Clinical Update

Naval Postgraduate Dental School
Navy Medicine Manpower, Personnel, Training and Education Command
Bethesda, Maryland

Vol. 31, No. 9 2009

Cone beam computed tomography in endodontics

Commander John S. Evered, DC, USN and Commander Terry Webb, DC, USN

Purpose

Computed tomography (CT) was invented by Sir Godfrey Newbold Hounsfield and Allan McLeod Cormack working independently in the late 1960's and early 1970's. They shared the Nobel Prize for Medicine in 1979 for this discovery. It was developed as a way to see a "slice" of a patient's body which was not available before with two-dimensional radiographs. CT machines are relatively large and expensive and expose the patient to high doses of radiation. Cone beam CT (CBCT) was developed in the late 1990's as an outgrowth of computed tomography. It offers reduced radiation exposure and scan time. Cone beam CT was approved by the FDA in 2000, and then introduced to North American dentists in 2001. Since then, it has presented new opportunities in endodontic diagnosis and treatment planning. This clinical update will define cone beam CT, present its diagnostic abilities compared to conventional two dimensional radiographs, and explain its endodontic applications.

Radiographic diagnostic procedures

Diagnosis is defined as "the art of distinguishing one disease from another." Radiographic examination is essential in endodontic diagnosis and treatment planning. The interpretation of an image can be confounded by the anatomy of the teeth and surrounding structures that can be superimposed in a two-dimensional image. Cone beam CT has the ability to eliminate superimposition of structures that normally overlap in two-dimensional radiology.[1] The ability of cone beam CT to assess an anatomic area of interest in three dimensions is of great benefit to clinicians.

What is cone beam CT?

Traditional medical CT uses a fan-shaped beam and makes multiple passes around the patient, whereas a CBCT uses a cone-shaped beam of radiation to acquire a volume in a single 360-degree rotation around the patient. Just as a digital radiograph is subdivided into pixels, the CBCT images are composed of voxels. A voxel is a 3-D pixel. (Fig.1) CBCT data is captured as a volume representing the patient's anatomy. The voxels are isotropic, meaning equal sided, which enables objects within the volume to be measured accurately. [2]

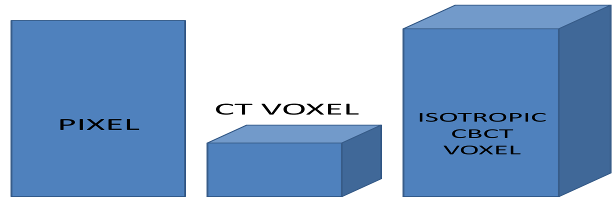

Fig. 1 Pixel, Medical CT Voxel, CBCT isotropic voxel

In addition to increased accuracy and higher resolution, CBCT offers significant scan-time reduction, radiation dose reduction, and reduced cost for the patient over medical CT. With the help of viewer software, the clinician is able to scroll through the entire volume and simultaneously view axial, coronal, and sagittal 2-D sections that range from 0.125–2.0 mm thick. The axial and proximal (sagittal in the anterior, coronal in the posterior) views are valuable, because they are not seen in traditional 2-D radiography.[2]

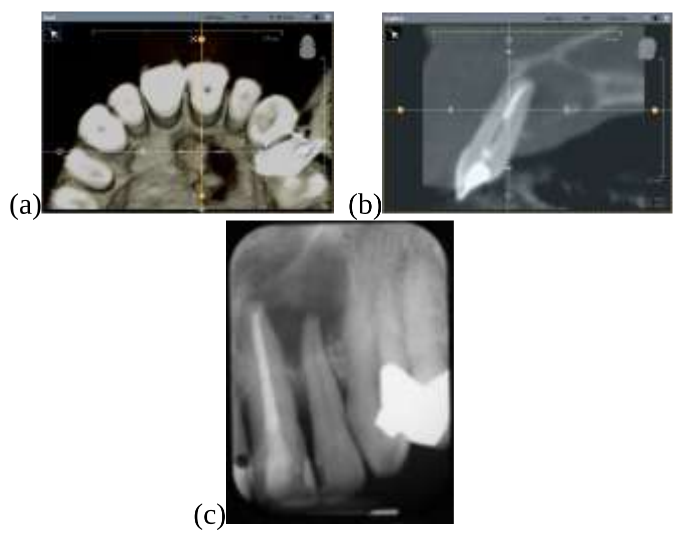

Fig. 2 (a) CBCT Axial view, (b) CBCT Sagittal views and (c) Conventional periapical radiograph of tooth #9 & #10

Cone beam CT radiation exposure

Cone beam CT radiation exposure will vary depending upon the manufacturer and the size or area of imaging, called field of view (FOV). The doses from CBCT are lower than conventional CT, yet still are higher than doses from traditional dental radiographs. Therefore, a risk/benefit analysis must be carried out before a CBCT image is requested. A traditional medical CT scan for a maxillary tooth implant site assessment can be as much as 2,100 μSV, the dose equivalent to 375 panoramic or digital images. In contrast, the

CBCT machines operate at doses ranging from approximately 40 to 500 μSv, or as little as four to six panoramic equivalents.[3]

Applications of cone beam CT in endodontics

- Primary periapical disease may be detected sooner and with greater sensitivity compared with periapical or panoramic radiographs.[4]
- Identification of root canal systems is more sensitive than CCD or phosphor plate digital periapical radiographs.[5]
- Assessment of root fractures from trauma.[1,6]
- Maxillary posterior scans can be used to assess the anatomical information relating to the size, shape, and position of roots and their relationship with the maxillary sinus. Knowing this should optimize the procedure and reduce the risk of complications.[7] This may be particularly useful in surgical endodontics.
- The relationship of anatomical structures such as the maxillary sinus, inferior alveolar nerve and mental foramen to the root apices are clearly visualized.[1]
- Radiographic differentiation between granuloma and cyst is proposed.[8,9]
- Early detection of periapical disease, leading to a higher quality diagnosis and treatment planning for retreatment cases.[10]
- Added value of this emerging technology will be the limited FOV which offers reduced radiation exposure and scan area.

Medical-legal issues interpreting a cone beam

The American Academy of Oral and Maxillofacial Radiology has stated that cone beam CT is a new valuable imaging technology. It should be used only by licensed referring practitioners. Practitioners that interpret a cone beam image are responsible for all information on the scanned image. Dentists using CBCT should be held to the same standards as board-certified oral and maxillofacial radiologists. Just as a pathology report accompanies a biopsy, an imaging report must accompany a CBCT scan, and be included in the patient's record. Images are part of the permanent record and should be stored in a suitable archival format. The practitioner who requests a CBCT image must examine the entire image dataset. This is predicated on a thorough knowledge of CT anatomy for the entire acquired image volume, anatomic variations, and observation of abnormalities. It is imperative that all image data be systematically reviewed for disease.[8]

Conclusion

With advances in cone beam CT, these images allow better visualization of various anatomical structures, pathologic defects and periapical pathosis over those of conventional radiographs. This additional knowledge will enhance the practitioner's ability to more accurately diagnose, and develop comprehensive treatment plans.

References

1. Cotton TP, Geisler TM, Holden DT, Schwartz SA, Schindler WG. Endodontic applications of cone-beam volumetric tomography. J Endod. 2007 Sep;33(9):1121-32.
2. Nair MK, Nair UP. Digital and advanced imaging in endodontics: a review. J Endod. 2007 Jan;33(1):1-6.
3. Ludlow JB, Davies-Ludlow LE, Brooks SL, Howerton WB. Dosimetry of 3 CBCT devices for oral and maxillofacial radiology: CB Mercuray, NewTom 3G and i-CAT. Dentomaxillofac Radiol. 2006 Jul;35(4):219-26.
4. Estrela C, Bueno MR, Leles CR, Azevedo B, Azevedo JR. Accuracy of cone beam computed tomography and panoramic and periapical radiography for detection of apical periodontitis. J Endod. 2008 Mar;34(3):273-9.
5. Matherne RP, Angelopoulos C, Kulild JC, Tira D. Use of cone-beam computed tomography to identify root canal systems in vitro. J Endod. 2008 Jan;34(1):87-9.
6. Youssefzadeh S, Gahleitner A, Dorffner R, Bernhart T, Kainberger FM. Dental vertical root fractures: value of CT in detection. Radiology. 1999 Feb;210(2):545-9.
7. Rigolone M, Pasqualini D, Bianchi L, Berutti E, Bianchi SD. Vestibular surgical access to the palatine root of the superior first molar: "Low-dose cone-beam" CT: analysis of the pathway and its anatomic variations. J Endod. 2003 Nov;29(11):773-5.
8. Simon JH, Enciso R, Malfaz JM, Roges R, Bailey-Perry M, Patel A. Differential diagnosis of large periapical lesions using cone beam computed tomography measurements and biopsy. J Endod. 2006 Sep;32(9):833-7.
9. Carter L, Farman AG, Geist J, Scarfe WC, Angelopoulos C, Nair MK, et al. American Academy of Oral and Maxillofacial Radiology executive opinion statement on performing and interpreting diagnostic cone beam computed tomography. Oral Surg Oral Med Oral Path Oral Radiol Endod. 2008 Oct;106(4):561-2.
10. Estrela C, Bueno MR, Azevedo BC, Azevedo JR, Pecora JD. A new periapical index based on cone beam computed tomography. J Endod. 2008 Nov;34:1325-1331.

Commander Evered is a graduate of the endodontic program at the Naval Postgraduate Dental School. Commander Webb is the Endodontic Residency Program Director at the Naval Postgraduate Dental School.