Basic Principles of Cone Beam Computed Tomography

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KEYWORDS

- Cone beam computed tomography • Flat-panel silicon detector
- DICOM viewer software • Beam-hardening artifacts

KEY POINTS

- The use of cone beam computed tomography (CBCT) imaging in the dental profession has blossomed since its inception 15 years ago. CBCT unit design has undergone many changes that enhance CBCT access and practical utility in dentistry. The scanners have become smaller, scan patients in an upright position, use primarily flat panel detectors, and readily convert projection data to DICOM file formats. Units themselves have various scanning options that include the size of the area to be scanned (field of view [FOV]), voxel size (spatial resolution), bit depth (contrast resolution), and scan times (frame rate).
- CBCT manufacturers have incorporated various aspects of imaging technology in a cost-effective, efficient, and practical manner. There are now numerous CBCT applications in many software formats that are helpful in a multitude of dental disciplines including but not limited to dentoalveolar disease and anomalies, vertical root and dentin fractures, jaw tumors, prosthodontic evaluations, and advances in orthodontic/orthognathic and implant patient evaluations. The latter also include mechanisms for surgical and prosthodontic splint design and the capability of CBCT scan data to bridge with computer-aided design/manufacturing image files for the fabrication of various dental restorations.
- Streaking and beam hardening remain as ominous imaging artifact that compromise CBCT utility in various case situations. However, because of the popularity of CBCT, computer hardware and software developers, machine manufacturers and dental researchers will continue to improve the applications of this imaging modality for the betterment of patient care.

INTRODUCTION

Imaging with cone beam technology has rapidly become a popular and frequently used imaging modality to assist dentists and other health care professionals in a multitude of diagnostic tasks to improve patient care.

Cone beam imaging technology is most commonly referred to as cone beam computed tomography (CBCT). The terminology "cone beam" refers to the conical

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shape of the beam that scans the patient in a circular path around the vertical axis of the head, in contrast to the fan-shaped beam and more complex scanning movement of multidetector-row computed tomography (MDCT) commonly used in medical imaging.

First introduced at the end of the millennium,[1,2] CBCT heralded a new dental technology for the twenty-first century. Its practical applications for implant dentistry and orthognathic/orthodontic patient care were the main applications at that time. Owing to the dramatic and highly positive impact that CBCT had on these disciplines, additional applications for this technology became apparent. New software programs were developed to improve the applicability and access of CBCT for the care of dental patients.

Two factors played a big part in the rapid incorporation of CBCT technology into dentistry, the first of which was the availability of improved, rapid, and cost-effective computer technology. The second was the ability of software engineers to develop multiple dental imaging applications for CBCT with broad diagnostic capability.

CBCT VERSUS COMPUTED TOMOGRAPHY

CBCT, by virtue of the terminology, is a form of computed tomography (CT). In a single rotation, the region of interest (ROI) is scanned by a cone-shaped x-ray beam around the vertical axis of the patient's head. Digitized information of objects in the ROI such as shape and density is acquired from multiple angles. These imaging data are then processed by specialty software that ultimately constructs tomographic images of the ROI in multiple anatomic planes, namely the standard coronal, axial, and sagittal anatomic planes (**Fig. 1**) and their various paraplanar derivatives, the parasagittal, paracoronal and para-axial planes.

The historically standard and more sophisticated form of CT, present since the 1970s, was developed in part by British engineer and Nobel Prize winner Sir Godfrey Hounsfield. It is of interest that by the end of the decade, the technology of Hounsfield's first scanner was followed by the development of a larger body scanner by a group of researchers in the United States headed by American dentist and physicist Robert S. Ledley.[3] This more advanced form of CT is known as MDCT, although other terms such as multislice CT and multirow CT are used. Because MDCT is more commonly used in medicine, it is often referred to as medical CT. However, this

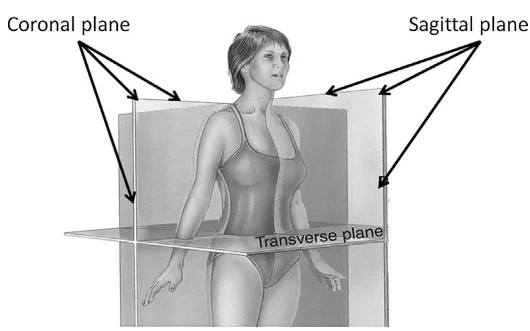

Fig. 1. Standard anatomic planes of imaging used for multiplanar reconstructions in cone beam computed tomography (CBCT) and multidetector-row computed tomography. (*Modified from* Washington CM, Leaver DT. Principles and practice of radiation therapy. Philadelphia: Mosby; 2004.)