Cone Beam Computed Tomography

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KEYWORDS

• Computed tomography • Cone beam computed tomography • CBCT

KEY POINTS

- In the last several decades, the need for 3-dimensional images in dentistry have developed.
- While computed tomography (CT) allowed conditions to be diagnosed with 3D images, is is hospital-based, expensive, and exposes patients to relatively high doses of radiation.
- In the late 90's, a new technology using a cone-shaped beam, called the cone beam computerized tomography (CBCT), made the perception of 3D easy to dentists.
- Clinical needs, advantages, disadvantages, and indications for use of this imaging modality are described.

INTRODUCTION AND HISTORY

The development of computed tomography (CT) in 1972, which was reported in 1973,[1] enabled conditions to be diagnosed with 3-dimensional (3D) images. These devices were used in many fields, and their use in dentistry became more frequent with the advent of implant surgery. Although CT devices are becoming more compact, they continue to be relatively large, expensive, and expose patients to relatively high doses of radiation.

Arai and colleagues[2,3] set out to develop a compact CT apparatus specifically for use in dentistry. In 1997, they created a prototype-limited cone beam CT (CBCT) device for dental use that was dubbed Ortho-CT. In about 2 years after that achievement, the device was used in approximately 2000 cases to evaluate conditions, such as impacted teeth, apical lesions, and mandibular and maxillary diseases, both before and after surgery in the Department of Radiology at the Nihon University School of Dentistry Dental Hospital, proving highly successful.[4]

This prototype apparatus, the Ortho-CT, was an improved version of the Scanora (Soredex Corporation, Helsinki, Finland), a multifunctional pantomography imaging

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apparatus. In the Ortho-CT, the section where the film cassette was installed was replaced with an image intensifier, resulting in improved operability, resolution, and reduced radiation doses.[2,3]

In 2000, this technology was transferred to Morita Co Ltd through the Nihon University Business Incubation Center. The 3DX multi-image micro-CT was developed as a limited CBCT device for practical use, enabling 3D imaging of the hard tissues (ie, bone, tooth) of the maxillofacial, ear, and nose regions.[5]

The NewTom QR 9000 (Mozzo and colleagues)[6], a volume imaging machine produced in Italy, received FDA (Food and Drug Administration) approval in April 2001 and then CDA (Canadian Dental Association) approval in August 2002.

The NewTom QR 9000 has been designed specifically to image the maxillofacial region. In a single scan, the x-ray source and a reciprocating x-ray sensor rotate around the head and acquire 360 pictures (one image per degree of rotation) using 17 seconds of accumulated exposure time.

CONE BEAM COMPUTED TOMOGRAPHY FUNDAMENTALS

CBCT uses an extraoral imaging scanner, specifically designed for head and neck imaging that produces 3D scans of the maxillofacial skeleton. It involves a unit that can be comparable in size with a conventional panoramic radiographic machine.

Cone beam machines use x-rays in the form of a large cone covering the head surface to be examined; instead of a linear array of detectors as in CT, a 2-dimensional (2D) planar detector is used.

Because the cone beam irradiates a large volume area instead of a thin slice, the machine does not need to rotate as many times as CT, it rotates once giving all the information necessary to reconstruct the region of interest (ROI).

This technique allows clinicians to obtain 2D reconstructed images in all planes, and reconstructions in 3 dimensions with low level exposure to x-radiation.[7]

Supine Versus Seated Positioning

There are many types of CBCT machines with different characteristics. One of these differences is the position of patients in the machine: standing, sitting, or lying on a table.

Clinicians are used to sitting or standing positioning for in-office 2D imaging. For 3D cone beam imaging, minimizing patient motion is critical for high-quality results to reduce blur and motion artifacts.[8]

Image Intensifier Versus Flat Panel Efficiency over Time

In early generation CBCT systems, image intensifiers were commonly used. Currently, different types of flat panel detectors (FPDs) are used instead, as these detectors are distortion free, have a higher dose efficiency and a wider dynamic range, and can be produced with either a smaller or larger field of view (FOV). Most existing CBCT systems use indirect FPDs whereby a layer of scintillator material, either gadolinium oxysulfide or cesium iodide, is used to convert x-ray photons to light photons, which in turn are converted into electrical signals.[9–11]

Field of View

The size of the FOV describes the scan volume of a particular CBCT machine and depends on the detector's size and shape, the beam projection geometry, and the ability to collimate the beam, which differs from one manufacturer to another. Beam