EDITOR'S NOTE: This is the first in a series of *Primers for New Implantologists.* Other articles will follow.

A. Norman Cranin

AN ILLUSTRATIVE STUDY OF THE ROLE OF TOMOGRAMS FOR THE PLACEMENT OF DENTAL IMPLANTS

Kavas H. Thunthy, BDS, MS, MEd
William R. Yeadon, DDS, FAGD
Hisham F. Nasr, DDS, MScD

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Before dental implants are placed, an evaluation of a presurgical bone site with tomograms will reveal information not available from panoramic or periapical radiographs. This article illustrates the importance of making tomograms before the placement of dental implants to determine the actual height, width, inclination, and undercut of alveolar bone; the shape, cortication, and irregularities of crestal alveolar bone; the density of alveolar bone; the relative location of anatomical landmarks, such as mandibular canal, maxillary sinus, nasal fossa, incisive canal, submandibular gland fossa, etc.; the bucco-lingual view of dental pathosis; the bucco-lingual evaluation of sinus graft following sinus-lift surgery; and the evaluation of surgically placed dental implants.

Dental implants are widely used in the restoration of edentulous sites of dental alveolar bone. Regardless of the type of intraosseous implant system used, the preoperative assessment requires a radiographic examination to facilitate the planning of the placement of implants.[1–8] Some clinicians evaluate the edentulous site solely on periapical and/or panoramic radiographs, but these 2 types of radiographs have a major disadvantage: they do not show

Kavas H. Thunthy, BDS, MS, MEd, *is a professor of Oral and Maxillofacial Radiology;* ***William R. Yeadon, DDS, FAGD,*** *is a clinical associate professor; and* ***Hisham F. Nasr, DDS, MScD,*** *is an assistant clinical professor at the Louisiana State University School of Dentistry in New Orleans, LA 70119. Address correspondence to Dr Thunthy, Department of Oral Diagnosis, Medicine, and Radiology, Louisiana State University School of Dentistry, 1100 Florida Avenue, New Orleans, LA 70119-2799.*

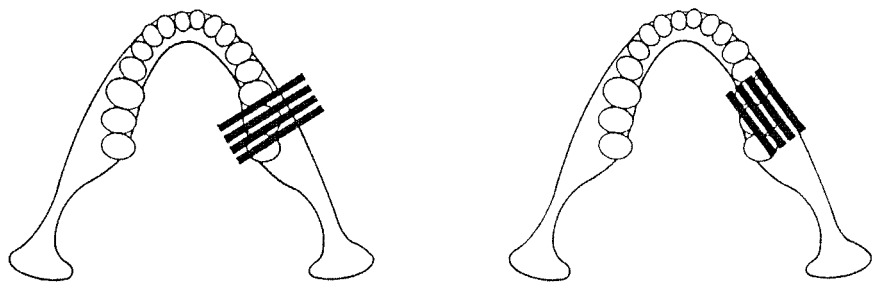
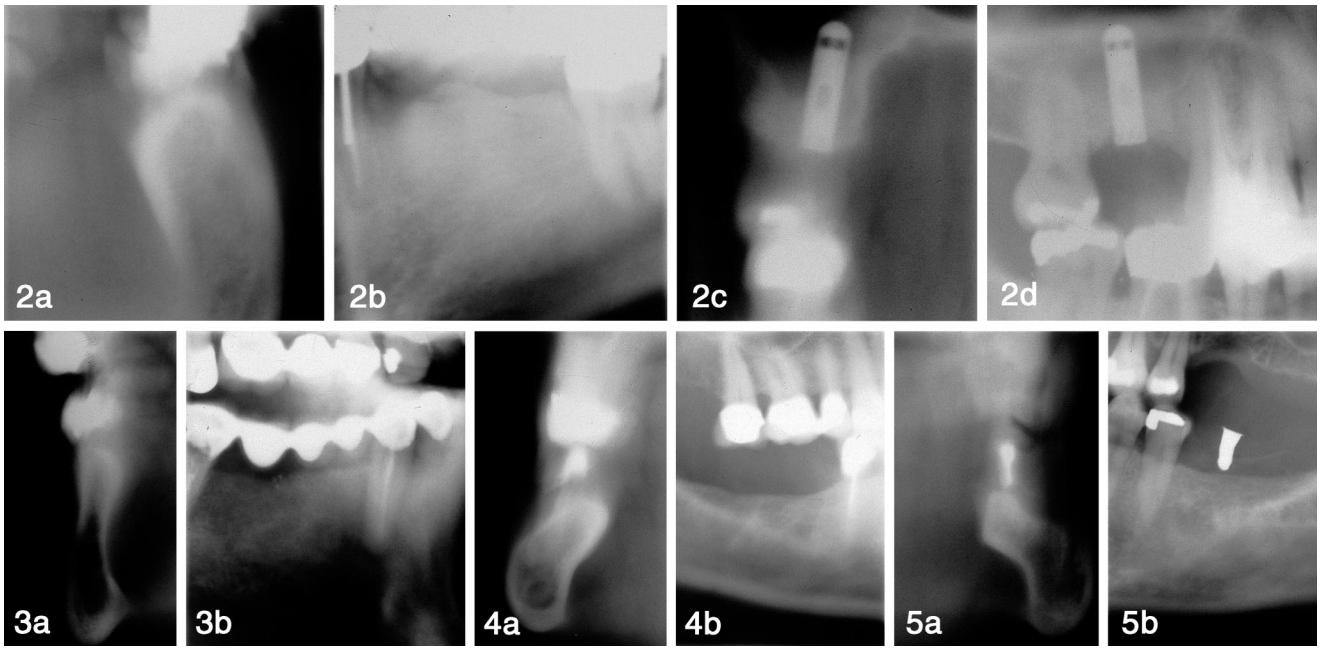


FIGURE 1. (a) Cross-sectional tomographic slices and (b) sagittal tomographic slices. A sagittal slice is mainly used for location and orientation of the multiple cross-sectional slices.



FIGURES 2–5. FIGURE 2. To determine the actual height of alveolar bone, the height of bone on the tomogram is multiplied by the magnification factor of the specific tomographic machine. Cross-sectional (a) and sagittal (b) slices show adequate alveolar bone height for implant placement when measured from the crest of the ridge to the mandibular canal. Additional cross-sectional (c) and sagittal (d) slices show inadequate alveolar bone height. As a result, the implant projected into the maxillary sinus. The dentist could have avoided the error in implant placement if tomograms had been taken before treatment. FIGURE 3. The cross-sectional slice (a) shows the narrow bucco-lingual width of the alveolar ridge. The sagittal slice (b) is unable to show the bucco-lingual width of the ridge, illustrating the importance of imaging in the third dimension, namely the cross-sectional slice. FIGURE 4. The cross-sectional slice (a) shows the lingual inclination of the alveolar ridge. The sagittal slice (b) is unable to show the inclination of the ridge, illustrating the importance of imaging in the third dimension, namely the cross-sectional slice. FIGURE 5. The cross-sectional slice (a) shows the severe undercut of the alveolar bone. The sagittal slice (b) is unable to show the undercut of the alveolar bone, illustrating the importance of imaging in the third dimension, namely the cross-sectional slice.

the dental alveolar ridges in the third dimension. Two other disadvantages that the 2 possess, especially with the panoramic radiograph, is of distortion and uneven and unpredictable magnification.

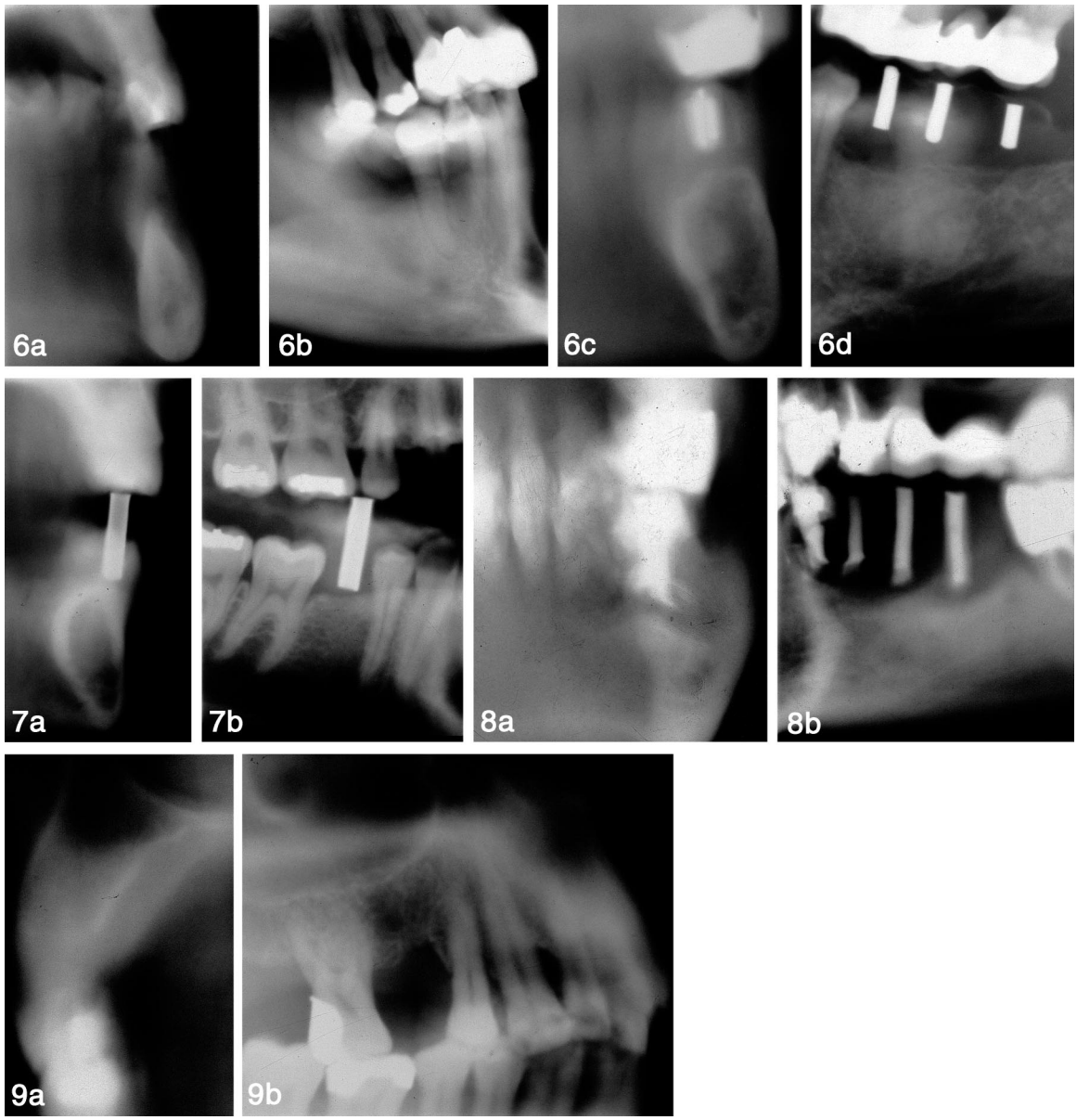
Some clinicians use the computerized axial tomography (CT) scan in their evaluation of presurgical sites for the placement of implants. The CT scan is an accurate imaging modality, but it has a number of liabilities: it is expensive to patients; it produces scatter artifacts of metal restorations; transferring information from a surgical stent is difficult; the interpretation of images is difficult; the chance of patient movement during exposure is likely; a large area of face is X radiated; and the patient receives a large X-ray dose.[9–11]

For dental offices, panoramic machines with the added capability of making conventional linear motion tomograms have been developed. The advantage of these panoramic/tomography machines is that they are much less expensive than CT machines and can be readily installed in a small area of a dental office. The disadvantages are that the tomographic slices are very thick, images are not custom-mapped for individual patients, and the layer depth depends on the bone orientation (vertical, horizontal, or oblique bone structures would produce vastly different section thicknesses). To overcome these disadvantages, complex motion tomographic machines with a computer that assists in custom-mapping the patient's den-

TABLE

Importance of tomograms for the placement of dental implants

1. Actual height of alveolar bone (Figure 2).
2. Actual width of alveolar bone (Figure 3).
3. Inclination of alveolar bone (Figure 4).
4. Undercut of alveolar bone (Figure 5).
5. Shape of crestal alveolar bone (Figure 6).
6. Cortication of crestal alveolar bone (Figure 7).
7. Irregularities of crestal alveolar bone (Figure 8).
8. Density of alveolar bone (Figure 9).
9. Relative location of anatomical landmarks, such as mandibular canal, maxillary sinus, nasal fossa, incisive canal, submandibular gland fossa, etc (Figure 10).
10. Bucco-lingual view of dental pathosis (Figure 11).
11. Bucco-lingual evaluation of sinus graft following sinus-lift surgery (Figure 12).
12. Evaluation of surgically placed dental implants (Figure 13).



FIGURES 6–9. FIGURE 6. The shape of the crestal alveolar bone may be flat, knife-edged, or rounded. The cross-sectional slice (a) shows the bucco-lingual crestal bone to be knife-edged. The sagittal slice (b) is unable to show the knife-edged shape of the crestal bone, illustrating the importance of imaging in the third dimension, namely the cross-sectional slice. Another cross-sectional slice (c) shows the bucco-lingual crestal bone to be flattened, but the sagittal slice (d) is unable to show the flattened shape of the crestal bone, illustrating the importance of imaging in the third dimension, namely the cross-sectional slice. FIGURE 7. The cross-sectional slice (a) shows the bucco-lingual cortication of the alveolar bone. The sagittal slice (b) does not show the cortication, illustrating the importance of imaging in the third dimension, namely the cross-sectional slice. The cylindrical radiopacity is a marker for the implant site. FIGURE 8. The cross-sectional slice (a) shows the bucco-lingual irregularities of the crestal alveolar bone. The sagittal slice (b) does not show the crestal-bone irregularities, illustrating the importance of imaging in the third dimension, namely the cross-sectional slice. FIGURE 9. The cross-sectional (a) and sagittal (b) slices show normal cancellous alveolar bone. The bone trabeculae are distinctly visible, and the bone appearance is not osteoporotic.

tal arch have been developed. The clinician is thus able to obtain thin tomographic slices that are very accurate with a constant magnification in all directions. This machine can also make panoramic radiographs. The disadvantage is that it is more expensive than the conventional panoramic/tomography machine; an advantage, however, is that it is much less expensive than the CT machine.[12–15]

Before discussing the importance of presurgical tomograms, it is necessary to define tomography. Tomography is body section radiography that shows more clearly a single layer of a structure by blurring out the shadows of superimposed structures. It is not a method of improving the sharpness of the image. On the contrary, it is a process of controlled blur-

FIGURES 10–13. FIGURE 10. Before placing an implant, it is necessary to know the anatomy adjacent to the implantation site. The cross-sectional slice (a) shows the location of the mandibular canal and its distance from the crest of the alveolar bone. The sagittal slice (b) also shows the mandibular canal. A second cross-sectional slice (c) shows the nasal fossa and bucco lingual location of the incisive canal, and the sagittal slice (d) shows the nasal fossa and mesio-distal location of the incisive canal. A third cross-sectional slice (e) shows the depression that the submandibular salivary gland forms in the lingual alveolar bone; however, the sagittal slice (f) does not show the depression of submandibular gland fossa, illustrating the importance of imaging in the third dimension, namely the cross-sectional slice. FIGURE 11. To see the bucco-lingual extension of pathosis, a cross-sectional slice is necessary. The cross-sectional slice (a) shows the bucco-lingual extension of the inflammatory apical lesion. The sagittal slice (b) shows the antero-posterior extension of the lesion. The apical lesion is thus seen in all 3 dimensions. Another cross-sectional slice (c) shows the mesio-distal fracture line of the mandibular first molar; however, the sagittal slice (d) cannot show the mesio-distal fracture line, illustrating the importance of imaging in the third dimension, namely the cross-sectional slice. FIGURE 12. The cross-sectional slice (a) shows the bucco-lingual extension of the sinus graft. The sagittal slice (b) shows the antero-posterior extension of the graft. The graft material is thus seen in all 3 dimensions. FIGURE 13. If presurgical tomographic evaluation of the implant site is not undertaken, the implant may inadvertently be placed in the wrong position. The first cross-sectional slice (a) shows the implant penetrating the lingual cortical plate and extending to the floor of the oral cavity. The first sagittal slice (b) gives the illusion of the implant being in bone, illustrating the importance of imaging in the third dimension, namely the cross-sectional slice. The circular radiopacity in both slices is a site marker in an acrylic stent. Both of the second slices, cross-sectional (c) and sagittal (d), show the tip of the implant penetrating the mandibular canal. Both of the third slices show the penetration of the

ring that merely leaves some parts of the image less blurred than others. For dental implants, tomograms are made in cross-sectional and sagittal modes (Figure 1). A cross-sectional slice (or cut) is made in a bucco-lingual direction analogous to a loaf of bread cut breadthwise in the traditional fashion. A sagittal slice (or cut) is made in an anterior-posterior direction, analogous to a loaf of bread cut lengthwise resulting in an image similar to that of a panoramic radiograph. The sagittal slice assists in the correlation of cross-sectional slices. In practice, several cross-sectional slices are made along with a corresponding sagittal slice. To determine the correct height and width of the alveolar ridge, measurements made on tomograms are multiplied by a magnification factor. Some manufacturers supply a magnified measuring scale that when placed on a tomogram gives the actual size of the applicable anatomy.

Some clinicians place implants based solely on the information derived from periapical and/or panoramic radiographs. It is not the intent of this article to suggest that clinicians make tomograms of all dental-implant patients. Each clinician must make that decision based on one's expertise and judgment. Suffice it to say that technology exists to obtain information of the dental alveolar arches in the third dimension. Consideration should also be given to medico-legal ramifications that may result from inadequate presurgical evaluation.

The Table lists the importance of presurgical tomograms for dental implants. Figure 1 shows the directions of the cross-sectional and sagittal slices. Figures 2 through 13 are cross-sectional and sagittal tomographic slices, which illustrate the importance of tomograms stated in the Table.

All tomograms in this article were made using a complex motion tomographic machine, the CommCAT model IS2000 (Imaging Sciences International, Hatfield, PA). It produced a constant magnification of 26% in all directions on cross-sectional and sagittal slices.

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implant into the maxillary sinus. The cross-sectional slice (e) shows the bucco-lingual penetration of the sinus. The sagittal slice (f) shows the antero-posterior penetration of the sinus. The penetration of the sinus by the implant is thus seen in all 3 dimensions. The fourth cross-sectional slice (g) shows 2 implants: 1 in the alveolar bone and the other inadvertently pushed into the maxillary sinus, showing the bucco-lingual relationship of the implant located in the sinus. The fourth sagittal slice (h) shows the antero-posterior relationship of the implant located in the sinus. The fifth cross-sectional slice (i) shows the implants placed labial to the alveolar ridge. The fifth sagittal slice (j) gives the illusion that the 2 implants are correctly placed in the alveolar bone, illustrating the importance of imaging in the third dimension, namely the cross-sectional slice.