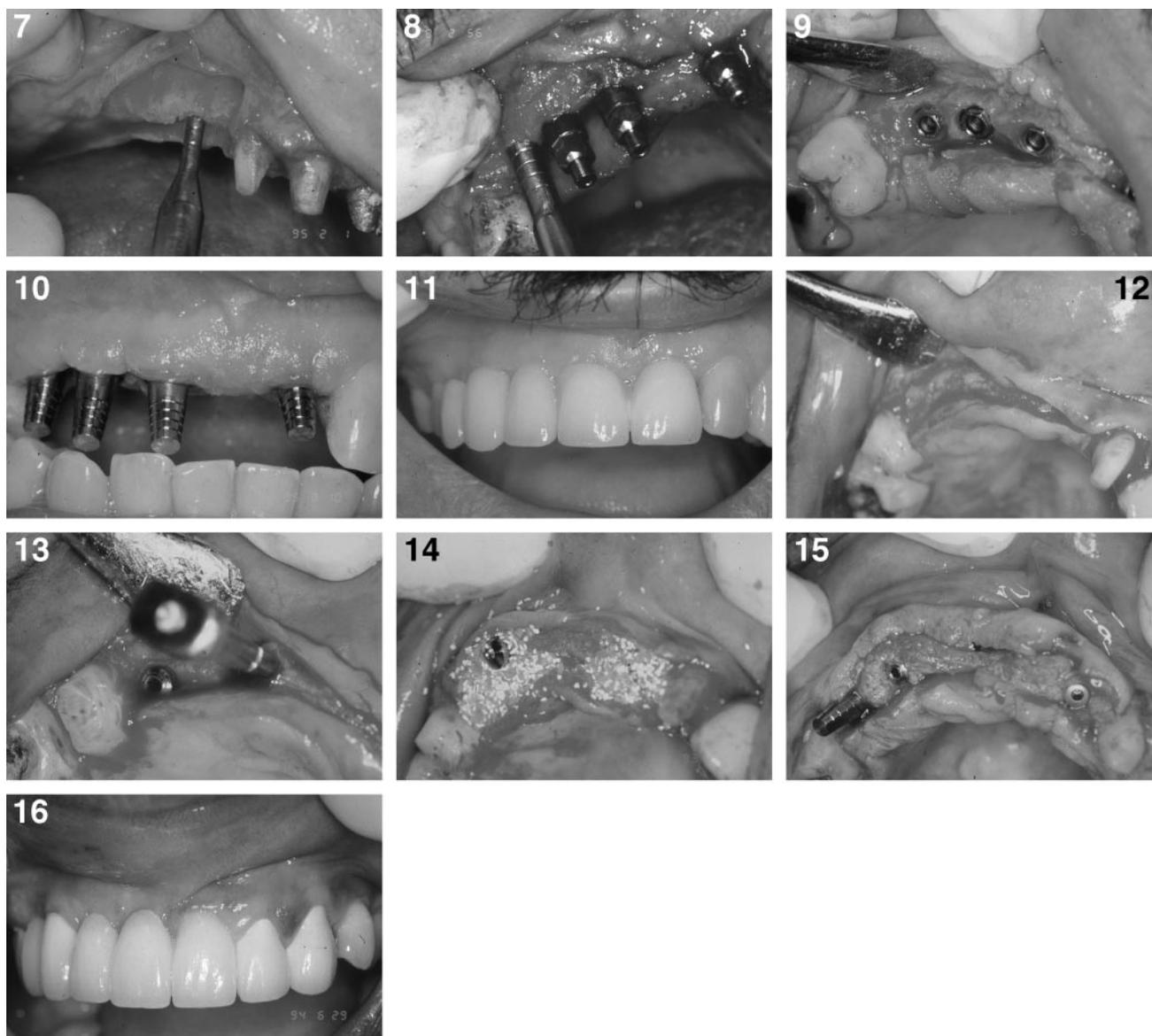


FIGURE 7. A 2-mm-diameter osteotome in position. FIGURE 8. A 3.25-mm-diameter osteotome compacting Type III bone and 3.8-mm-diameter hydroxyapatite threading implants in place before fixture mount removal. FIGURE 9. Implants that were placed by osteotome compaction techniques uncovering at 7 months. FIGURE 10. Implant with abutment before preparation for fixed crowns. FIGURE 11. Finished crowns in place at a 3-year follow-up. FIGURE 12. Crestal bone exposed for ridge expansion with osteotomes. Notice minimum reflection leaving periosteum on buccal and lingual aspect. FIGURE 13. Osteotome malleted into place gradually expanding the buccal and lingual plates of bone. FIGURE 14. Implants in place covered with grafting material; Osteograph/N (Ceramed Corp) and freeze-dried demineralized bone (Pacific Coast Tissue Bank). FIGURE 15. Expanded ridge with implants uncovered 8 month after insertion. Note new bone formation surrounding the three implants. FIGURE 16. Final fixed prosthesis at 2-year follow-up.

made in an apical direction for the purpose of flap relief.

A surgical template is utilized to indicate the desired implant position. With the template in place, a no. 8 round slow-speed bur is used to penetrate the cortical crestal bone only deep enough to mark the implant position. After the position has been

marked, the surgical template is removed, and with a periosteal elevator, the buccal and lingual soft tissue flaps are reflected to expose the crest of the bone only deep enough to mark the implant position. A 1.5-mm twist drill in a slow-speed, high-torque hand-piece is now placed in the dimple created by the no. 8 round bur, and a pilot

hole is drilled in the predetermined direction to the desired depth. A periapical radiograph may be taken with the 1.5-mm pilot drill in the osteotomy to verify the osteotomy positioning. The degree of resistance encountered in this initial drilling procedure will enable the operator to confirm the density of the bone at the site. Bone in the

posterior maxilla is generally softer (Type III-IV) than that in the anterior maxilla and mandible (Type II). Assuming that the bone is Type III or Type IV, the tip of a 2.0-mm-diameter osteotome is pushed and rotated into the pilot hole (Fig 5). Although a number of osteotomy systems are available, the author prefers to use osteotomes that are rounded at the tip rather than blunt or convex. The tapered, round osteotomes appear to pass with less resistance in the bone, which is desirable because if the resistance increases as the osteotome is inserted apically, the buccal or lingual plate of bone may fracture. The less dense the bone, the more easily the osteotome will penetrate it. Depending on the density, gentle tapping with a mallet may be necessary to insert the osteotome to the proper depth.

The first osteotome is removed by a simultaneous pulling and rotating motion, and a 2.7-mm osteotome is pushed and/or tapped to depth, enlarging the osteotomy. If the bone is narrow and the operator encounters resistance while tapping the osteotome into place, he may choose at this point to place a 3.25-mm threaded implant, allowing it to self-thread. (A 3.25-mm threaded implant is actually 2.7 mm in diameter in the area between the threads.)

If the bone is wider, a 3.25-mm osteotome is inserted in the hole and used in the manner already described. The operator may then decide to self-thread a 3.8-mm-diameter implant (for which the intra-thread diameter is 3.25-mm). If the crestal cortical bone is dense, the operator may use a counter-bore to prepare the bone for the top or neck area of the implant.

With sufficient width and no substantial resistance, a 3.8-mm osteotome may be utilized to enlarge the osteotomy to receive a 4.5-mm or 5.0-mm threaded implant. Alternatively, a 3.8-mm cylindrical implant (which has a uniform 3.8-mm diameter along its length) may be considered. If the bone is extremely wide, a 5.0-mm osteotome

can be utilized in preparation for a 5.0-mm-diameter cylindrical or a 6.0-mm-diameter threaded implant.

Usually, the wider the bone in the posterior maxilla, the less dense it is. At times in Type IV bone, the operator may even choose to place a cylindrical implant that is wider than the final osteotome utilized. As it is tapped into place in an underprepared osteotomy, the cylindrical implant itself acts as an osteotome, compacting the surrounding bone still further.

In some osteotomy sites, the operator may encounter areas of increased bone density. This may occur in the cortical crestal area or in the apical portion of the osteotomy as the sinus cortical floor is approached. In such cases, the doctor may wish to combine the osteotome compaction technique with conventional handpiece drilling.

In cases where the bone is extremely soft, with very sparse trabeculation, grafting material may be placed into the osteotomy and osteotomes used like an amalgam plugger. This combination will aid in providing enough support to stabilize the implant at the time of placement (Fig 8).

Ridge expansion

The second indication for the use of osteotomes is when it becomes necessary to expand the buccolingual width of the ridge. Narrow ridges are common, and when the initial width is less than 4 mm, standard root-form implants cannot be accommodated. Other reasons for expanding the ridge include reducing maxillary undercuts, changing the emergence angulation, improving the chances of matching opposing landmarks, and expanding the buccal or labial bone for esthetic reasons.

Because bone is visco-elastic, the width of the alveolar ridge can also be increased by using osteotomes to create pressure between the buccal and lingual cortical plates in a slow, organized manner. A minimum initial width of 3.0 mm is recommended. When the ridge is narrower than 3.0 mm, better results will be obtained

with conventional techniques such as onlay autogenous grafts, particulate with membrane grafts, and ridge "splitting" (spreading the buccal/lingual plates of bone).

Preoperative oral or intravenous sedation should be considered when a bone expansion is to be performed. Denser trabecular bone is often encountered in narrow ridges because the buccal and lingual cortical walls exert compaction force. Therefore, more force must be applied to the osteotomes. This is accomplished with firmer malting. Such malting may cause the patient to be more apprehensive, but sedation helps to control or eliminate the apprehension. Local anesthetic also is administered on the buccal and lingual aspects of the entire areas to be expanded.

The procedure begins with the making of a midcrestal incision that is longer than the area to be manipulated. The soft tissue is reflected just enough to expose the buccolingual dimension of the crestal bone. However, the periosteum is left intact (Fig 9). Blood supply to the alveolar bone comes from two sources: nutrient canals in medullary bone and the periosteum. Penetration and compaction of the medullary bone with the osteotomes tends to obliterate the nutrient canals and destroy their function as a blood supply. Keeping the periosteum on the bone, however, maintains the blood supply to the buccal and lingual cortical plates. The intact periosteum helps to keep the fractured pieces in position. The periosteum has thus been described as acting like a guided tissue membrane.

Once the tissue has been reflected, a no. 8 round bur is used to penetrate the crestal cortical bone at the implant site. A 1.5-mm pilot or twist drill is then used to create an initial osteotomy to the desired depth and position.

A 2-mm osteotome is placed against the opening of the osteotomy, and a surgical mallet is used to give two firm taps to the end of the osteotome handle. The osteotome is then left in po-

sition for at least 8–10 seconds to enable the bone to relax and adjust to the slightly expanded ridge contours (Fig 10). The osteotome is then turned in a reverse direction and pulled out of the bone. Care should be taken not to force the osteotome in a buccal or lingual direction; otherwise a complete fracture of the plates may occur. This procedure is repeated until the osteotome is driving to the desired depth. Each time the osteotome is tapped with the mallet, the surgical assistant should place his or her thumb and index finger on both the buccal and lingual aspects of the ridge to brace the bone and help prevent fracturing.

The same procedure is repeated using a 2.7-mm-diameter osteotome. If the surgeon judges that further expansion cannot be performed, a 3.25-mm-diameter implant may now be placed. Because the bone is invariably dense (Type II, perhaps now compacted to Type I), a thread former should be used before placing the implant. If any microfracturing has occurred, care must be taken to avoid displacing the fractured pieces and to ensure that they remain on the periosteum. Alloplastic grafting material mixed with blood may be placed over the implant site to facilitate bone healing.

If the operator determines that further expansion can be accomplished, a 3.25-mm-diameter osteotome is slowly driven into place, utilizing the above-described technique. After the 3.25-mm-diameter osteotome has been seated at the desired depth and removed, the operator should visually inspect and manually feel for the presence of any loose fragments of buccal bone. If any fracturing has occurred, thread forming is not recommended, and a 3.25-mm cylindrical implant may be used and a 3.8-mm implant placed.

In the experience of the author, implants larger in diameter than 3.8 mm can rarely be used in conjunction with the ridge-expansion technique in Type II bone.

Once again, it is sometimes necessary to use conventional drilling in

combination with osteotome bone expansion, depending on what the operator encounters clinically. In any case, bone expansion with osteotomes must be done slowly and by practitioners experienced in dealing with bone reaction to surgical manipulation. Case I is represented in Figs 12–14 and Case II is represented in Figs 15–17.

Sinus floor elevation

The third major indication for using osteotomes is when alveolar bone in the posterior maxilla has resorbed so much that less than 10 mm remains between the crest of the ridge and the sinus floor. In such cases, studies have shown that when the maxillary cortical floor is fractured immediately prior to implant placement, an implant as much as 2–3 mm longer than the bone depth can be placed, and new bone will form around the apex. Longer implants that provide better load distribution and support can thus be employed. For example, a 12-mm-long implant can be placed in 10 mm of bone.

In this procedure, it is important that the Schneiderian membrane be left intact because the membrane provides a barrier similar to the guided-tissue membranes used in bone-grafting procedures. However, even when small perforations of the Schneiderian membrane have occurred, no postoperative complications have ensued in the author's experience.

The following is a description of the procedure utilized most commonly to fracture the nasal and sinus cortical floors in order to gain an additional 2–3 mm bone height.

The implant site is determined by the use of surgical guides, diagnostic wax models, or mounted study models. A no. 8 bur is used and drilling proceeds in an apical direction until the nasal or sinus floor is just touched. The depth may be verified by taking a periapical radiograph (Fig 18).

When the operator is satisfied that the sinus cortical floor has been reached, the designated step-by-step sizing drills or osteotomes are used to

create an osteotomy of the diameter necessary for the preselected implant. The quality of the bone should determine whether osteotomes or drills are used for this task. Before the implant is placed, however, the largest diameter osteotome that will fit into the prepared osteotomy is inserted to the point where the cortical floor begins. With the operator's thumb and forefinger resting on the crest of the ridge and holding the osteotome to stabilize it, the end of the osteotome is tapped with a mallet, just hard enough to fracture the sinus cortical floor. Care must be taken to prevent the osteotome from entering too deeply into the sinus cavity (Fig 19).

The osteotome is then removed. Because the resistance of the cortical floor has now been lessened, the implant can be inserted into the osteotomy and screwed or pushed beyond its apex (Fig 20).

Within 6–8 months, bone will reform around the implant apex, providing more stability and resistance to vertical loading.

After the sinus floor fracture and before implant placement, some practitioners have chosen to place grafting material (typically autogenous bone mixed with a resorbable hydroxyapatite) into the osteotomy. This material is then pushed apically as the implant is seated to its final position. However, in the author's experience, the use of such grafting material is unnecessary in most cases. Two objects cannot occupy the same space. Therefore, placing graft material and an implant into the sinus floor fracture area may exacerbate any tendency of the membrane to tear.

It is important to note that whenever an increase in the alveolar bone height of more than 3 mm is required, conventional procedures involving creation of a window in the lateral wall of the maxilla must be utilized. However, when an increase of between 1 mm and 3 mm is sought, using an osteotome to fracture the antral floor is sim-

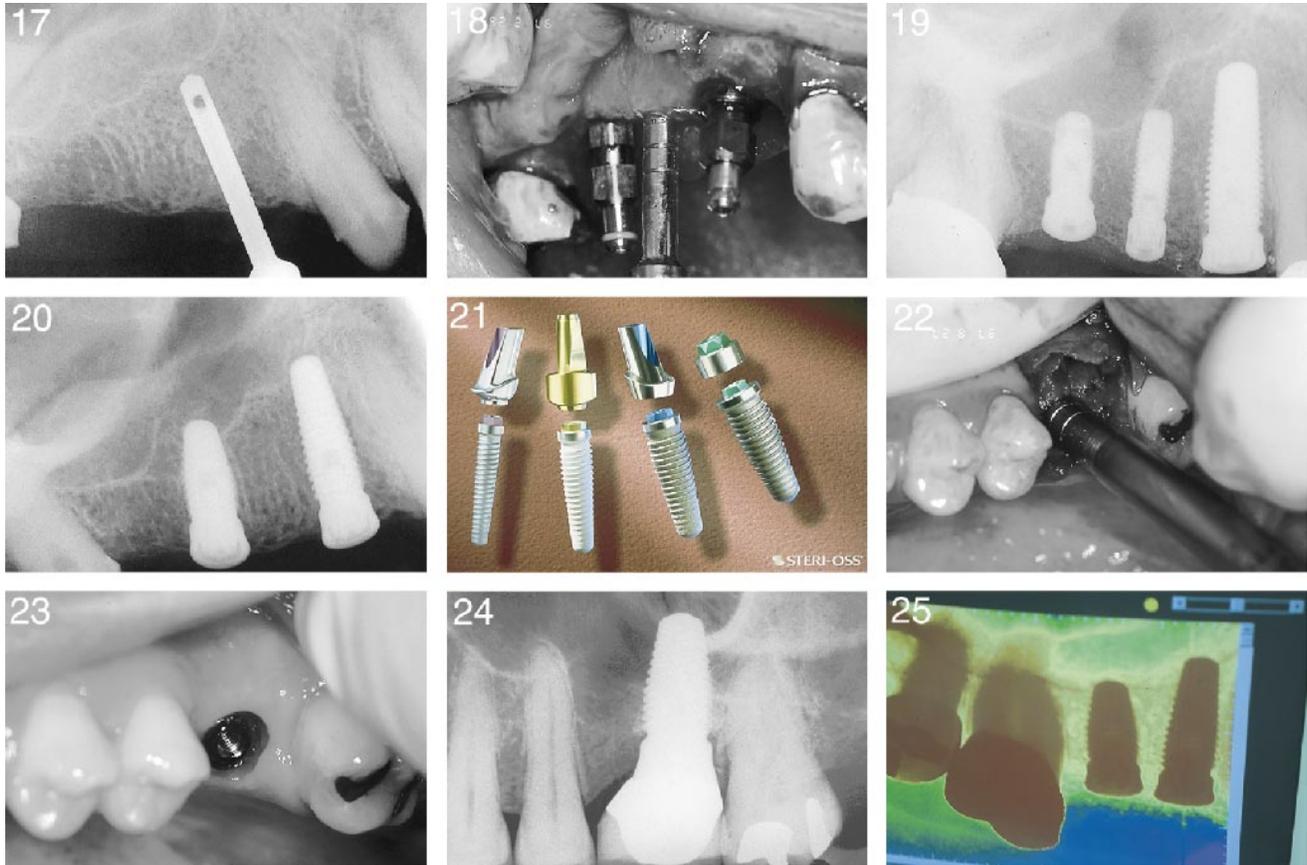


FIGURE 17. Radiograph of 2-mm pilot drill to antral floor. FIGURE 18. Osteotomes in place before malleting to infracture sinus cortical floor. Note 5-mm-diameter Replace implant anterior to osteotome and 6-mm-diameter Replace implant posterior to osteotome. FIGURE 19. Radiograph of implants in bone at 6 months postinsertion. Implant 1 was placed immediately postextraction. Implant 2 site was prepared with osteotomes (compaction). Implant 3 site was prepared by osteotome compaction and sinus floor infracture. FIGURE 20. Radiographs of implants showing bone remodeling at the apex. Note 4.3-mm-diameter Replace implants 16 mm and 13 mm in length. FIGURE 21. Replace implants by Steri-Oss (Yorba Linda, Calif): 6 mm tapering to 3.8 mm—green; 5 mm tapering to 3.25 mm—blue; 4.3 mm tapering to 2.7 mm—gold; 3.5 mm tapering to 2.4 mm—magenta. FIGURE 22. A 6-mm-diameter osteotome in palatal root socket after maxillary first molar extraction. FIGURE 23. A 6-mm-diameter Replace implant before abutment placement. FIGURE 24. Radiograph of immediately placed 6-mm-diameter, 16-mm-length implant where apex of palatal socket was elevated with 6-mm-diameter tapered osteotome. One year follow-up. FIGURE 25. Visio-radiograph of two 5-mm-diameter Replace implants. Osteotomes were utilized to prepare osteotomes.

pler and less invasive than the traditional sinus floor elevation technique.

Tapered osteotomes

The author helped to develop the Replace Tapered Implant System (Nobel-Biocare, Yorba Linda, Calif), introduced in March 1997. A special set of tapered osteotomes corresponds to this system. Replacement implants are offered in lengths of 10, 13, and 16 mm. Four diameters are available: a 3.5 mm tapering to 2.4 mm, a 4.3 mm tapering to 2.7 mm, a 5.0 mm tapering to 3.25 mm, and a 6.0 mm tapering to 3.8 mm. The tops of the implants are color coded with a titanium oxide, and the cor-

responding osteotomes have the same color (Fig 21). The technique for utilizing Replace osteotomes is the same as previously described.⁸

SUMMARY

The three procedures described in this article may be used in various combinations. Compaction can be combined with cortical floor elevation or with ridge expansion. Conventional drilling may be used in concert with osteotome compaction or ridge expansion. Any of the previously described techniques also can be combined with particulate grafting. For example, the surgeon may elect to use osteotomes

for ridge expansion, then place grafting material in the preparation, and place the implant only after the ridge has healed. Or the bone may be so soft in some sites that it may be necessary to add grafting material for increased trabeculation during compaction, then place implants after the site has healed.

All of these approaches require that the implant practitioner be able to recognize the properties of bone and understand how bone responds to manipulation. Practitioners who master these skills will find osteotomes to be a useful and necessary tool for enhancing long-term clinical success.

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