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

Md Asad Iqubal[1], Sunil R. Panat[2], Mobeen Khan[3], Kausar Parwez Khan[4], Prateek Jain[5], Swetarchi[6]

[1]Post Graduate Students, Department of Oral Medicine and Radiology, Institute of Dental Sciences, Bareilly, India.
[2]Professor and HOD, Department of Oral medicine and Radiology, Institute of Dental Sciences, Bareilly, India.
[3]Post Graduate Students, Department of Oral Medicine and Radiology, Institute of Dental Sciences, Bareilly, India.
[4]Post Graduate Students, Department of Periodontology and Implantology, Institute of Dental Sciences, Bareilly, India.
[5]Post Graduate Students, Department of Orthodontics and Dentofacial Orthopedics, Institute of Dental Sciences, Bareilly, India.
[6]Post Graduate Students, Department of Oral Medicine and Radiology, Institute of Dental Sciences, Bareilly, India.

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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.

Corresponding Author

Asad Iqubal
Email: - md.asadiqubal@gmail.com

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 analyse 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 diskectomy.
- 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 CSCT; 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 Endodontics

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.[10] 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, andTooth/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

1. Bianchi SD, Lojacono A. (1998). 2D and 3D images generated by cone beam computed tomography (CBCT) for dentomaxillo-facial investigations. In: Lembe H, Vannier MW, Inamuson K, Farman A, eds. CAR '98 Computer Assisted Radiology and Surgery. *Amsterdam: Elsivier*; 2, 792-797.
2. Scarfe WC, Farman AG, Sukovic P. (2006). Clinical applications of cone-beam computed tomography in dental practice. *J Can Dent Assoc*, 72, 75-80.
3. Heiland M, Schulze D, Rother U, Schmelzle R. (2004). Postoperative imaging of zygomaticomaxillary complex fractures using digital volume tomography. *J Oral Maxillofac Surg*, 62(11), 1387–91.
4. Dolly M J, Siewerdsen JH, Moseley DJ et al. (2006). Intraoperative cone beam CT for guidance of head And neck surgery: assessment of dose and image quality using a C arm. *Prototype*, 33, 3767-3780.
5. Honda K, Matumoto K, Kashima M, Takano Y, Kawashima S, Arai Y. (2004). Single air contrast arthrography for temporomandibular joint disorder using limited cone beam computed tomography for dental use. *Dentomaxillofac Radiol*, 33(4), 271–273.
6. Tsiklakis K, Syriopoulos K, Stamatakis HC. (2004). Radiographic examination of the temporomandibular joint using cone beam computed tomography. *Dentomaxillofac Radiol*, 33(4), 196–201.
7. Hatcher DC, Dial C, Mayorga C. (2003). Cone beam CT for pre-surgical assessment of implant sites. *J Calif Dent Assoc*, 31(11), 825-833.
8. Hua Y, Nackaerts O, Duyck J, Maes F, Jacobs R. (2009). Bone quality assessment based on cone beam computed tomography imaging. *Clin Oral Implants Res*, 20(8), 767-771.
9. Hassan B, Metska ME, Ozok AR, van der Stelt P, Wesselink PR. (2010). Comparison of five cone beam computed tomography systems for the detection of vertical root fractures. *J Endod*, 36(1), 126-129.
10. Hassan B, Metska ME, Ozok AR, van der Stelt P, Wesselink PR. (2009). Detection of vertical root fractures in endodontically treated teeth by a cone beam computed tomography scan. *J Endod*, 35(5), 719-722.
11. Adibi S, Zhang W, Servos T, Neill P. (2012). Cone Beam Computed Tomography for General Dentists, 1, 519.

12. Farman AG, Scarfe WC. (2006). Development of imaging selection criteria and procedures should precede cephalometric assessment with cone-beam computed tomography. *Am J Orthod Dentofacial Orthop*, 130(2), 257-65.
13. Bart Vandenberghe, Reinhilde Jacobs, Hilde Bosmans. (2010). Modern dental imaging: a review of the current technology and clinical applications in dental practice. *Eur Radiol*, 10, 330.
14. Erickson M, Caruso JM, Leggitt L. (2003). Newtom QR-DVT 9000 imaging used to confirm a clinical diagnosis of iatrogenic mandibular nerve paresthesia. *J Calif Dent Assoc*, 31(11), 843-5.
15. Gracco A, Lombardo L, Cozzani M, Siciliani G. (2006). Quantitative evaluation with CBCT of palatal bone thickness in growing patients. *Prog Orthod*, 7(2), 164- 174.
16. Choi YS, Hwang EH, Chung KR, Kook YA, Nelson G. (2007). Surgical positioning of orthodontic mini-implants with guides fabricated on models replicated with cone-beam computed tomography. *Am J Orthod Dentofacial Orthop*, 131(4), 82-89.
17. Yang F, Jacobs R, Willems G. (2006). Dental age estimation through volume matching of teeth imaged by cone-beam CT. *Forensic Sci Int*, 159(1), 78-83.
18. Nakagawa Y, Kobayashi K, Ishii H, Mishima A, Ishii H, Asada K, Ishibashi K. (2002). Preoperative application of limited cone beam computerized tomography as an assessment tool before minor oral surgery. *Int J Oral Maxillofac Surg*, 31(3), 322-326.
19. Ludlow JB, Davies-Ludlow LE, Brooks SL, et al. (2006). Dosimetry of 3 CBCT devices for oral and maxillofacial radiology: CB Mercuray, NewTom 3G and i-CAT. *Dentomaxillofac Radiol*, 35, 219–226.
20. Schulze D, Heiland M, Thurmann H, et al. (2004). Radiation exposure during midfacial imaging using 4- and 16-slice computed tomography, cone beam computed tomography systems and conventional radiography. *Dentomaxillofac Radiol*, 33, 83–86.