# CONE BEAM COMPUTED TOMOGRAPHY- THE THIRD ERA IN DENTAL RADIOLOGY


**ABSTRACT**

Cone-beam computed tomography (CBCT) is a new imaging technique that generates 3-D images at a lower cost and absorbed dose compared with conventional computed tomography (CT). Productions of high diagnostic quality images are indispensable for appropriate diagnosis and treatment plan in clinical dentistry. Now, CBCT has been specifically designed to produce undistorted three dimensional images of the maxillofacial skeleton especially the teeth and supporting structures. The purpose of this article is to review the clinical applications of CBCT in different dental disciplines, in order to update the general dental practitioners on the current status of this new imaging technology.



**Keywords:** Cone beam computed tomography [CBCT], conventional tomography, dental practitioners



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**Introduction:**

Complete assessment of dental patient is important for the proper diagnosis and treatment planning in which radiographic analysis play an important role. Earlier conventional and digital two dimensional images were used for the assessment of dental structures. The information gained from these images are limited because of the fact that 3 dimensional anatomy of the area being radiographed is compressed to a 2 dimensional image. Now CBCT imaging technique has been emerged into the field since they generate 3 dimensional images at low cost and absorbed dose when compared to conventional medical computed tomography.

This imaging technique is based on a cone shaped x-ray beam centred on a 2-D detector that performs one rotation around the object, producing a series of 2-D images. These images are re-constructed in 3-D using a modification of the original cone-beam algorithm developed by Feldkamp et al. in 1984[1]. For most dental practitioners, the use of advanced imaging has been limited because of cost, availability and radiation dose considerations. However, the introduction of cone-beam computed tomography (CBCT) provides multiplanar imaging of maxillofacial region. CBCT data are amenable to reformation in a volume, rather than a slice, providing 3-dimensional information.

**Types of CT scanners:**

There are two types of beams are used for CT including fan-beam and cone-beam.

1. Fan-beam scanners, a narrow fan-shape ray passes through the axial plan of the body contiguously. The final 3D images are produced by stacking all the two dimensional (2D) axial slices together [2]. In a multi-detector helical CT unit, multiple slices of two dimensional images can be produced by a single scan of the fan shaped helical X-ray source, which reduces exposure time and dosage [3].
2. Cone-beam scanner uses a cone shaped beam and the reciprocating detector, which rotates around the patient and acquires projection data. Using a backfiltered projection along with sophisticated computer software, a 3D image is produced. Both fan-beam and cone-beam 3D images can be reconstructed in axial, coronal and sagittal planes.

**Advantages of CBCT:**

1. Produce isotropic volumetric image, which means the voxels generated have equal dimension in all three planes
2. Contributes to high resolution, accuracy, and reproducibility of images
3. Reduces the size of irradiated area by collimating the x ray beam to the area of interest thereby reducing the radiation exposure [3.69-50.3µSv]
4. Compact size and affordability have allowed CBCT to be suitable for the dental office setting.
5. CBCT image can be reformatted to a panoramic, cephalometic or bilateral multiple cross-sectional views for the evaluation of maxillofacial lesions.
6. Produces images in a single rotation with reduced scanning time (<60sec)
7. Reduction in the amount of image artifacts

**Disadvantages of CBCT:**

1. Not the best imaging modality to image soft tissues.
2. Unlike CT scan, Hounsefield units of tissue density are not caliberated in CBCT.
3. Chances of motion artifacts exists.

**Importance and Application of Cone beam computed tomography for dental practitioners:**

CBCT technology is well suited for clinical dental practice than the conventional CT scanners which is large and bulky to maintain. Space, cost as well as dose limitation is an important feature in this procedure. In addition, scanning is limited to the head region which is one of the most important concern for a dental specialist.

**General dentists:**

Radiology is an important aspect in the day to day schedule for a dental practitioner. Based on the literature, cone beam technology is not utilized in clinics to detect occlusal caries since the cost and the dose is more when compared to normal conventional radiography and no additional information is gained. But it has shown its part in the detection of proximal carious lesions and the assessment of its depth which improved the use of this technology in general practice.. The following table shows the typical dose ranges of various radiographic procedures utilized in dental practices.

**Table 1:**

| Radiographic Procedure | Dose [mSv] |
|---|---|
| Intraoral | Upto 0.004mSv |
| Full mouth set | 0.080mSv |
| Lateral Cephalogram | Upto 0.005mSv |
| Panoramic view | 0.015mSv |
| CBCT [both jaws] | 0.068mSv[9] |
| CT Scan [both jaws] | 0.6mSv |

**Oral and maxillofacial pathologies:**

Low radiation dose, high quality bony definition and compact design with minimum space requirement have made CBCT desirable in-office imaging technique for the examination of head and neck pathologies. Uses of CBCT in detecting oral and maxillofacial pathologies include the following:

1. Examination of fractured teeth and bone
2. Diagnosis of cysts, tumors and infections in alveolar process
3. Evaluation of intraosseous lesions that are in close proximity to important vital structures
4. Useful to delineate extent and boundaries of oral and maxillofacial tumors
5. Evaluation of post-surgical complications [advantageous because of the low level artifacts in CBCT]

CBCT have become useful tool as it is more acceptable to the patients. It enables dental surgeon to provide a more conservative treatment approach, thereby reducing various iatrogenic errors. Computer assisted virtual treatment planning using CBCT is still under investigation. The use of CBCT along with 3D virtual software will be an excellent tool for treatment planning for oral and maxillofacial pathologies.

**Temporomandibular Joint [TMJ] Disorders:**

Imaging of TMJ was done using CT and MRI scans as they demonstrates the hard tissue and soft tissue structures in and around TMJ respectively. But now CBCT has gained its ability to define the true position of the condyle in the glenoid fossa, which often reveals the possibility of dislocations of the joint and also the limit of translation of condyle in the fossa.

In a study published by Huntjens et al. [4] demonstrates that condylar shape and volume can be measured accurately using CBCT-based method. But CBCT technique is not ideal for imaging soft tissues of TMJ mainly due to limited image resolution, for that case MRI will be the technique of choice. In addition to these, other advantages of using CBCT in case of TMJ include the following:

1. Trauma
2. Pain
3. Dysfunction
4. Fibro-osseous ankylosis
5. Condylar cortical erosion
6. Detection of pathologies such as cysts, tumors, etc

Therefore CBCT can provide valuable information for diagnosis and treatment planning of TMJ diseases[11].

**Oral surgery and Implantology:**

Nowadays there is an increased demand for the replacement of missing teeth with dental implants. But, the technique needs a highly accurate implant site measurements too aid in treatment planning and especially to avoid damage to the underlying vital structures during the surgical procedures[7]. Traditional 2D radiographs were used previously that provide information regarding the proposed implant sites. However, limited size, image distortion and uneven magnification restricts their use in several cases. In addition, conventional CT scan has also been used for the pre-surgical evaluation of dental implant patients[8,10]. But due to certain limitations such as image artifacts, high radiation dose as well as high procedure cost, CBCT has overtook conventional CT scan in implant site imaging.

Important information prior to implant placement such as morphology of alveolar bone, location of maxillary sinuses with respect to the specified implant site, incisive canal, mandibular canal and mental foramen can be assessed on CBCT images. The ability of CBCT to produce cross sectional images with low radiation exposure and low cost makes it applicable for dental implant patients and contributes to precise treatment planning , thereby low risks for surgical CT

Georgescu et al. published a study in 2010 that stated CBCT was evaluated as a method of quantitative and

qualitative analysis of the alveolar crest in the anterior mandible. The study concluded that CBCT provides the clinicians all the necessary information when planning dental implants. In another study, Bortoluzzi et al stated that CBCT should be advised prior to dental extraction inorder to avoid potential complications.

**Prosthodontics:**

Few authors have reported the enhancement of CBCT in visualizing the maxillofacial bones. It mainly focuses on displaying the bones of the jaws, thereby highlights various problems associated the placement of implants later. Therefore proper treatment planning can be assured before the surgical removal of any impacted or displaced tooth, which is essentially useful in cases of craniofacial malformations[11].

**Orthodontics:**

CBCT technology is being used for the comprehensive imaging of orthodontic patients.

Here it is mainly used for growth assessment, pharyngeal airway analysis, orthognathic surgical planning[12], planning of temporary anchorage devices.3D advanced imaging of CBCT had additional advantage over conventional imaging for orthodontics in providing valuable diagnostic informations.

**Conclusion:**

CBCT imaging is now emerging as a most valuable diagnostic tool in dentistry. Now it has been widely used in various areas in dentistry. Basic knowledge regarding this imaging is required for general dentist as well which lead to better diagnosis.

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