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Open Your Eyes to 3D Imaging

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Open Your Eyes to 3D Imaging

By Lea Al Matny, DDS, MS

Abstract

The intent of this article is to identify different applications that may benefit from an investigation with a cone beam computed tomography scan beyond implant planning. These indications include variations of anatomical landmarks, detection of periapical pathosis, radicular fractures, external cervical resorption, and airway analysis.

Cone beam computed tomography (CBCT) has changed the way clinicians diagnose and determine the best course of treatment. This can often mean the difference between solving the mystery of a patient's pain or missing a vital indicator. CBCT has advanced from unique use to almost commonplace use in dentistry as cost decreases and access to the technology increases.¹

Dental specialists quickly embraced three-dimensional imaging as a means by which they can distinguish their practices as being on the cutting edge of technology. Oral surgeons, periodontists, and orthodontists valued the anatomical structures visible in a large field of view CBCT scan, whereas endodontists appreciated the extraordinary level of detail achieved in high resolution, focused

Figure 1 — High-resolution, focused field of view CBCT scan of the posterior left mandible.

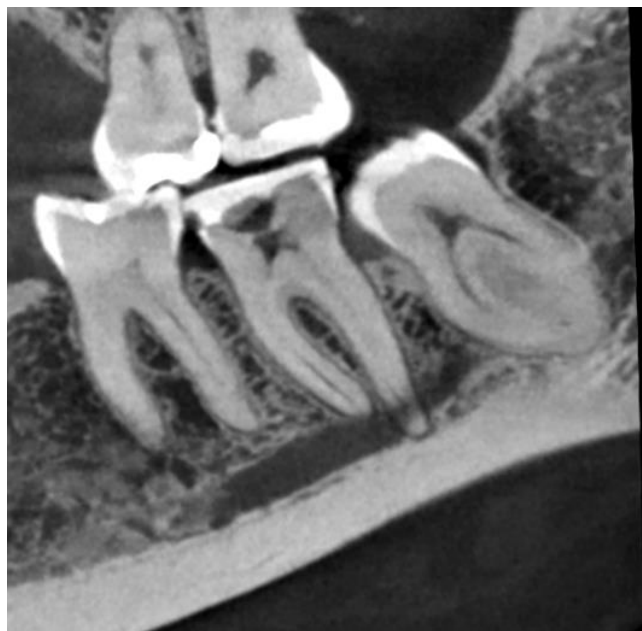
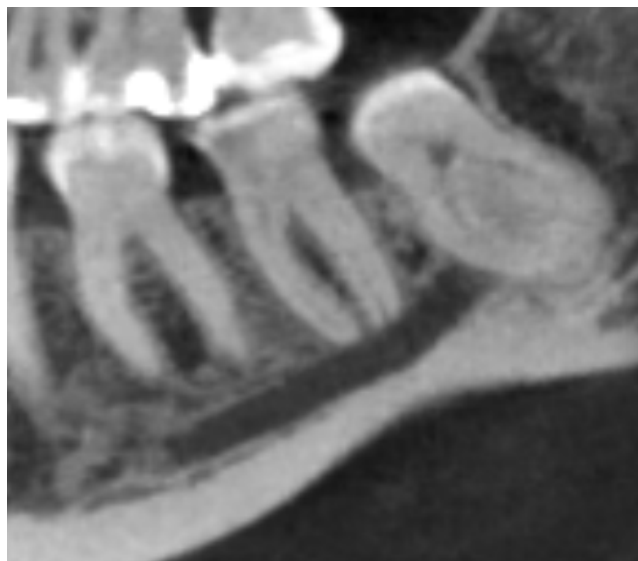


Figure 2 — Low-dose, large field of view CBCT scan on the same patient.



field of view scans. Even maxillofacial prosthodontists have pointed out the advantage of not being bound by two dimensions in a three-dimensional world.²

General dentists soon recognized the impact three-dimensional imaging can have on diagnosis. Today, patients expect their dentist to be contemporary and utilize the latest technology available in treatment.

As more clinicians adopt this technology, it is important for users as well as referring practitioners to understand the basic concepts of this imaging modality. The large field of view, low-dose CBCT scan acquired by the patient's orthodontist does not help address the questions raised by the patient's endodontist when a root canal treatment is warranted. Recognizing when CBCT is needed, why it can be beneficial, and which imaging protocol provides more relevant information in each case is the key to benefiting from this technology.

Customize imaging protocols for your patients

Every patient is unique, and every clinical situation requires a treatment plan customized to meet each patient's needs. In the same way, CBCT imaging can and should be customized to each patient or diagnostic task to optimize image quality and increase diagnostic accuracy. It can be easy to "set it, forget it" and take the same scan on every patient who needs a scan, but tailoring the settings on a CBCT machine can significantly affect image quality and increase diagnostic accuracy.

Some of the configurable factors include field of view, voxel size, patient positioning, and metal artifact reduction (MAR) reconstruction algorithm.

It would also be simple and straightforward to reduce radiation doses to extremely low levels, but such extreme low dose levels may render images diagnostically useless. In fact, imaging protocols have evolved in adapting the traditional ALARA (As Low as Reasonably Achievable) principle toward ALADAIP (As Low as Diagnostically Acceptable being Indication-oriented and Patient-specific).³ What constitutes adequate image quality depends on the modality being used and the clinical question being asked.

Evaluate CBCT scans in a comprehensive manner

There is little dispute that CBCT provides superior representation of anatomy vs. two-dimensional plain films. 3D imaging facilitates the localization of anatomical variations, relationships of structures, and helps identify the origin of pathosis (untreated/unobturated canals, root resorptions, or fractures).

Variations of normal anatomical structures. Knowledge of anatomical variations is extremely important for planning treatment and avoiding complications postoperatively. Precise imaging becomes especially

important in surgical cases that might involve vulnerable structures, including sinus cavities, nerve channels, or blood vessels. One of the variations rarely discussed is the canalis sinuosus, a neurovascular canal, nerve branch of the infraorbital canal, that passes the anterior superior alveolar nerve.⁴

Detection of periapical pathosis. Furthermore, 3D imaging identifies up to 40% more of previously

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Figure 3 — Coronal view of the anterior maxilla presenting the "s-shaped" canalis sinuosus on the right side.

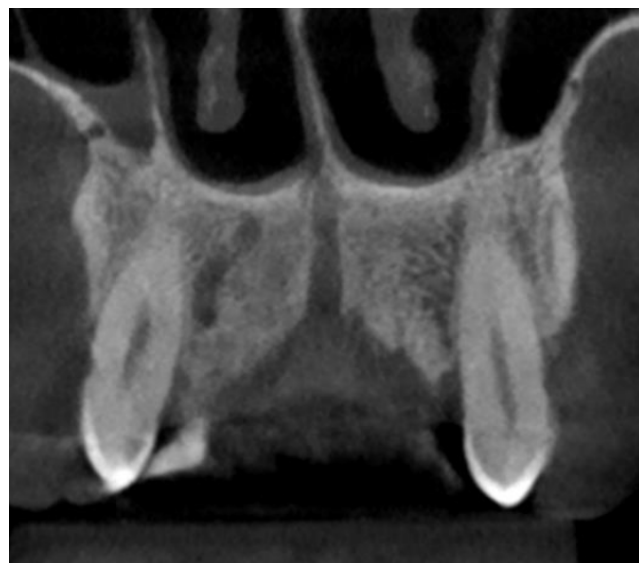


Figure 4 — Periapical radiograph of posterior right maxilla.



Figure 5 — Sagittal view of a focused field of view CBCT scan on the same patient.

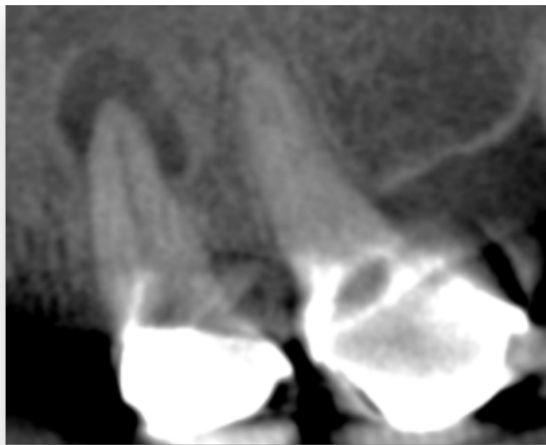
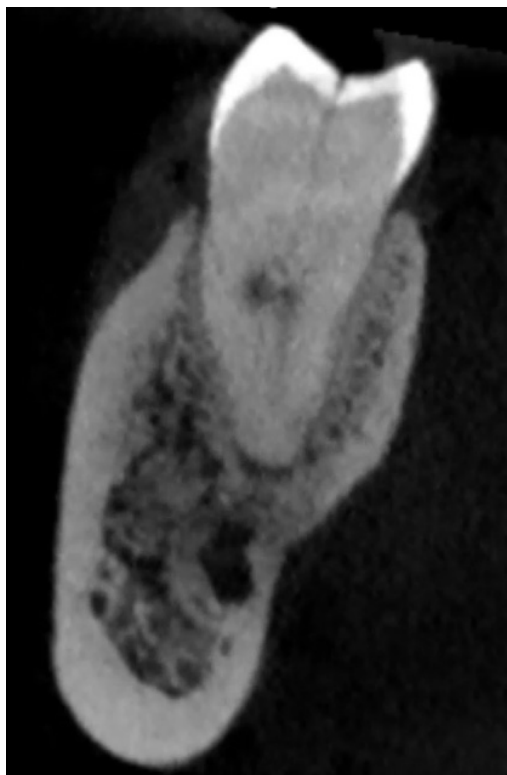


Figure 6 — Coronal view showing a radicular fracture extending from the occlusal surface.



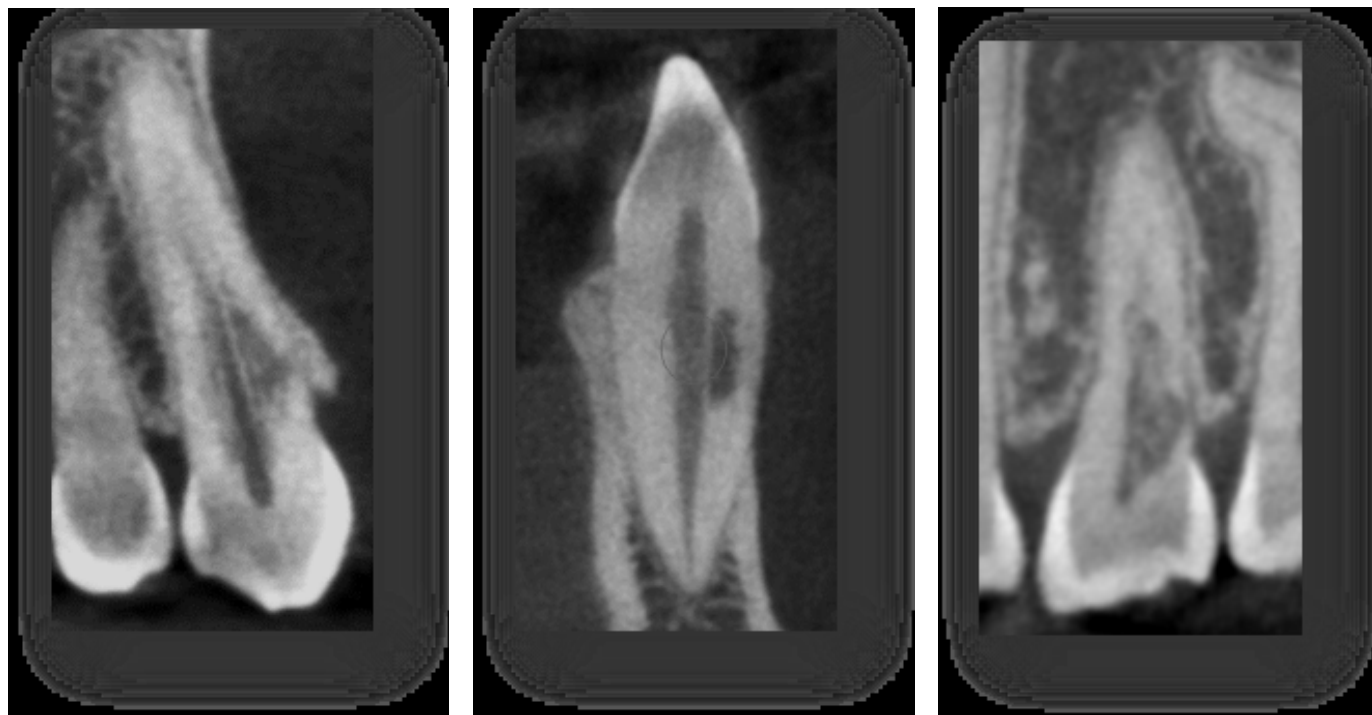
undetectable lesions.⁵ Two-dimensional imaging modalities provide patchwork information of anatomic segments to represent three-dimensional anatomy. This diagnostic variability is noticed in endodontically treated and untreated teeth, especially in the posterior maxilla. Patel et al. also elaborate on the limitations of detecting periapical lesions using periapical radiographs in necrotic teeth.⁶ A visible radiolucency surrounding an apex depends on the size of the lesion, density, and thickness of the cortical plate and the distance between the lesion and cortical plate.

Vertical root fractures. Vertical root fractures can be even more difficult to visualize on routine radiographic techniques. Long-standing fractures usually show changes in the surrounding bone pattern. However, a recently fractured tooth can be more difficult to identify radiographically, especially in the presence of metal artifacts caused by metal restorations, endodontic posts, root fillings, and implants. Therefore, reconstruction algorithms such as MAR (metal artifact reduction) can greatly enhance the quality of images and reduce the effect of beam hardening and scatter present.

Figure 7 — Sagittal view of the same tooth presenting localized angular bone loss on the distal aspect.



Figure 8-10 — External cervical resorption on thin CBCT slices varying in extent, location and occupying volume.



External cervical root resorption. Other times, incidental findings such as external cervical root resorption require dynamic navigation through the three axes provided on a focused field of view CBCT scan to determine prognosis and possible treatment plan options. The clinical presentation of external cervical resorption depends considerably on the size and extent of the resorptive process. Some cases classified as Heithersay class I or II, typically assigned with a “good” prognosis, could present with up to 28% of the root structure affected by the resorptive defects.⁷

Airway analysis. Surely, there is more to CBCT imaging than endodontic diagnosis. The ultimate goal of imaging is to portray the anatomic truth to help in diagnosis and treatment planning. CBCT imaging for the primary evaluation of the airway has been greatly debated. Studies have shown that certain craniofacial patterns are related with smaller dimensions of the upper airway.⁸ Some of the most common qualitative factors include retrognathia, steep mandibular plane, hypoplastic maxilla, and reduced transverse dimension of the maxilla. Quantitatively, the airway volume, minimum cross-sectional area, and length of the airway can be au-

tomatically computed using the imaging software.⁹

Use of 3D imaging beyond implant planning

Software capabilities permit visualization of a CBCT scan from any angle, and specific areas in a scan can be segmented for further analysis. The use of CBCT has partly intensified due to its advanced software tools. Three-dimensions imaging was not just used as a diagnostic tool, but rather a productivity tool that helps dentists treat patients more efficiently.

Over the next few years, dynamic software applications based on 3D imaging will also mature and become more enriched. We have already witnessed the effect of computer-aided design/computer-aided manufacturing (CAD/CAM) technology and 3D implant planning. CBCT scans can be automatically merged with digital impressions within seconds without points matching. Then, virtual implants can be planned with the final restoration in mind. The communication between different platforms makes the entire process faster and more efficient, which is important for a busy practice with many implant surgeries on the schedule.

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Figure 11 — Airway analysis presented on the volume rendering of a large field of view CBCT scan.

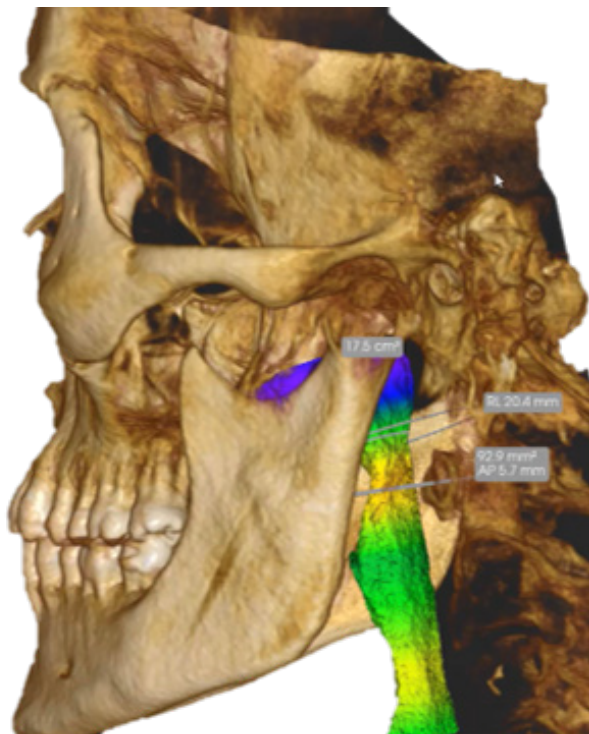


Figure 12 — Volume rendering merged with facial scan and digital impression for patient education.



About the Author

Lea Al Matny, DDS, MS, is a licensed oral and maxillofacial radiologist at SeeThru Reports (seethrureports.com) and a clinical education specialist at Carestream Dental. She attended the University of Texas Health in San Antonio, where she received both a certificate in oral and maxillofacial radiology and a master's degree in dental science. She is a reviewer for *Oral Surgery*, *Oral Pathology*, *Oral Medicine*, *Oral Radiology* and is actively involved in multiple committees at the American Association of Oral Maxillofacial Radiology.



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Improvements in software technology will bring more capabilities, including virtual treatments, simulations, and new possibilities for guided surgery, than are available now. CBCT will go beyond a static image to create something tangible.

Some of the applications include the ability to incorporate a dynamic element to reproduce occlusion and the movement of the arches. These applications are driven by the idea that both static and dynamic parameters should be considered in order to achieve complete diagnostics.

Other applications involve dynamic navigation systems that track the position of the tip of the implant drill and map it to a pre-acquired CBCT scan of the patient's jaw to provide real-time drilling and placement guidance/feedback. Dynamic navigation is gaining traction in endodontics as well, especially in calcified canals.

These advancements in software and static/dynamic guide partners have brought more proficiency, flexibility, and precision to treatment planning.

Conclusion

CBCT technology is becoming more integral in daily practice. The anatomic and diagnostic accuracy provided by three-dimensional imaging have enormous impact on the prognosis and reliability of treatment plan provided. Incorporating 3D imaging will allow practitioners to approach cases in a comprehensive manner, beyond focusing on the tooth in question. ●

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