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Review Article

CBCT: Opening New Horizons in Dentistry

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Abstract

The advancement of imaging methods has empowered oral radiology, enabling them to improve their diagnoses and ensuing treatment strategies. However, even when present Imaging has been regarded as one of the most essential, accurate, precise, and non-invasive technologies for assessment, analysis, and choosing the current treatment plan among the variety of modern diagnostic procedures available. Oral rehabilitation requires meticulous diagnostic therapy planning, which is impossible to do without the aid of diagnostic imaging. Cone beam computed tomography (CBCT), which has a reputation for accuracy and a wide range of therapeutic applications, was developed as a result. Cone-beam tomography is assisting in diagnosis in the modern day by providing a massive three-dimensional image. For proper treatment planning and efficient dental care, CBCT is employed not only in the disciplines of surgery, endodontics, prosthodontics, and orthodontics, but also in forensics and radiotherapy. The purpose of this study is to inform dental clinicians about the use of CBCT in various dental sciences domains.

Keywords: *CBCT, Radiology, Diagnosis, Dentistry.*

Introduction

An amazing period in medical history began in 1895 with Sir Wilhelm Conrad Roentgen's discovery of X-rays. With the advent of diverse imaging technologies and intricate physical concepts, diagnostic imaging has advanced over the past few decades.[1] There is skepticism that two-dimensional (2D) radiography, which was the foundation of diagnostic imaging for many years, will continue to contribute given its limitations (superimpositions, distortions, etc.). The main reasons for CT's underuse in dentistry, however, were its high cost, restricted availability, and higher radiation exposure. A comparatively recent technology called CBCT was introduced to dentistry in the late 1990s.[2-4]

CBCT has become more widely available thanks to ongoing technological advancements in these hardware and software systems as well as cost-saving measures for both patients and medical professionals. Furthermore, CBCT uses in dentomaxillofacial imaging have increased significantly as a result of the many apparent advantages it has over traditional computed tomography (CT) and traditional panoramic and intraoral imaging.**[**5-7**]**

Principle of CBCT: Four very significant technological advancements that came about at the beginning of the 1990s helped make it possible to assemble CBCT machines for very low prices that are small enough to be utilised in dental offices for maxillofacial imaging without taking up a lot of room:

- The development of x-ray detectors capable of quickly acquiring many basic pictures.
- Development of x-ray generators with the appropriate high output.
- Development of effective algorithms for combining and acquiring images.

The two main components of computed tomographic (CT) scanners are an x-ray source producing unit and a detector situated on a rotating gantry. The x-ray source generates radiation throughout the gantry's revolution, while the receptor captures any radiation that remains after being attenuated by the exposed tissues of the patient. These recordings typically serve as the "raw data" that a computer program uses to recreate a number of cross-sectional images. The picture element (pixel) values are the fundamental part of these grayscale images. Each pixel's grayscale value or intensity is related to the quantity of photons that are impinging on the detector.

An x-ray source and detector are mounted on a rotating platform, or gantry, which is used to perform CBCT imaging. The region of interest (ROI) is traversed by a diverging cone-shaped or pyramidal source of radiation, and the residually attenuated radiation beam is projected onto an area x-ray detector on the other side. The ROI's middle serves as the rotating centre around which the x-ray source and detector revolve. The final acquired image volume is centred at this rotational axis. As the x-ray source and detector rotate across an arc of 180 to 360 degrees, numerous sequential planar projection images are captured. These single-projection images—also known as basis, frames, or raw images—make up the raw main data. With the exception of one being slightly offset from the previous, basis images resemble cephalometric radiography images in appearance. The picture volume is generated and built using typically several hundred two-dimensional basis images. The projection data refers to the entire collection of photos. Only one rotating scan of the gantry of 180 to 360 degrees is required to collect adequate data for volumetric image creation because CBCT exposure incorporates the whole ROI. These projection data are subjected to software applications that incorporate complex techniques, such as filtered back projection, to create a volumetric data set that may be utilised to produce primary reconstruction pictures in three orthogonal planes (axial, sagittal, and coronal).[8-10]

Application of CBCT in Dentistry

Oral Medicine and Radiology:

CBCT produces 3D images useful for many oral and maxillofacial situations that can guide in diagnosis and assessment of disease severity, planning and delivery of treatment, and follow-up.[5]

CBCT in Oral Surgery:

Major uses of CBCT examination in oral surgery include pre-surgical evaluation of impacted teeth, detection of inflammatory conditions of the jaws and the sinuses, evaluation of cysts and tumors, assessment of the temporomandibular joints, dentofacial fracture detection, implant planning and as an aid in diagnosing unexplained symptoms of pain.[11] The current available literature indicates that CBCT diagnostic radiography provides true and precise anatomical information with high intraobserver and interobserver reproducibility. This enables accurate and reliable diagnoses thereby reducing the possibility of missing clinically relevant findings. This radiographic modality has a vast array of utility in oral surgery and allows pragmatic surgical planning and subsequent post-operative evaluation with submillimetric accuracy.[12,13]

CBCT in Orthodontics:

For morphometric examination of structures and anatomic linkages crucial for addressing varied orthodontic demands, CBCT provides superimposition free pictures that are self-corrected for magnification and with a practical 1:1 measuring ratio.

Assessment of palatal bone thickness, skeletal growth patterns, dental age estimation, visualization of impacted teeth, determination of available alveolar bone width for buccolingual movement of teeth, assessment of the upper airway, and planning of orthognathic and facial orthomorphic surgeries are some of the uses of orthodontics.**[**14-17**]** The best method for determining facial growth, age, airway function, and abnormalities in tooth eruptive patterns has been found to be the availability of software such as Dolphin and In Vivo Dental in combination with CBCT pictures for cephalometric analysis. CBCT offers visual instructions for placing mini implants safely, preventing unintentional damage to critical structures that cannot be repaired.**[**18,19**]**

CBCT in Periodontics: Compared to digital intraoral radiography, CBCT enables better identification of bone craters, crestal bone loss, fenestrations, dehiscence, and furcation involvements. The scientists also came to the conclusion that CBCT imaging is unique for detecting bone topography with little error and lesion architecture, but with accuracy comparable to that of 2D for determining bone height. The majority of CBCT software has features for evaluating bone density, which help determine and forecast the treatment mode and its prognosis.**[**20**]**

CBCT is not recommended as a routine procedure, despite its great value in periodontics. But traditional radiographic examinations typically do not yield the high-resolution image required for therapy in cases of infrabony (buccal or lingual) deformities and furcation involvements. Within a month, CBCT can be helpful for surgical defect filling or bone density assessment, which cannot be seen on standard radiographs. It can also take the place of subtraction radiography.**[**21,22**]**

CBCT in Implantology:

Sagittal, axial, and coronal are the three spatial planes that CBCT offers cross-sectional images of the alveolar bone in order to measure its height, width, density, and angulations. Additionally, cross-sectional views, which are invisible on panoramic scans due to overlapping, can be used to delineate the loss of buccal or lingual cortical plates as well as unexpected concavities. In addition to defining the boundaries of important vital structures in surgical preparation for dental implant planning, such as the incisive canal, mental foramen mandibular canal, and maxillary sinus, CBCT images also show the quantity and quality of bone that is available for implant placement.

We may learn about ridge patterns like irregular ridge, narrow crestal ridge, and knife shape ridge from cross-sectional photographs. The purpose of CBCT in implantology is to measure the distance between an implant and important anatomical structures in order to determine whether a bone By assessing the alveolar bone thickness, density, and bony contours, determining the implant type and size for a specific patient, and last but not least, determining the implant site and optimal angulations in accordance with individual anatomization, it is possible to determine if a graft or sinus lift is necessary or not.[23]

CBCT in Endodontics:

With traditional 2D imaging modalities, it becomes challenging to analyze the amount of periapical diseases, canal morphology, root fractures, specific placement of damaged instruments in root canals, etc. Cone-beam computed tomography offers a better read for finding opaque canals, calcified canals, and root curvature. CBCT is a useful diagnostic tool since it makes measurements related to roots, such as root length, kind of canals present, angle of curvature, etc.[24]

CBCT in TMJ Disorder:

The hard tissues of the temporomandibular joint (TMJ) have mostly been assessed by conventional CT, but due to several of its limitations, including the time required for exams and the sensitivity of the technology, its use for diagnosis by dental doctors has been restricted.15 The examination of bony or hard tissue alterations to the joint has been the most important use of CBCT in imaging the TMJ. The best way to see pathologic alterations, including fractures, ankylosis, dislocations, and growth anomalies like condylar hyperplasia, is using a computed tomography (CT) scan.[25]

CBCT in Forensic Dentistry:

Age estimation is an important aspect of forensic dentistry. Enamel is typically resistant to changes beyond regular wear and tear; nonetheless, with advancing age, the pulpodentinal complex exhibits physiologic and pathological changes. Typically, tooth extraction and sectioning are required to quantify these alterations, which is not always a practical option. However, CBCT provides a non-invasive alternative.[26]

CBCT in Virtual Treatment Planning:

Virtual treatment planning, such as implant planning, is possible using the software (either primary or third-party) provided with CBCT images. This planning can then be transported to the surgical site either directly by using image guided navigation or indirectly by building surgical guides (10, 63, 64). The surgical guides may be manufactured by rapid prototyping or may be modified laboratory imaging stents. utilizing three-dimensional computer-aided design (CAD) data, a scale model of a physical item or assembly can be swiftly constructed utilizing a variety of processes known as rapid prototyping. The majority of the time, "additive layer manufacturing" or 3D printing is used to construct the item or assembly. In dentistry, fast prototyping is used to create actual-size, dimensionally accurate models of anatomical structures. These models are used to simulate procedures for a variety of complicated oral and maxillofacial conditions, including trauma, tumor removal, distraction osteogenesis, and—more frequently—dental implants. With these models, the practitioner can increase their confidence before the procedure and cut down on the amount of time needed for anesthesia and surgery.**[**27-29**]**

Advantages of CBCT [30,31**]**

1. Precise identification and detection of periapical lesions
2. Detection of Mandibular Canal
3. A complete 3D Reconstruction and Display from any angle
4. Patient Radiation dose five times lower than normal CT
5. Easy Patient Positioning
6. Accurate three-dimensional image moreover there is no overlapping of profile dose in the single slices which leads to reduced irradiation.
7. Excellent Resolution

Limitations of CBCT:

Its price is the only drawback. However, considering the great advantages, this cost effect should be disregarded because the system is simple to operate and ideal for even quick diagnostic operations.**[**30**]**

Conclusion

While CBCT's therapeutic applications have multiplied in the current environment, we must also keep its drawbacks and restrictions in mind before prescribing. This should not discourage dental surgeons from using CBCT, either. However, with careful use, the inherent hazards of CBCT technology can be outweighed by the remarkable potential benefits. To achieve the wise application of CBCT technology, oral maxillofacial radiologists and dentists must have the appropriate training and education.

References

1. Paul S, Chawla M, Saraf BG, et al. Cone-beam Computed Tomography in Pediatric Dentistry: Case Series and Review. J Oral Health Comm Dent 2020;14(2):62–69.

2. Boeddinghaus R, Whyte A. Current concepts in maxillofacial imaging. Eur J Radiol 2008;66(3):396–418. DOI: 10.1016/j.ejrad.2007.11.019.

3. Aps JK. Cone beam computed tomography in paediatric dentistry: overview of recent literature. Eur Archi Paediat Dentis 2013;14(3):131–140. DOI: 10.1007/s40368-013-0029-4.

4. Qu XM, Li G, Sanderink GCH, et al. Dose reduction of cone beam CT scanning for the entire oral and maxillofacial regions with thyroid collars. Dentomaxillofacial Radiol 2012;41(5):373–378. DOI: 10.1259/dmfr/30200901.

5. Venkatesh E, Elluru SV. Cone beam computed tomography: basics and applications in dentistry. J Istanb Univ Fac Dent 2017;51(3 Suppl 1):102–121. DOI: 10.17096/jiufd.00289.

6. Vandenberghe B, Jacobs R, Bosmans H. Modern dental imaging: a review of the current technology and clinical applications in dental practice. Eur Radiol 2010;20(11):2637–2655. DOI: 10.1007/s00330-010-1836-1.

7. Mozzo P, Procacci C, Tacconi A, et al. A new volumetric CT machine for dental imaging based on the cone-beam technique: preliminary results. Eur Radiol 1998;8(9):1558–1564. DOI: 10.1007/s003300050586.

8. Kapshe N, Pujar M, Jaiswal S. Cone beam computed tomography: A review. Int J Oral Health Dent 2020;6(2):71-77.

9. Scarfe WC, Li Z, Aboelmaaty W, Scott SA, Farman AG. Maxillofacial cone beam computed tomography: essence, elements and steps to interpretation. Aust Dent J. 2012;57:46–60.

10. Feldkamp LA, Davis LC, Kress JW. Practical cone-beam algorithm. J Opt Soc Am. 1984;1(6):612–9.

11. Ahmad M, Jenny J, Downie M. Application of cone beam computed tomography in oral and maxillofacial surgery. Aust Dent J. 2012;57(1):82–94. doi:10.1111/j.1834-7819.2011.01661.x

12. Mukherji A, Singh MP, Nahar P, Bhuvaneshwari S, Daga D. Utilising CBCT in oral surgery. J Oral Med, Oral Surg, Oral Pathol, Oral Radiol 2021;7(2):91-97.

13. Ahmad M, Jenny J, Downie M. Application of cone beam computed tomography in oral and maxillofacial surgery. Aust Dent J. 2012;57(1):82–94. doi:10.1111/j.1834-7819.2011.01661.x.

14. Aboudara CA, Hatcher D, Nielsen IL, Miller A. A three-dimensional evaluation of the upper airway in adolescents. Orthod Craniofac Res. 2003;6(s1 Suppl 1):173–5. 10.1034/j.1600-0544.2003.253.x

15. Harrell WE., Jr Three-dimensional diagnosis and treatment planning: the use of 3d facial imaging and 3d cone beam CT in orthodontics and dentistry. Aust Dent Pract. 2007;18(4):102–13.

16. Kapila S, Conley RS, Harrell WE Jr. The current status of cone beam computed tomography imaging in orthodontics. Dentomaxillofac Radiol. 2011. January;40(1):24–34. 10.1259/dmfr/12615645

17. Peck JL, Sameshima GT, Miller A, Worth P, Hatcher DC. Mesiodistal root angulation using panoramic and cone beam CT. Angle Orthod. 2007. March;77(2):206–13.

18. Kim SH, Choi YS, Hwang EH, Chung KR, Kook YA, Nelson G. Surgical positioning of orthodontic mini-implants with guides fabricated on models replicated with cone-beam computed tomography. Am J Orthod Dentofacial Orthop. 2007. April;131(4 Suppl):S82–9. 10.1016/j.ajodo.2006.01.027 \

19. Kim SH, Kang JM, Choi B, Nelson G. Clinical application of a stereolithographic surgical guide for simple positioning of orthodontic mini-implants. World J Orthod. 2008;9(4):371–82.

20. Mengel R, Candir M, Shiratori K, Flores-de-Jacoby L. Digital volume tomography in the diagnosis of periodontal defects: An in vitro study on native pig and human mandibles. J Periodontol. 2005;76:665-673.

21. Dang V. Focus on cone beam computed tomography. Dent Pract. 2009;9:10–12.

22. Tyndall DA, Rathore S. Cone-beam CT diagnostic applications: Caries, periodontal bone assessment, and endodontic applications. Dent Clin North Am. 2008;52:825– 841.

23. Ludlow JB, Ivanovic M. Comparative dosimetry of dental CBCT devices and 64-slice CT for oral and maxillofacial radiology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008;106:106-114

24. Wahane K D, Bansod A V, Mattigatti S, et al. (March 21, 2023) Cone-Beam Computed Tomography (CBCT) Analysis of an Unusual Configuration of the Upper First Molar With a C-shaped Canal With Apically Fused Roots: A Case Report. Cureus 15(3): e36474. DOI 10.7759/cureus.36474

25. Larheim TA, Abrahamsson AK, Kristensen M, Arvidsson LZ. Temporomandibular joint diagnostics using CBCT. Dentomaxillofac Radiol. 2015;44(1):20140235. doi: 10.1259/dmfr.20140235. PMID: 25369205; PMCID: PMC4277441.

26. Yang F, Jacobs R, Willems G. Dental age estimation through volume matching of teeth imaged by cone-beam CT. Forensic Sci Int. 2006. May;159 Suppl 1:S78–83. 10.1016/j.forsciint.2006.02.031

27. Abou-ElFetouh A, Barakat A, Abdel-Ghany K. Computer-guided rapid-prototyped templates for segmental mandibular osteotomies: a preliminary report. Int J Med Robot. 2011. June;7(2):187–92. 10.1002/rcs.387

28. Jayaratne YS, Zwahlen RA, Lo J, Tam SC, Cheung LK. Computer-aided maxillofacial surgery: an update. Surg Innov. 2010. September;17(3):217–25. 10.1177/1553350610371626

29. D'Urso PS, Barker TM, Earwaker WJ, Bruce LJ, Atkinson RL, Lanigan MW et al.. Stereolithographic biomodelling in cranio-maxillofacial surgery: a prospective trial. J Craniomaxillofac Surg. 1999. February;27(1):30–7. 10.1016/S1010-5182(99)80007-9

30. Govila S, Gundappa M. Cone beam computed tomography - an overview. J Conserv Dent 2007;10:53-8

31. Mozzo P, Prococci C, Tacconi A, Tinazzi Martine, Bergamo P, Andries A. new volumetric CT Machine for dental imaging based on Cone¬beam technique: preliminary results. Oral Radial, 1998: 8: 1558-1564.