Improvements in the Crestal Osteotome Approach Have Decreased the Need for the Lateral Window Approach to Augment the Maxilla

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The use of the crestal approach to augment vertical height of the posterior maxilla for dental implant placement is reviewed in this article. The review of the literature documents the success of using a procedure that has minimal complications associated with it when performed correctly. An algorithmic approach is presented to guide surgeons on using the crestal osteotome approach for posterior maxillary augmentation.

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Bone availability is the key to successful placement of endosseous implants in the posterior maxilla. When the vertical height of the bone between the maxillary sinus and the alveolar crest is limited, increasing the bone height by grafting will provide support for implants and prosthetic restoration. The resultant graft must provide adequate viable bone to stabilize the implant initially and encourage osseointegration. Materials used for sinus floor grafting include autogenous bone, allogeneic bone, xenograft, and recombinant bone morphogenetic protein.[1-4]

The amount of bone available on the alveolar crest dictates the method and material chosen for vertical augmentation in the posterior maxilla. The consensus conference sponsored by the Academy of Osseointegration[5] and other studies indicate that xenografts used by themselves or combined with autogenous bone worked as well as autogenous bone alone.[3] This finding supports using fewer autogenous bone grafts and more xenografts to form bone within the sinus to support dental implants. The lateral window approach has been used to place the graft for vertical bone augmentation. However, this procedure may be technically challenging in specific cases, and postoperative complications, when they occur, are quite morbid for the patient.[5]

The crestal osteotome method can be used to place maxillary implants and to increase vertical bone thickness. The main concerns with the lateral window approach are perforations in the membrane, graft migration, sinusitis postoperatively, and in general, patient morbidity.[6] The crestal osteotome method avoids extensive membrane manipulation and may have a lower rate of complications.[7]

Preoperative Radiographic Screening to Choose Method

The preoperative radiographic examination begins with a cone-beam scan. The clarity of the maxillary sinus, the presence of septa in the proposed surgical site, and an approximation of the thickness of the alveolar bone are documented. Patients may have wide aerated sinuses or narrow sinus cavities. A site with a concave shape with surrounding walls creates a well-defined space for an anatomically positioned graft. Cross-sectional images are used to document ridge width, height, and morphology of the sinus floor.

Anatomic Considerations of Materials and Methods for Sinus Augmentation

BONE THICKNESS

Bone thickness will affect the choice of method used to increase bone thickness in the posterior

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maxilla. Development of a lateral window with elevation of the sinus membrane along the floor and medial wall is used when the bone is thin. Sinus floor elevation through the alveolar crest is a method that is used when the bone is not severely atrophic.[8]

In my practice, if the vertical bone thickness is 6 mm or greater, then the sinus floor is usually elevated from the crestal approach, through the implant preparation site, with placement of an implant 3 to 4 mm taller than the height of the residual bone. If the bone thickness is 6 mm, then a 9- to 11-mm-tall implant is used. If the floor thickness is 8 mm, then an 11- to 12-mm-tall implant is chosen. If the vertical alveolar height is less than 6 mm, the crestal osteotome method is used to increase the thickness of a thin ridge of 4 to 6 mm. After 4 months, a second crestal approach can be used on the resultant thickened ridge with simultaneous implant placement. This eliminates the need for a lateral window approach. A lateral window approach is chosen when the sinus is relatively flat without a well-confined space for the crestal elevation to hold the graft.[8]

When removing a posterior maxillary tooth that has lost bone from caries or fracture, there is often minimal bone present from furcation to the sinus. Alveolar bone height can be increased by using intra-socket osteotomies to elevate bone in the furcation into the sinus, effectively elevating the floor 5 to 7 mm.[9,10] This method is used when there is less than 7 mm of residual bone available at the time of tooth removal. Implants are placed after the bone has formed within the extraction socket. If needed, additional bone height can be developed by osteotome methods through the implant site, which avoids a lateral window approach.

PRESENCE OF TOOTH ROOTS ALONG SINUS FLOOR OR SEPTI

Sinus membrane elevation through a lateral window has the potential complication of membrane perforation. The cone-beam scan allows the surgeon to see the intimate relationship of the tooth roots to the sinus floor. Often, these teeth are removed and the sockets are grafted before the sinus augmentation because of infection. The question is, How long should the surgeon wait before elevation of the sinus membrane for augmentation? The membrane may be difficult to elevate in areas of adhesions at the previous root site, which also may have bone irregularities around it. These sites are often potential perforation locations. For this reason, the crestal osteotome technique may be chosen.

Material Considerations

XENOGRAFT PARTICLES

Deproteinized bovine bone is an anorganic, pathogen-free bovine bone. It is a carbonate-containing apatite with few hydroxyl groups. Methods of preparation vary depending on manufacturer.[11,12] In general, pathogen-free young cows are used to obtain long bones. The bones are cut into small pieces and washed with delipidizing agents to remove organic materials. Different agents are used, with different times for soaking and washing, varying according to manufacturer.[11-13] After the organic material is removed, the bone is particulated and sieved to size. It is heated to further remove organic material and to increase crystallinity. An increase in osteoconductivity was shown when comparing 600°F with 1,000°F, with the lower sintering temperature resulting in bone that was more osteoconductive than bone sintered at the higher temperature.[13] Higher temperatures will increase crystallinity. Resorption of xenografts is a slow process that may or may not be clinically observed. In a xenograft composed of cancellous particles with increased porosity, the particles can compact over time.

ALLOGRAFT PARTICLES

Human mineralized bone particles have been used for extraction-site healing. This material is osteoconductive but does not maintain thickness when used as an onlay. The bone has the same crystallinity as autogenous bone because it is typically washed and freeze dried without a sintering process.[14]

Crestal Osteotome Approach for Sinus Elevation

CRESTAL APPROACH WITH NO GRAFT PLACEMENT

Elevation of the sinus membrane without graft placement from a lateral window or crestal approach has been shown to result in bone formation between the elevated membrane and intact floor of the sinus. Maintenance of the space created after membrane elevation may be important for bone formation to occur.[15-20] The decision to use an osteotome method via the crestal approach allows elevation of the membrane with or without graft placement, which can result in adequate bone function for long-term implant success.[7]

Six studies reported bone gains ranging from 1.8 to 5.7 mm using a crestal approach with no graft placement.[16,17,19-22] Deviations in reporting and data collection prevent a meaningful statistical analysis other than noting the consistency of results.

CRESTAL APPROACH WITH GRAFT PLACEMENT

There are studies that evaluated augmentation of the ridge using allograft and xenograft, with "bone" gains ranging from 3.5 to 6.0 mm.[18,23,24] These

studies confirm that placing a material to maintain space will result in bone gain.

The bone gain from using the osteotome technique from the crestal approach ranges from 4 to 6 mm, with or without grafting.[16,17,19-26] Different grafting materials did not seem to affect implant success rates.[7,24] In a series of over 120 patients who were treated with the crestal approach, there were no differences reported comparing the use of allograft or autograft.[7] In general, a narrow sinus will result in more predictable bone augmentation with the crestal approach compared with a wide sinus.[27] A study comparing radiofrequency values for different approaches and timing did not review differences in implant stability after bone had formed.[28] The data comparing the lateral window and crestal approaches using no graft or different graft materials in one study are not available. Therefore, a thorough review of publications is useful to show consistencies in the reports.

What is the reported success rate when using the crestal osteotome approach to place implants? When there is greater than 5 mm of bone, the success rate for implants placed immediately using the crestal approach without a graft ranges from 86 to 98%.[7,21-25,29] The success rates comparing the placement of implants by the crestal approach with the osteotome technique versus conventional placement using a 2-step lateral window were similar.[23,28]

When there was less than 5 mm of bone before the crestal approach, the range of implant success varied.[7,26] The success rate when using the osteotome technique was shown to be improved when there was initial bone thickness of greater than 5 mm, as compared with more deficient ridges, which underwent the technique with grafting and immediate implant placement.[7] As an alternative or in cases in which less than 8 mm was formed, the use of shorter implants did result in favorable clinical outcomes but long-term follow-up was not reported.[26]

On the basis of the published reports and the consistency of the bone gain and implant success rates, the following sections describe a suggested algorithm that may clarify how to choose when to use a crestal osteotome approach.

BONE HEIGHT OF 9 MM OR GREATER

Implants can be placed without a graft. On the basis of clinician preference, the floor can be elevated during the implant preparation process to place longer implants.[30-32]

BONE HEIGHT OF 5 MM OR GREATER

Because the long-term evidence is not conclusive with the use of implants 4 to 6 mm tall, in the posterior maxilla, clinicians may choose to place implants 9 mm or longer. When the cone-beam cross section shows 5 to 8 mm of vertical height, the sinus floor can be elevated during the implant preparation process, with simultaneous implant placement.[7,21-23,29] There is evidence that sinus membrane elevation with no graft material placed may result in bone formation between the membrane and sinus floor.[17-20]

BONE HEIGHT OF 3 TO 5 MM

In this situation a clinical decision is made to use a crestal or lateral window approach based on the difficulty of raising the sinus membrane without perforation. If a molar tooth recently had been removed with its root tips within the sinus, the membrane may be difficult to elevate because it may be adherent to the prior root tip site. If there are septi present or remnants from a mucocele or other sinus pathology, the membrane may be difficult to elevate.

A lateral window approach has a greater evidence base than the crestal approach for bone of this crestal bone height.[5,33-36] If the lateral window approach is used, the resultant bone height for implant placement may exceed 11 mm on a predictable basis. If the crestal approach is used in this clinical scenario, the resultant 6 to 9 mm of bone height may require a second crestal elevation at the time of implant placement.

BONE HEIGHT OF 2 MM OR LESS

In this clinical situation, the lateral window approach is usually chosen, although the crestal approach may be viable as evidence becomes available.

Surgical Technique for Crestal Approach for Sinus Elevation

In an edentulous site in the posterior maxilla, the following technique can be used for a bone thickness of 3 mm or greater (Figs 1, 2). A cross-sectional image from the cone-beam scan is used to measure the distance from the crest to the sinus floor. Local anesthesia is administered, and an incision is made slightly palatal to the crest, with vertical release incisions. The reflection identifies the buccal and palatal edges of the crest. A round bur is used to mark the initial preparation of the crest. Increasing-diameter drills that have stops on them control the depth of the preparation. The drill length is chosen to be 1 mm less than the measured thickness of the maxillary crest. The diameters of the drills, with the stops in place, increase until the desired final preparation site diameter is reached. A small amount of graft material is placed into the preparation site. A flat-surfaced osteotome is used to fracture the floor of the sinus. The osteotome can be taken to the desired elevation gently and slowly or

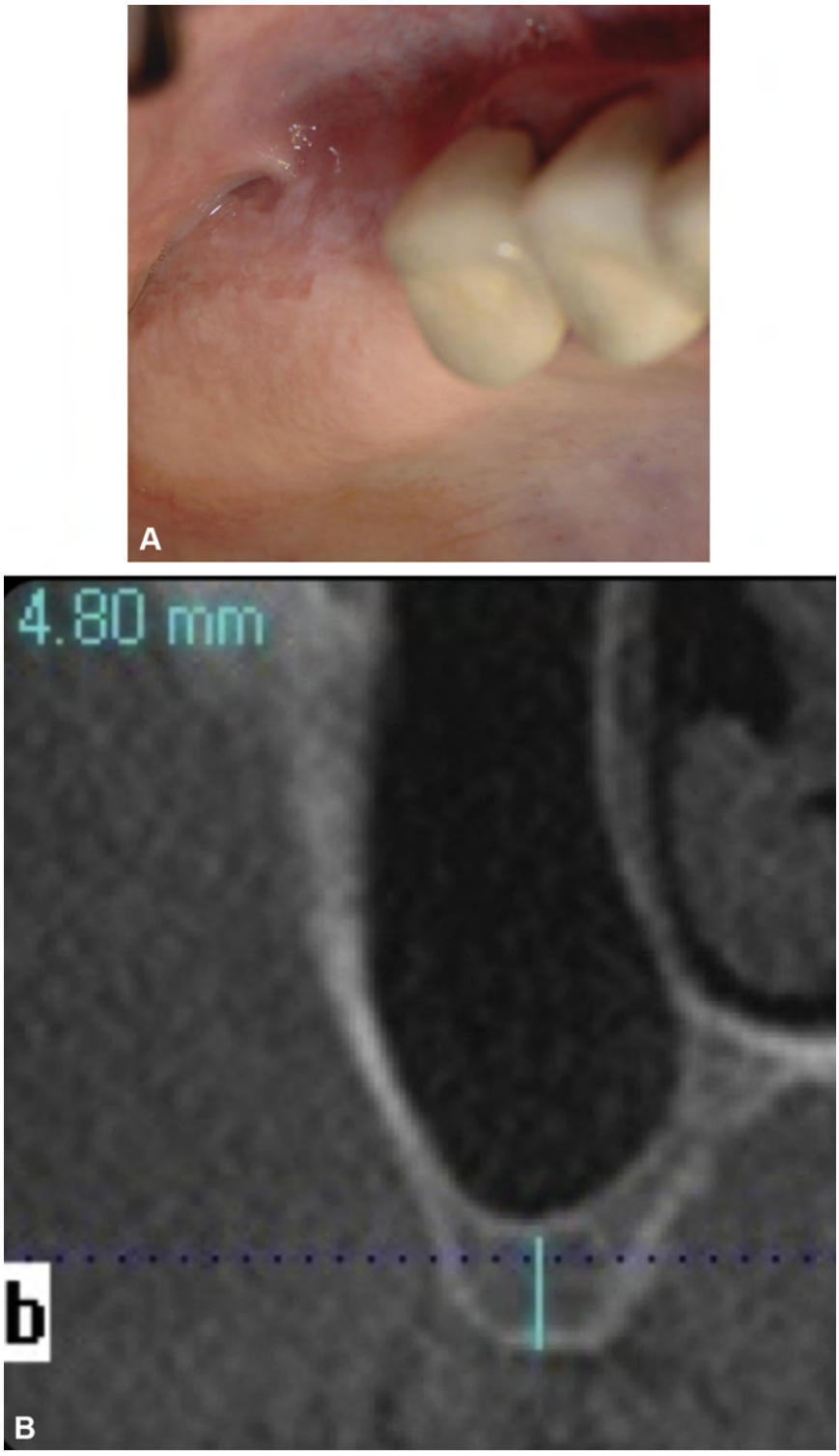

FIGURE 1. *A*, A 65-year-old male patient missing maxillary right molars. *B*, Bone height of 4.8 mm as measured using preoperative cross-sectional image. **(Fig 1 continued on next page.)**

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can be elevated with the graft in place in a sequential manner. The graft is placed and gently elevated with an osteotome. A xenograft is chosen in the elevated site within the sinus.[5] Multiple sites in an edentulous arch can be grafted simultaneously as needed. The crestal aspect is grafted with allograft or xenograft depending on clinician preference. The incision is closed. Patients receive antibiotics and, as a

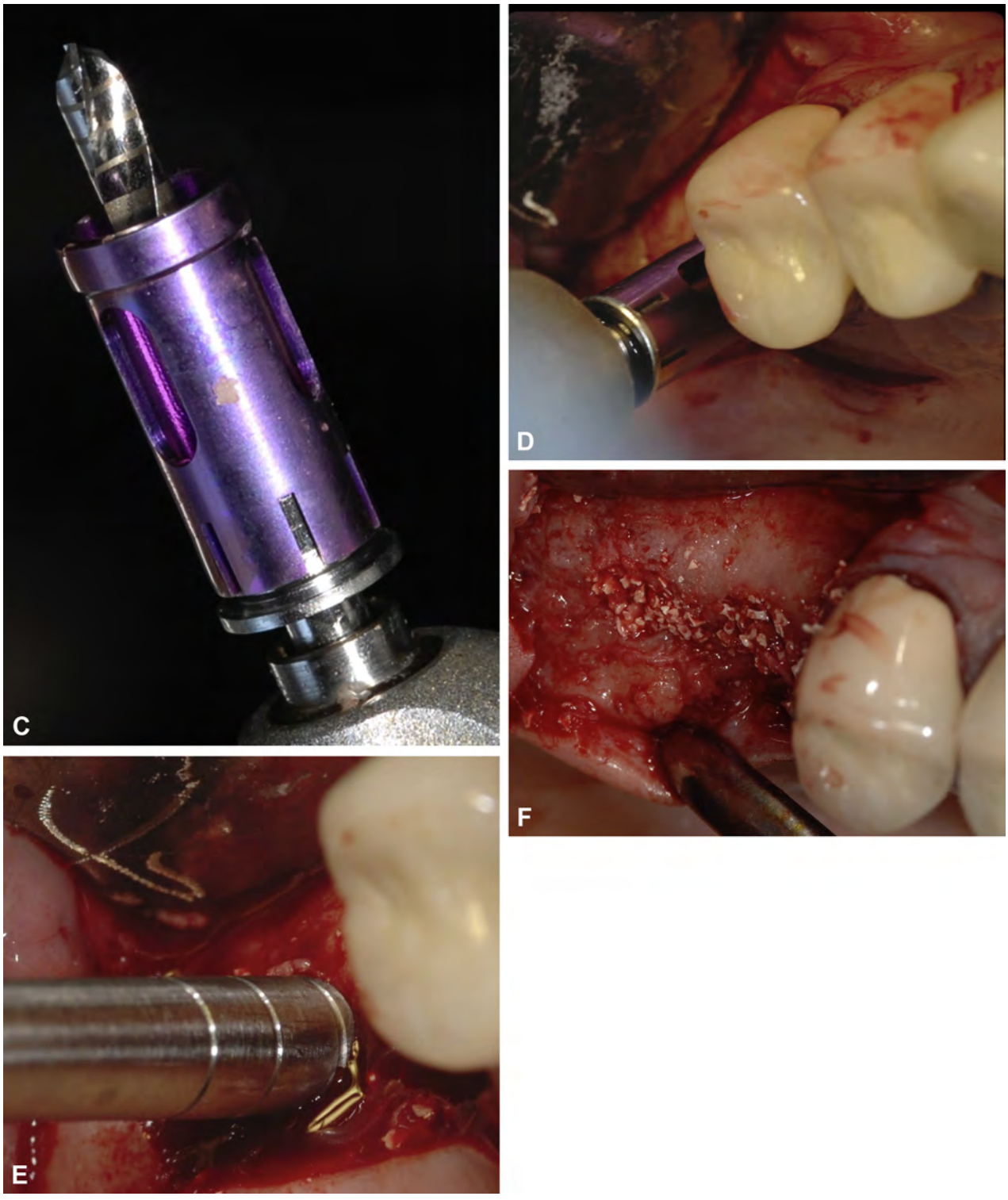

FIGURE 1 (cont'd). *C*, Drill with stop at 5 mm used to create osteotomy to within 1 mm of sinus floor. *D*, Drill used to depth guided by stop. *E*, Osteotomes used to up-fracture floor and elevate membrane for 9 mm of thickness. *F*, Xenograft placed into site. **(Fig 1 continued on next page.)**

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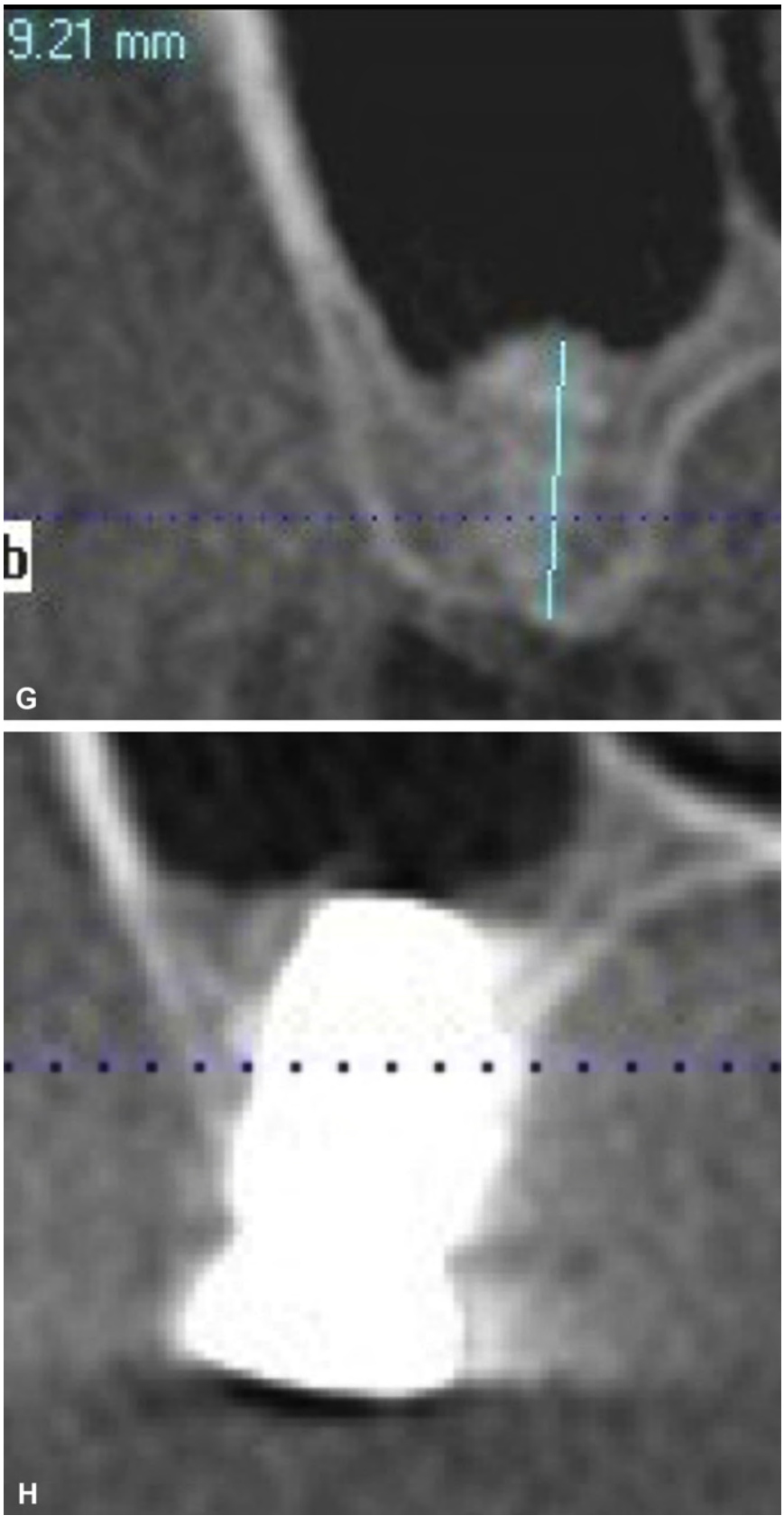

FIGURE 1 (cont'd). *G*, Cross-sectional image obtained 3 months postoperatively showing elevation of floor and over 9 mm of thickness. *H*, Radiograph obtained 4 months after implant placement showing 10-mm-tall implant with no additional grafting necessary after initial graft placement.

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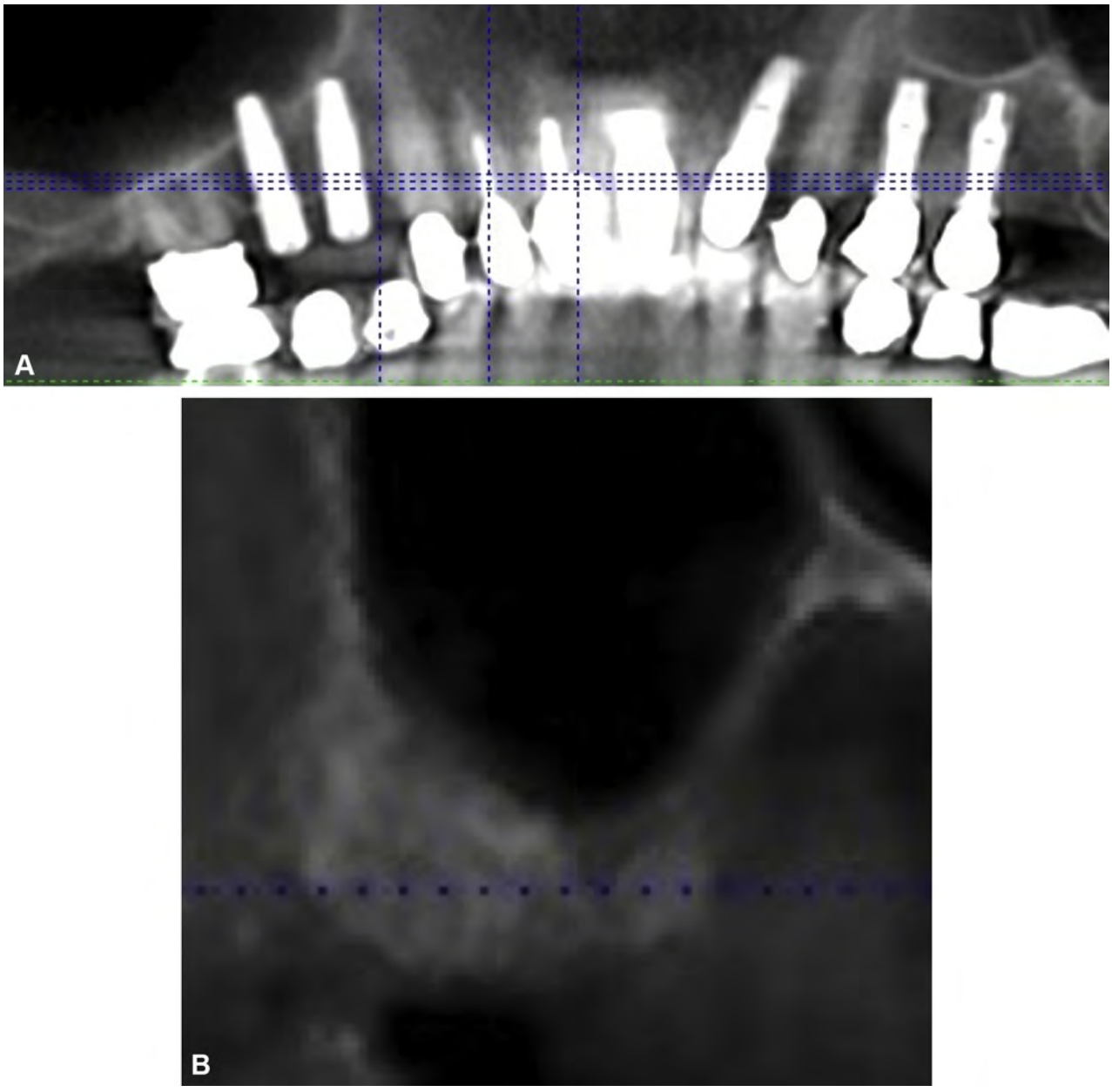

FIGURE 2. *A*, Preoperative panoramic reconstruction image of 68 year old healthy woman showing minimal bone around maxillary right first molar. This tooth was removed, and the sockets were grafted with allograft. No attempt was made at the time of tooth removal to augment the vertical maxillary bone because the patient did not plan to undergo future implant placement. *B*, Cross-sectional image of bone height, which measured 5 mm. At this point, the patient desired implant placement in this location. **(Fig 2 continued on next page.)**

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precaution, are advised to avoid the Valsalva maneuver for 4 months.

CRESTAL ELEVATION WITH IMPLANT PLACEMENT

The same procedure is followed as described earlier. The only difference is that the osteotomes are used to final implant length. Xenograft is placed with the aid of an osteotome. Depending on implant taper or diameter, the final implant drills may be used to allow for implant seating after the membrane has been elevated. The burs are used at a slow speed to avoid membrane trauma. After the size of the sites is finalized, the graft is placed and the implants are placed to crestal depth. Healing abutments are placed. The incision is closed around the healing abutments. Sinus precautions are given and antibiotics prescribed.

SINUS ELEVATION AT TIME OF TOOTH REMOVAL

Preoperative evaluations of patients who need their molars removed are chosen for this method

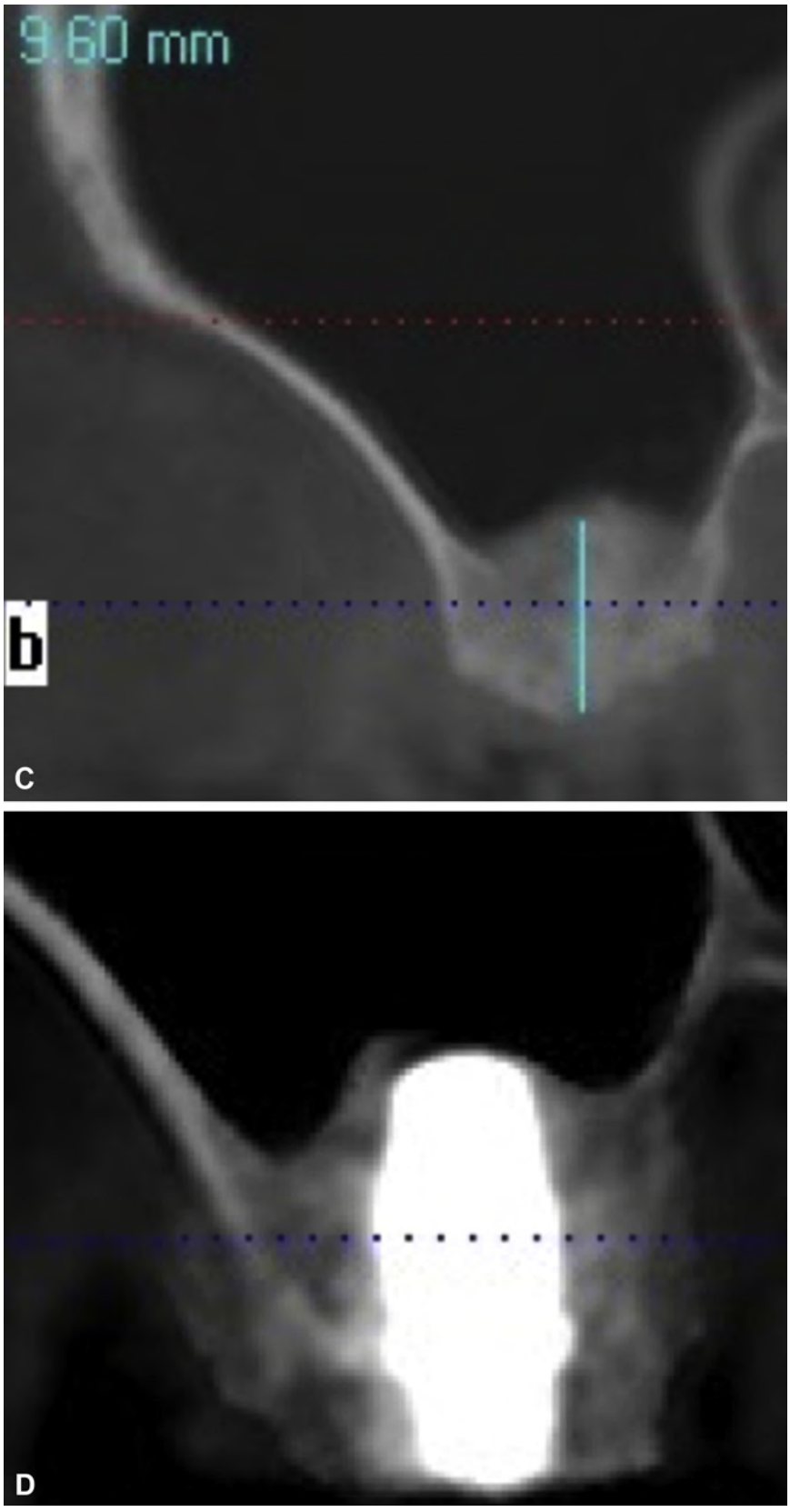

FIGURE 2 (cont'd). *C*, Immediately postoperatively, osteotome elevation increased the ridge thickness from 4 to 9.6 mm. After crestal ridge exposure, drills with 3-mm stops were used to prepare a 4.3-mm-diameter site. The floor was elevated by use of one osteotome and xenograft placed to augment ridge thickness. *D*, Cross-sectional radiograph 6 months after crestal osteotome graft, with a 10-mm-tall implant placed, with no additional procedures needed because of the result from the prior crestal approach graft.

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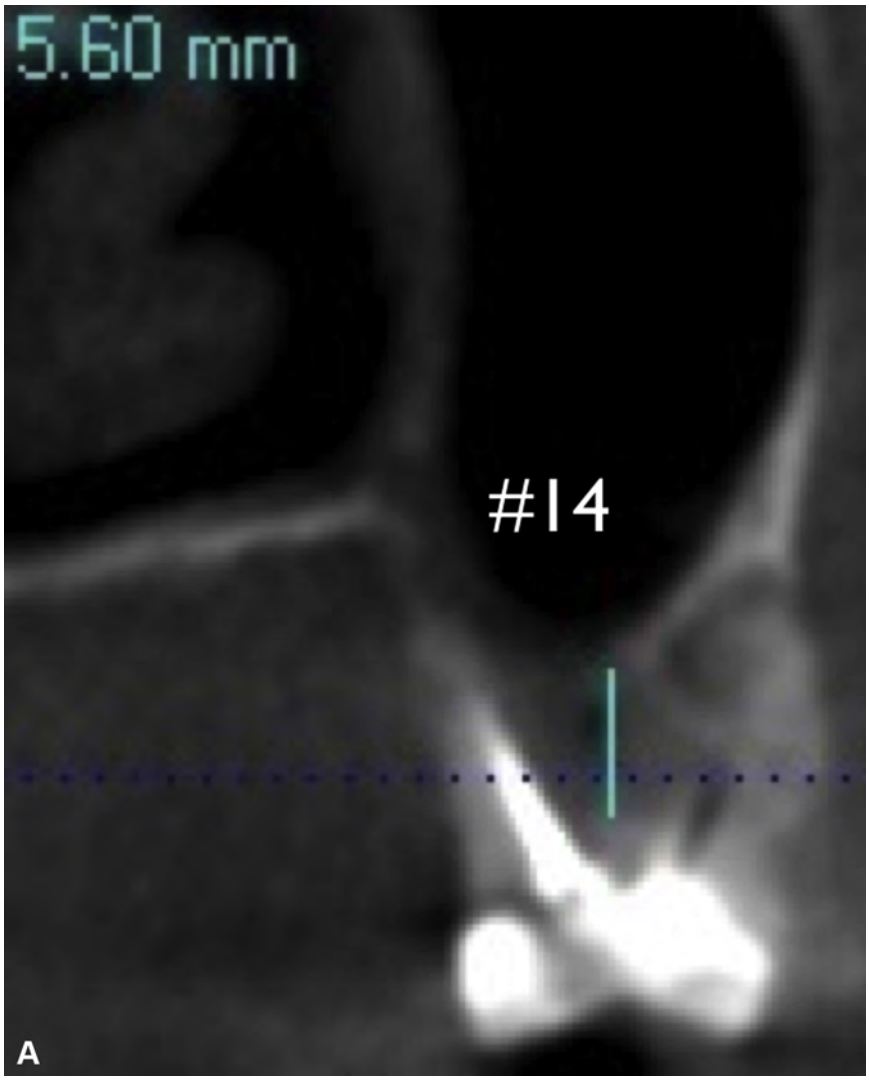

FIGURE 3. *A*, A 35-year-old female patient with a non-restorable maxillary left first molar with 5 mm of bone in the furcation. **(Fig 3 continued on next page.)**

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(Fig 3).[9,10] They commonly have roots protruding through the sinus floor, which—after their removal—increase the difficulty with membrane elevation. In addition, the presence of septi or convoluted bone surfaces creates a scenario that the surgeon anticipates as being more difficult to manage with traditional lateral window approaches because of the difficulty in raising the membrane without perforations.

This technique was initially introduced by Jensen et al[9] in 2006 and has been modified to include the use of Piezosurgery (Piezosurgery Inc., Columbus, OH) instrumentation and grafting.[10] Jensen et al reported their experiences with intentional intrusion of the interradicular bone after extraction of 20 maxillary molar teeth. They used straight osteotomes to create the osteotomies and elevated the bone with gentle tapping. If found, sinus perforations were covered with oxidized cellulose. After 4 months of healing, implants were placed, and they were later restored successfully. The technique increased vertical dimension by about 4 mm on average and allowed placement of longer endosseous implants.

After infiltration of local anesthesia, a sulcular incision is combined with vertical release incisions. A conservative flap is reflected to allow for closure at the conclusion of the procedure. As needed, a periosteal release is performed. The tooth is removed preserving labial and interradicular bone. This may include the use of a periotome, Piezosurgery periotome-like tips, and a drill to section the tooth and deliver the roots.

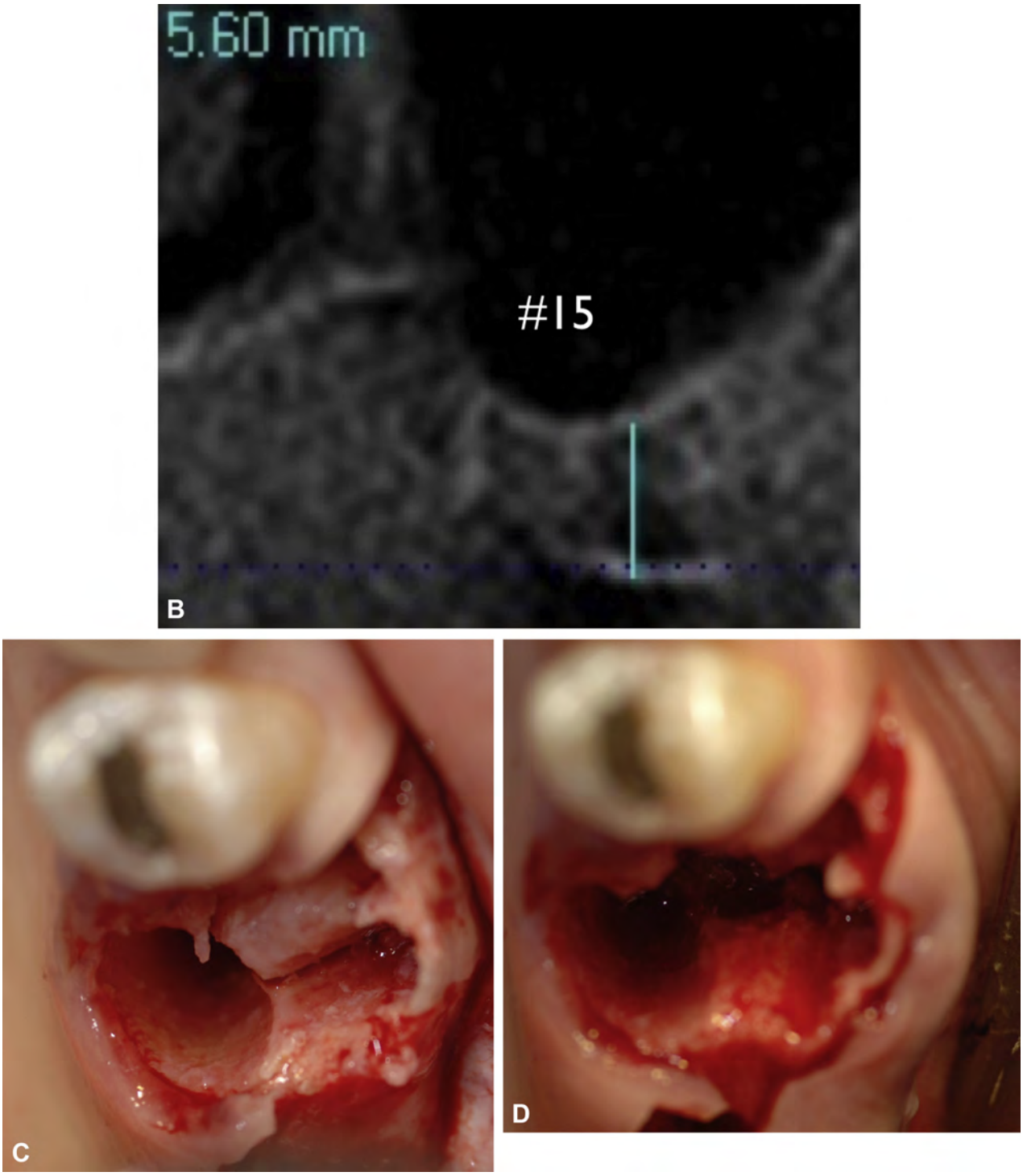
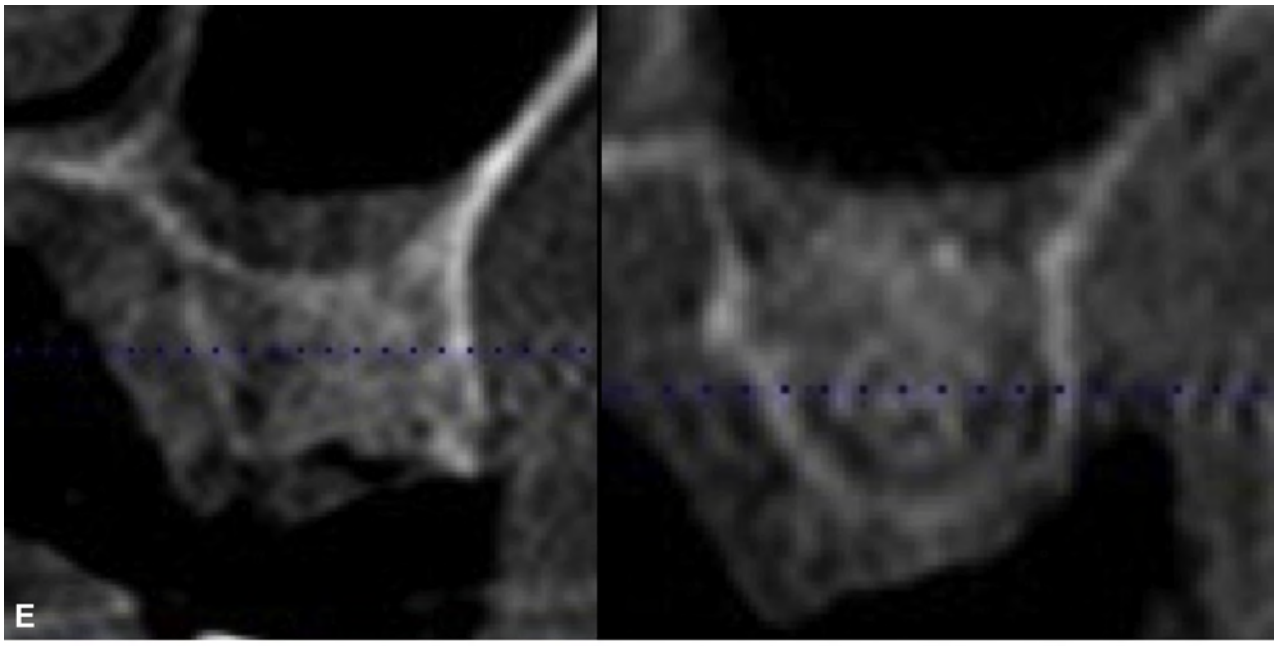


FIGURE 3 (cont'd). *B*, The same patient was missing the second molar with 5 mm of ridge thickness. *C*, After exposure of the tooth and crest sites, the first molar was removed. A Piezosurgery cutting tip was used to create osteotomies connecting the 3 root sites. *D*, A blunt-tipped osteotome was used to elevate the furcation bone by 5 mm. Xenograft was placed in the apical region and allograft in the crestal portion of the socket. In the second molar site, a crestal osteotome approach was used to augment the vertical thickness of the ridge from 5 to 10 mm. **(Fig 3 continued on next page.)**



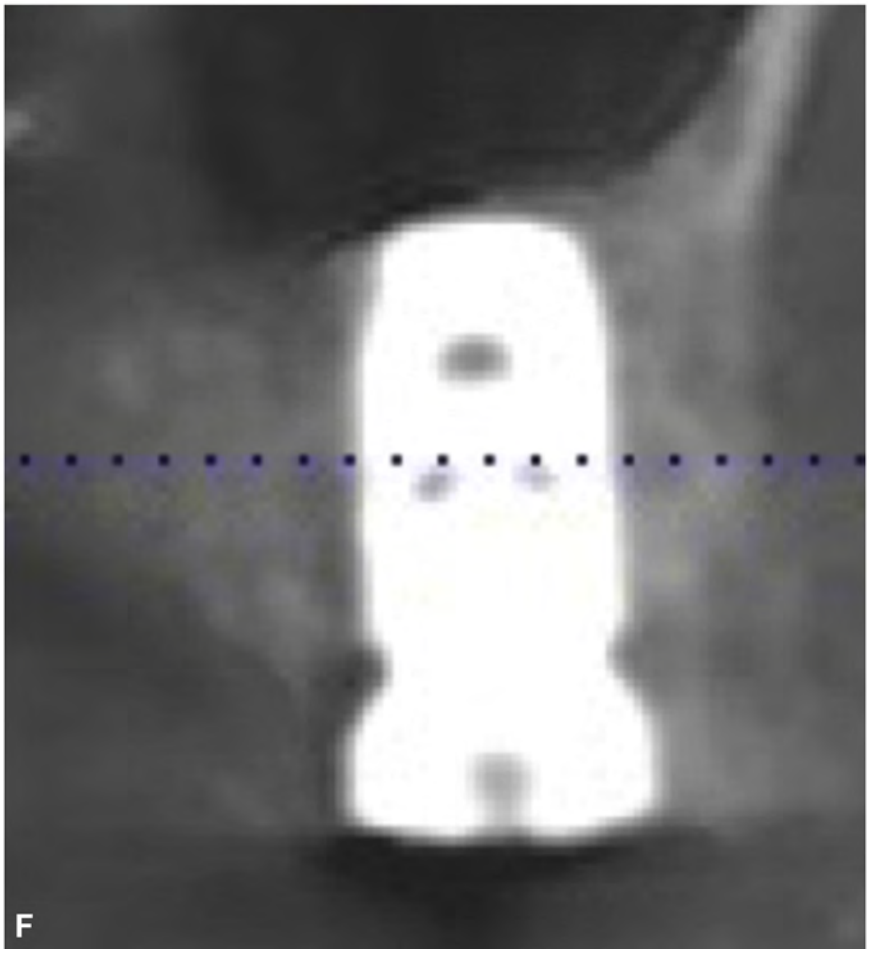


FIGURE 3 (cont'd). *E,* Cross-sectional radiographs immediately after surgery. The left image shows bone thickness of 10 mm at the first molar location. The right image shows ridge thickness of 10 mm at the edentulous second molar site. *F,* Four months after the grafts, implants were placed using dynamic navigation. The first molar implant is shown immediately after implant placement. **(Fig 3 continued on next page.)**

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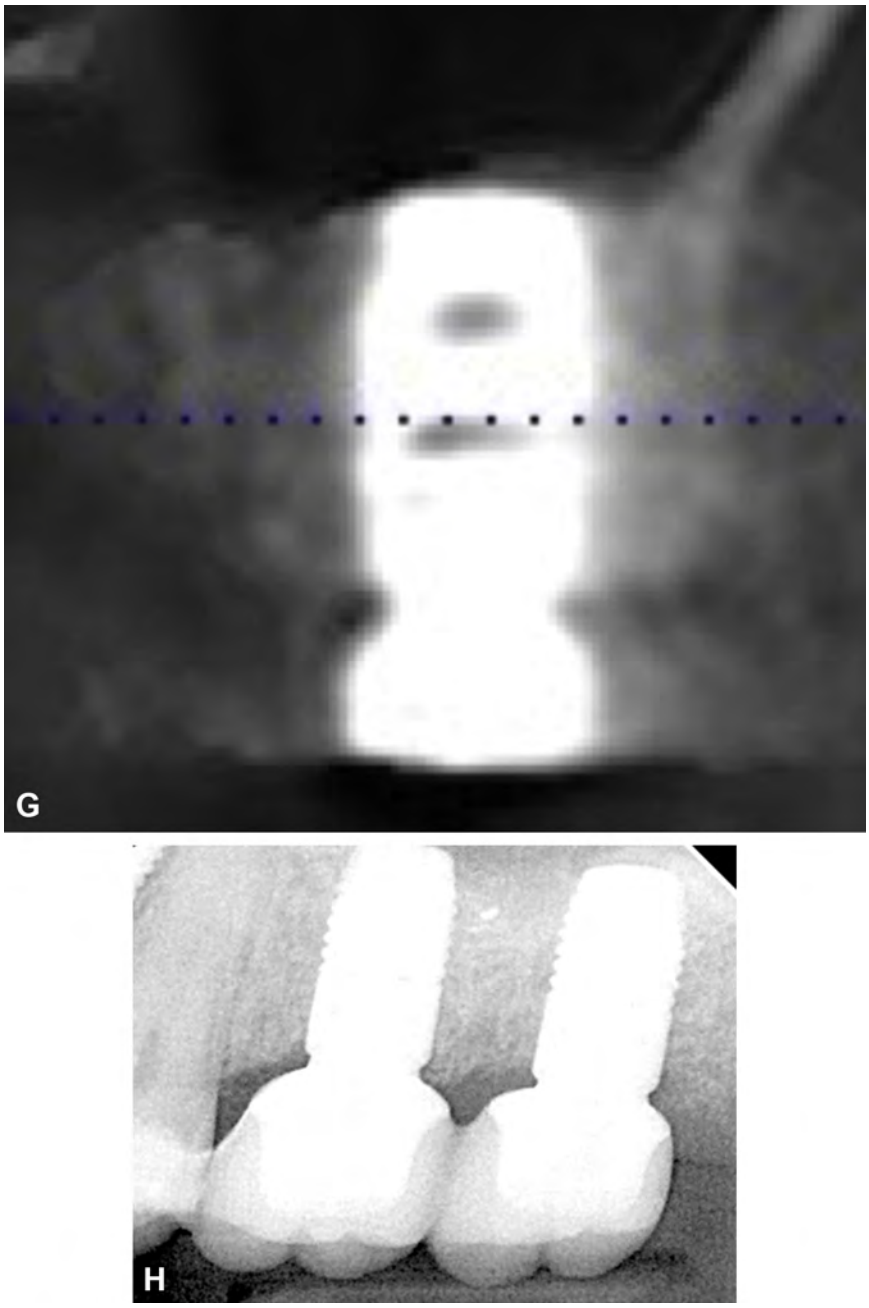

FIGURE 3 (cont'd). *G*, The second molar implant is shown immediately after implant placement, 4 months after the grafts. No additional grafting was necessary after the first grafting procedure. *H*, Final restorations 5 months postoperatively showing bone in the apical region of the implants.

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After the tooth is removed, osteotomies are performed connecting the 3 roots. The bony cuts are carefully made and go through the sinus floor without perforation of the membrane. The result is a mobile piece of bone, which is the bone superior to the molar furcation. This segment is gently tapped superiorly 5 to 6 mm.

Xenograft is placed into the socket against the elevated piece of bone. Allograft is placed into the socket to the crest. The incision is closed, and if necessary, the palatal root socket is covered with a piece of resorbable collagen.

Antibiotics are administered, and the patient is instructed to avoid the Valsalva maneuver.

Approximately 3 to 4 months after the sinus elevation and graft placement, a cone-beam scan is taken to determine the next step. Depending on the vertical height gained, another sinus elevation by the crestal approach can be performed with implant placement or the implant can be placed if sufficient bone height has been gained. On healing, the patient usually can have implants placed into these sites with intra-alveolar sinus elevation for another 3 to 4 mm of bone height development or may have sufficient height for routine implant placement.[8]

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