Three-Dimensional Imaging and Guided Surgery for Dental Implants

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KEYWORDS

- Computed tomography/cone beam computed tomography • Dental implants
- Computer-aided design • Computer-aided manufacturing
- Guided Surgery Applications

KEY POINTS

- As technology continues to improve, and imaging modalities become widely available, clinicians worldwide are increasingly adopting guided surgical applications for dental implants.
- All aspects of the 3-D interactive treatment planning phase are based on sound surgical and restorative fundamentals.
- As an integral part of the implant team, dental laboratories have now moved from analog to the digital world, providing the necessary support to the new digital workflow.
- Guided surgery applications are dependent on careful diagnosis using the advanced tools that 3-dimensional imaging offers in combination with advanced interactive treatment planning software.
- Clinicians who wish to achieve true restoratively driven implant dentistry must be aware that the diagnostic phase often begins before the scan is taken.
- The use of diagnostic wax-ups, radiopaque scanning appliances, and the incorporation of intraoral optical scanners can significantly enhance the process and improve accuracy.
- The digital workflow is here to stay, providing clinicians with enhanced diagnostic tools for enhanced implant planning, surgical intervention, and links to computer-aided design software and computer-aided manufacturing process, and will continue to evolve over the next decade.

A 2-dimensional periapical radiograph has been the standard in dentistry for aiding clinicians in the diagnosis and treatment planning for various procedures including, but not limited to, the detection of dental caries, identifying pathology, periodontal disease, endodontic treatment, need for tooth extraction, and locating receptor sites for dental implants (Fig. 1). However, periapical radiographs and panoramic radiology are

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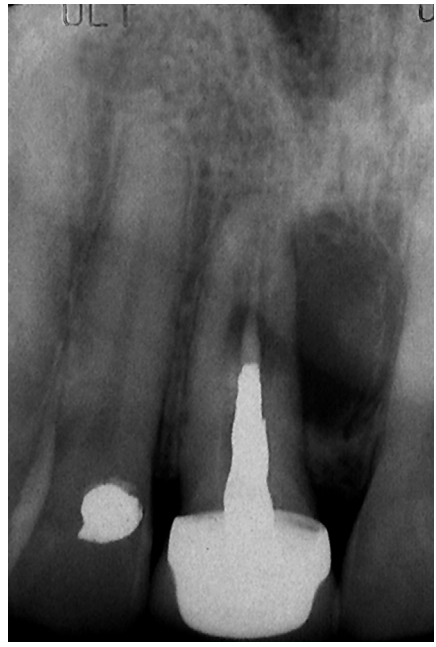

Fig. 1. A 2-dimensional periapical radiograph may not be sufficient to diagnose 3-dimensional anatomy or pathology.

inherently limited in the ability to accurately represent maxillomandibular structures. Two-dimensional radiography can only relate information about height or mesial-distal width but can not describe bone density, thickness of the cortical plates, or the true relationship of the natural tooth to the alveolar housing. When planning for dental implants, and especially when guided surgical applications are considered, it is essential that the true 3-dimensional anatomic presentation is understood and that all adjacent vital structures be accurately visualized.

The advent and acceptance of 3-dimensional computed tomography (CT), and newer-generation lower-dose cone beam CT scan devices (CBCT) in combination with interactive treatment planning software provides the clinicians with the ability to truly appreciate each patient's anatomic reality. Regardless of the device used to acquire the dataset (CT vs CBCT), it is imperative that there is an understanding of how each image can provide important undistorted information that can be used for diagnosis and treatment planning for a variety of surgical and prosthetic interventions to improve accuracy and limit complications. Generally, the 3-dimensional dataset consists of 4 basic views: (1) the axial, (2) the cross-sections, (3) the panoramic reconstructed view, and the 3-dimensional reconstructed volume. Each of these views is important, as no one view alone should determine the ultimate desired treatment.

The cross-sectional view is important to help determine the quality of the bone, the thickness of the cortical plates, sinus pathology, periapical pathology, and the trajectory of the tooth within the alveolus. Often the natural tooth is positioned far to the facial or buccal of the alveolar bone (**Fig. 2**). Therefore, when considering dental implant placement, clinicians can mistakenly try to position the implant within an extraction socket, which can result in less than satisfactory results. An appreciation