APPLICATION OF CONE BEAM COMPUTED TOMOGRAPHY (CBCT) IN DENTAL PRACTICE: A REVIEW

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ABSTRACT
Recent decades have seen the development of imaging modalities like Computed Tomography (CT), Magnetic Resonance Imaging (MRI), nuclear medicine and ultrasonography that have revolutionized dental and medical diagnosis. Static projection images were relied upon for diagnoses in the maxillofacial region, but we are now moving toward digital, 3-dimensional and interactive imaging applications. Much of this movement is attributed to a recently introduced CT technology known as cone-beam computed tomography. It is considered by many as “what was missing” in the field. The original CT technology which is used extensively in medical diagnosis is designated as medical CT, and the newer modality used primarily in dentistry is Cone-Beam Computed Tomography (CBCT) also termed as Cone-Beam Volumetric Tomography (CBVT), Dental Volumetric Tomography, Cone-Beam Volumetric Imaging (CBVI), or Dental Computed Tomography.

INTRODUCTION
Cone beam computed tomography (CBCT) is a new method which uses the reciprocal rotation of a two-dimensional receptor and a cone-shaped x-ray beam to gain volume data. [1] Interest in CBCT from all fields of dentistry is extraordinary because it has created a revolution in maxillofacial imaging, and it play an important role in diagnosis of the maxillofacial disorders and guide in surgical procedures by way of third party applications software. 3-D imaging has improved the diagnostic efficiency and practice of dentistry in a variety of ways: from routine evaluation to complex analysis of unusual pathology and congenital deformities.

Conventional tomography involves the use of complex multidirectional movements in order to achieve radiographic slices of the volume under investigation. More recently, conventional tomography has been largely replaced by CT and CBCT. Regardless of the technique, plain radiography has only a limited capability in the evaluation of 3-D relationships. Technological advances in radiological imaging have moved from 2D projection radiography towards digital, 3-D and interactive imaging applications. This has been achieved first by the use of conventional single and later multi slice, CT (MSCT) and more recently by CBCT. So many areas of dentistry, the conventional panoramic and/or the full mouth survey would be adequate, but there may come a time when a multi-planar image such as Computed Tomography (CT) is needed.[2]
CBCT in Oral And Maxillofacial Surgery

CBCT enables the analysis of:
- Jaw pathology.
- The assessment of impacted teeth.
- The assessment of supernumerary teeth and their relation to vital structures.
- To assess the changes in the cortical and trabecular bone related to bisphosphonate-associated osteonecrosis of the jaw.
- To analyze and assessing paranasal sinuses.
- To assess the mid-face fracture, orbital fracture.
- For orthognathic surgery planning [3].

Honda et al. describe a clinical case in which the time needed to complete a tooth auto-transplant case was significantly shortened owing to the application of CBCT [4].

CBCT in Temporomandibular Joint

Morphologic changes of the temporomandibular joint (TMJ) as depicted with conventional MRI, CT, and radiographic imaging are often useful in diagnosing pathologic processes such as:
- Degenerative changes and ankylosis.
- Joint remodeling after disectomy.
- Malocclusion and congenital and developmental malformations.

CBCT is a technique that has recently inspired research in TMJ imaging, though preliminary experiments have yet to translate into clinical studies. Several cadaveric series have explored the use of TMJ CBCT to assess per articular bony defects, flattening, osteophytes, and sclerotic changes. Preliminary studies have also directly compared CBCT with radiography, multidetector row CT (MDCT), and linear tomography for detection of osseous abnormalities of the TMJ [5, 6].

Uses of CBCT in Implantology

Path of insertion, with CBCT scans, the dentist can accurately determine bone augmentation elevating implant treatment: triangle bone concept utilizing CSCS; many new and profound developments in 3-D dental imaging technology were unveiled. These new developments enable dentists to visualize the internal anatomy of the head and jaws with unparalleled accuracy and clarity. CBCT scans can also be used for identifying occult fractures of the crown or root that cannot be detected by any other means. CBCT has reduced implant failures by providing information about bone density, the shape of the alveolus, and the height and width of the proposed implant site for each patient [7, 8].

CBCT in Endodontology

CBCT is a very useful tool in diagnosing apical lesions including periapical abscess, periapical cyst [9]. CBCT also used in detecting fractured roots. Vertical and horizontal root fracture detection is described in several clinical cases. It is also agreed that CBCT is superior to peri-apical radiographs in detecting these fractures, whether they are bucco-lingual or mesiodistal. In cases with inflammatory root resorption, lesions are detected much easier in early stages with CBCT compared. In other cases, such as external root resorption, external cervical and internal resorption, not only the presence of resorption was detected, but also the extent of it. CBCT can also be used to determine root morphology, the number of roots, canals and accessory canals, as well as to establishing the working length and angulations of roots and canals.

When ordering CBCT to evaluate a suspicious periapical lesion, or already failed root canal therapy, it is important to select the correct parameters, such as small volume and a voxel size of 0.125 mm, to achieve a diagnostic quality image [11].

Utilization of CBCT in Orthodontics

The introduction of new software in orthodontic assessment has enabled the use of CBCT images in cephalometric analysis and has led to CBCT becoming the tool of choice for assessing facial growth, age, airway function and disturbances in tooth eruption [12, 13]. CBCT is a reliable means in assessing the proximity of the tooth to vital structures that may interfere with orthodontic treatment. In cases that require the placement of tiny screw implants as temporary anchors, CBCT acts as a useful visual guiding technique for safe insertion of these anchors as well as to assess the bone density before, during and after treatment. CBCT incorporates multiple different views of an object in one scan (e.g., frontal, right lateral, left lateral, 45-degree, and sub-mental views), which is an additional advantage of the technique. CBCT is therefore considered a more accurate option for the clinician because the images are self-corrected for magnification, producing orthogonal images with a 1:1 ratio [14-16].

CBCT in Prosthodontics

The impact of CBCT technology on maxillofacial imaging since its introduction cannot be underestimated. This does not imply that CBCT is appropriate as an imaging modality of first choice in dental practice.

CBCT in Forensic Dentistry

Dental age estimation methods, which are a key element in forensic science, are described in the literature. CBCT was established as a non-invasive method to estimate the age of a person based on the pulp–tooth ratio. Typically, extraction and sectioning are required to quantify these morphological changes, which is not always a viable option. CBCT, however, provides a non-invasive alternative [17].

CBCT in Oral Radiology

The main indication for the examination was implant planning in diagnosis or exclusion of dental infection or peri-implantitis represented of the
examinations, and Tooth/root or foreign body localization. Subjectively, the bone structure of TMJs could be determined clearly in CBCT images and these images gave more radiographic information than the panoramic radiographs. In addition to identification of the bone contours of the condyle and glenoid fossa in CBCT images, the joint space could be evaluated. The CBCT is used for the diagnosis of maxillofacial pathologies and treatment planning [18].

Advantages of CBCT
- It has a rapid scan time as compared with panoramic radiography and gives complete 3D reconstruction and display from any angle.
- Its beam collimation enables limitation of X-radiation to the area of interest.
- Image accuracy produces images with sub milli meter isotropic voxel resolution ranging from 0.4 mm to as low as 0.076 mm.
- Reduced patient radiation dose (29–477 μSv) as compared with conventional CT (approx. 2000 μSv). Patient radiation dose is five times lower than normal CT, as the exposure time is approximately 18 seconds, that is, one-seventh the amount compared with the conventional medical CT.
- CBCT units reconstruct the projection data to provide interrelational images in three orthogonal planes (axial, sagittal, and coronal).
- Multiplanar reformation is possible by sectioning volumetric datasets nonorthogonally.
- Multiplanar image can be “thickened” by increasing the number of adjacent voxels included in the display, referred to as ray sum.
- 3D volume rendering is possible by direct or indirect technique.
- The three positioning beams make patient positioning easy. Scout images enable even more accurate positioning [19, 20].

Disadvantages
The only disadvantage is its cost. But considering the enormous benefits, this cost effect can be overlooked.

CONCLUSION
CBCT allows complete visualization of the oral and maxillofacial region. CBCT technology aids in the diagnosis AND TREATMENT OF periapical pathosis and endodontic pathosis. CBCT has increased accuracy, higher resolution, and reduced scan time. CBCT eliminates superimposition of surrounding structures. The development and rapid commercialization of CBCT technology dedicated for imaging the maxillofacial region will certainly increase dental practitioner access to 3D radiographic assessments in dental practice.

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REFERENCES


Cone-beam computed tomography (CBCT) systems, which have been used more recently in dental applications in recent years and which are developed especially for the display of dentomaxillofacial structures, enable the acquisition of three dimensional volumetric data with single rotation and very low radiation dose. CBCT devices, which are cheaper and have lower radiation doses than medical computed tomography (CT) devices, allow for detailed analysis and reordering of images in multiplanar planes (coronal, sagittal and oblique). The cone beam computed tomography (CBCT) technique was first inserted in dental imaging 15 years ago. Due to this technique 3D imaging in dentistry has been excessively changed. Cone-beam computed tomography (CBCT) systems have been designed for imaging hard tissues of the maxillofacial region. CBCT is capable of providing sub-millimetre resolution in images of high diagnostic quality, with short scanning times (10-70 second). Increasing availability of this technology provides the dental clinician with an imaging modality capable of providing a 3-dimensional representation of the maxillofacial skeleton with minimal distortion. This article provides an overview of currently available maxillofacial CBCT systems and reviews the specific application of various CBCT display modes to clinical dental practice.

Authors: William C Scarfe; Allan G Farman; Predag Sukovic. Cone beam computed tomography is a quite modern and recent technology in dental medicine. It's actually about 15 to 20 years old, and has been introduced in the year 2000 into our field. To a dental cone beam computed tomography? The cone beam, as you see on the image on the left, enables us to take an image with one rotation, which is in contrast to CT imaging where the slice, or the fan beam actually leaves us to take an image of a head by doing a lot, or multiple rotations. If you go back to the core of a CBCT, the core of the image, actually, that's a voxel. Voxel can be of different sizes. Of a sitting CBCT device, our patients are actually awake, and they move. And when they move, we can have slight artifacts.