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Review Article

CBCT an inbound necessity in dentistry

Anusha Rani[1]*, Nagraj[1], Fouzia Sultana[1], Deepak K Sharma[2], Farhana B[3]

[1]*Anu Dental Pvt. Ltd., Hyderabad, Telangana, India*
[2]*Rajasthan Dental College, Rajasthan, India*
[3]*S. B Patil Dental College, Bidar, Karnataka, India*

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ABSTRACT

CBCT has become increasingly important in treatment planning and diagnosis in implant dentistry, ENT, orthopedics, and interventional radiology (IR), among other things. Perhaps because of the increased access to such technology, CBCT scanners are now finding many uses in dentistry, such as in the fields of oral surgery, endodontics and rthodontics. Integrated CBCT is also an important tool for patient positioning and verification in image-guided radiation therapy

1. Introduction

Dentistry has experienced significant major advancement in technology and innovations over the past decade. Even With these leading innovation for a more precise and accurate diagnosis and as a prognostic indicator there is a need of advanced diagnostic tools, especially in imaging modality have become mandatory. In the field of modern dentistry there is a availability of various imaging options From the simple intra-oral periapical X-rays to a advanced imaging techniques like computed tomography, cone beam computed tomography, magnetic resonance imaging and ultrasound. The advent of digital imaging has revolutionized radiology, Changing from analogue to digital radiography has not only made the process simpler and faster but also made image storage, manipulation (brightness/contrast, image cropping, etc.) and retrieval easier. The three-dimensional imaging has made the complex cranio-facial structures more accessible for examination and early and accurate diagnosis of deep seated lesions.[1]

Rapid progress in medical imaging physics and technology, involving several hardware and computational methods, has overcome many challenges to achieve 3D dental imaging (known as CBCT) and to offer tools to improve 3D image quality in terms of spatial resolution, contrast, and anatomical coverage.[2,3] CBCT is also known as digital volume tomography, which refers to representation of image data in digital forms, and most essentially, depiction of anatomy in three dimensions.[4]

Dental radiological imaging can be used to evaluate the stage of development and growth of an individual for identification or other legal purposes including establishment of age for criminal sentencing or immigration reasons. It may also be used to evaluate dentate identification for establishment of a person's individuality as part of a legal research. Dental radiographs provides a significant revelation of dental treatment, post mortem examination and transcription of ante mortem data, the two odontograms are compared. Feature evaluated include;

1. Anodontia, Hypodontia, Hyperdontia
2. Dental restorations (posts, implants, root canal fillings, ceramic fillings)

* *Corresponding author*.
E-mail address: anudentalcare@gmail.com (A. Rani).

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3. Skeletal and dental malformation
4. Bony pathology (cysts, fractures, etc.)
5. Tooth morphology and associated bony structure
6. Architecture of bone

Subsequent to drastic events such as natural disasters, outbreak of wars or air traffic accidents, positive identification of victim's gender becomes, perhaps, the most difficult task to encounter in forensics. Anthropometric measurement obtained from CBCT scan can be used for evaluation of sexual dimorphism. 3D imaging is becoming more relevant in all aspects of human life and substantial effort is spend for the models regarding the human body. 3D reconstruction of image is possible with their provided data.[2]

The idea of CBCT was implemented in radiology soon after the creation of the first CT scanner. The introduction of cone-beam computer tomography in Endodontics has provided valuable information that greatly aids diagnosis and treatment planning, as well as providing three-dimensional guidance during root canal treatment.[5]

Cone beam computed tomography (CBCT)-also known as digital volumetric imaging-is an extraoral imaging technique that was developed in the late 1990s to produce 3D scans of the maxillofacial skeleton at a considerably lower radiation dose than computed tomography**.** The entire 3D volume of data is acquired in the course of a single sweep by the scanner, using a simple, direct relationship between sensor and source, which rotate synchronously around the patient"s head. There is a between 180 to 360 degree rotation of x-ray source and detector around the patient. Unlike CT scans, most CBCT scans are taken with the patient sitting or standing up. The X-ray beam is cone-shaped (hence the name of the technique), capturing a cylindrical or spherical volume of data, described as the field of view (FOV). The FOV varies between different CBCT scanners.[4] Voxel, analogous to a number of volumetric pixel encpampassed in an each reconstructed image and a typically Voxel size ranges from between 0.08 to 0.125 mm[3]. Small FOV CBCT scanners usually have a lower effective dose than CT scanners.

Field of view (FOV) size' influence the quality of radiographic images and the radiation dose received by patients. In cone-beam computed tomography (CBCT) FOV should be selected according to therapeutic purposes. The size of FOV is indirectly proportional to voxel size, increase in size of FOV reducing the number of projection images taken as the X-ray source rotates around the patient may further declines the radiation dose.

Typically, images are displayed in the three orthogonal planes-axial, sagittal and coronal-simultaneously. Coronal and axial views of the tooth are readily produced, allowing the clinician to gain a truly 3D view of the entire tooth and its surrounding anatomy. For the first time, the clinician is able to use a patient-friendly imaging system to easily view areas of interest in any plane, rather than being restricted to the superimposed 2D images available with conventional radiography.

There are many limitation with conventional radiography overcame by CBCT such more accuracy in assessing a alveolar crest height, early detection of invasive cervical resorption lesions, widening of periodontal ligament space, vertical root fractures, and three-dimensional evaluation of the root canal space and surrounding anatomy and thus directly influencing treatment planning and decisions making. Accurate data leads to better treatment decisions and potentially more predictable outcomes.

Intraoral radiography is based on the transmission, attenuation. For an accurate projection of the tooth and recording of X-rays on an analog film or digital receptor, requires optimized geometric configuration of the X-ray generator, tooth, and sensor. The anatomical structures surrounding the tooth superimpose the standard x-ray picture and render it hard to interpret it.[3]

The gold standard of imaging modalities is to preview patient's anatomy in 3D formats, Cone Beam Computed Tomography (CBCT) provide a thorough understanding of a complex architecture of a facial skeleton and its content and eliminate the challenging situation to be encountered by surgeons to find a surgical access. CBCT imaging has clear indications and limitations. CBCT offers multi-planar views providing a sensitivity to discriminate between objects with small difference in density like blood and fat or blood and cerebrospinal fluid.[6]

CBCT imaging studies are mathematical constructs. These constructs are a powerful, effective solution to the problem of anatomical overlap we experience with periapical (PA) projection radiography. The CBCT reconstruction process also generates a host of artifactual findings that can mimic the appearance of common pathologic findings in PA projection radiography. These artifactual.

Findings complicate CBCT image interpretation, making it more difficult and more error-prone than PA radiography, even for clinicians who are highly experienced with two-dimensional (2D) PA radiography.

Cone-beam computed tomography (CBCT) provide dynamic multi-plane navigation, choices of volumetric parameter, such as slice thickness and slice intervals and data acquisition.

CBCT has become interestingly important in treatment planning and diagnosis in implant dentistry, ENT, orthopaededics etc.

CBCT has brought clinical advantage to almost all field of dentistry.

Therefore, in contemporary Endodontics, technological innovations supported by three-dimensional CBCT studies have established a true revolution, which has naturally led to the need to review some structured concepts based on conventional imaging methods.

1.1. Parts of CBCT

Parts of CBCT

1.1.1. Components used

1. X-ray generator
2. Image sensor
3. Image reconstruction

CBCT uses a cone- or pyramid-shaped beam as opposed to a fan-shaped beam. Secondly, it acquires all the data in a single rotation (or in some cases, even half a rotation). Thirdly, a small volume of the patient can be imaged, rather than the entire axial slice of the patient. This means there must be a detection area large enough to image the entire field of view required, as unlike MDCT the scanner needs to gather all the information in a single rotation. CBCT scan volume is likely to be small, so machines with small detector plates are suitable for endodontic purpose. For maxillofacial applications, the detector plates may have to be significantly larger to capture the entire region of interest In MDCT the centre of rotation is in the middle of the patient and the X-ray fan-shaped beam and detectors are large enough to image the whole axial slice. Most machines available on the market also scan with the patient standing or sitting, rather than lying down. The reason for this is for ease of use, and it allows CBCT machines to have a smaller footprint, similar to that of panoramic X-ray machines, which is making them easy to accommodate in dental practices and imaging centers.

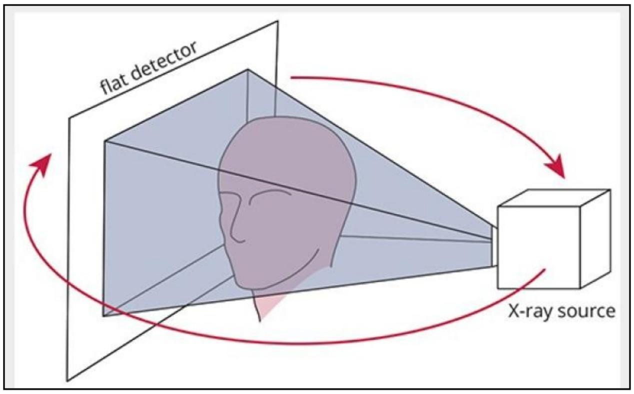

Figure 1: CBCT beam, showing cone-shaped X-ray beam against flat detector

Figure 2: Photograph of 3D Accuitomo 180 scanner (J Morita MFG, Osaka, Japan)

Figure 3: Photograph of i-CAT scanner (Imaging Sciences International, PA, USA)

1.1.2. Image intensifier

This is an older technology; however, it is still used daily in most general radiology departments in fluoroscopy suites. It works by increasing the size of the signal detected through acceleration of particles and minification of the image. The first screen (scintillator) is composed of caesium iodide and through phosphorescence converts the X-rays into visible light. This light is absorbed by the closely attached second layer (photocathode, which is made of antimony caesium) and is converted into electrons. The electrons acceleration takes place along a vacuum tube and focused onto a small output screen, where there is conversion of high-energy electrons back into visible light by the output phosphor (zinc cadmium sulphide). Thus, the acceleration process and the minification of the image means one incoming X-photon detected at the detector plate is converted to enough visible light to

1.1.3. Ideal machine characteristics

1. Good value and easy to use
2. Stable footprint
3. Low dose
4. Good software
5. Adjustable field of view-reduces scatter and dose
6. Adjustable exposure parameters-reduces scatter and dose
7. Quick scanning-reduces movement artefact
8. Good contrast and spatial resolution
9. Small X-ray tube target-reduces penumbra/geometric unsharpness
10. Good detection efficiency (see Comparing the three detector types)
11. Reliable
12. Easily serviceable
13. Easily upgradable
14. Fully integrable into practice/hospital infrastructure
15. DICOM compliant

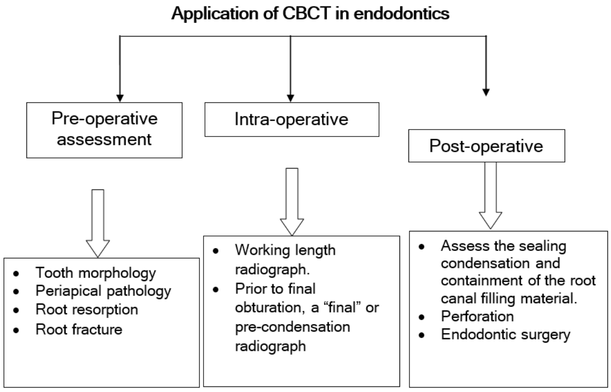

Figure 4:

Critical component in diagnosis, treatment, and evaluation of healing is a radiographic interpretation. The film-based radiograph or digital imaging interpretation continues to be a somewhat subjective process.[7] showed that the agreement between six examiners was only 47% when evaluating healing of periapical lesions using 2D periapical radiographs. In a follow-up study,[8] also reported that when examiners evaluated the same films at two sdifferent times, they only had 19– 80% agreement with their previous interpretations. In recent study, periradicular radiolucencies evaluated by interobserver and intra-observer reliability using a digital radiography. Agreement among all six observers for all radiographs was less than 25 %, and agreement for five of six observers was approximately 50%.[9]

CBCT's undeniable advantage of multiplanar reconstruction has revolutionised implant dentistry; it allows visualisation without the superimposition of structures. This ability to view structures from 'different angles' helps to more accurately evaluate the architecture and dimensions of the bone; the contour and visual density, the cortex and trabeculae pattern within the bone and the surrounding anatomical structures.[10]

With regard to the mandibular fractures it has been stated that CBCT is superior to panoramic radiography as condylar and coronoid fractures and the anterior part of the mandible were more difficult to detect due to superimposition.[11]

Soft tissue calcification is common and caused by a wide range of pathologies. Radiographs might show soft tissue calcifications, which can be suggestive of a specific diagnosis. In patients presenting for dental treatment, some calcifications can be detected at panoramic radiography owing to the proximity of soft tissue structures to the focal trough.[1] However, these images are inherently planar and 2-dimensional (2D), making localization and diagnosis problematic which can be overcome by CBCT.[12]

Regarding temporomandibular joint (TMJ) dysfunction, CBCT was regarded as an accurate and reliable tool for assessing 3D condylar volume, shape, and angulation objectively in paediatric patients with bilateral cleft lip and palate, unilateral posterior crossbite, and juvenile idiopathic arthritis.[13]

2. Conclusion & Future Perspective

Dental X-Rays are important for diagnosing and treating patients by helping to detect oral health issues when they can't be detected by visual or physical examination alone. Though 2 Dimensional X-Ray and Panoramic radiography can predict diagnosis in number of clinical cases, certain situations demand multiplanar imaging, one such technology is CBCT. Although CBCT has become an indispensable tool for various dental applications, there is a lot of room for dose reduction of this modality by following the optimization and justification principles. The principle of optimization hold that operator should use every reasonable means to reduce unnecessary exposure to their patients, their staff, and themselves. It can be seen that a few recent innovations are already implemented in clinical practice by one or a few manufacturers and may or may not

Table 1: Advantages and disadvantages of CBCT

	CBCT
Advantages	1. Provides accurate cross sectional information. 2. Short scanning time. 3. No superimposed tomographic blurring. 4. Multiplanar views and 3 D reconstruction possible. 5. Uniform magnification.
Disadvantages	1. Imaging of entire jaw rather than site of interest in the majority of scanners. 2. Relatively expensive 3. Amalgam and metallic restorations can cause artefacts 4. Limited bone density information provided[14]

become the standard for the near future. MSCT a recent optimization imaging modalities, can provide a further optimization. A few other potential optimizations are more speculative, and their added value and marketability remains to be investigated. Nevertheless, the effective radiation dose to patients when using CBCT is higher than in conventional intraoral radiography and any benefit to the patient of CBCT scans should outweigh any potential risks of the procedure, in order to be justified. The radiation should be as low as reasonably achievable (ALARA). Finally, the combination of CBCT with optical imaging and its use in nondental applications is gradually being explored, and the use of phase contrast tomography has been demonstrated experimentally and might be introduced into clinical practice. The 3D reconstructed image produced, reveals multilayer images in 3 orthogonal planes (coronal, sagittal and transverse).[15]

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None.

4. Conflict of Interest

None.

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Author biography

Anusha Rani, Endodontist

Nagraj, Chief Dental Surgeon

Fouzia Sultana, Chief Dental Surgeon

Deepak K Sharma, Principal

Farhana B, PG Student

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