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ROLE OF CBCT IN ORTHODONTICS: A BRIEF REVIEW

Orthodontics

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ABSTRACT

Cone beam computed tomography (CBCT) is a relatively new method that produces three-dimensional (3D) information of the maxillofacial skeleton, including the teeth and their surrounding tissue, with a lower effective radiation dose than traditional CT scans. Specific endodontic applications for CBCT are being identified as the use of this technology becomes more common. For precise diagnosis, more reliable treatment planning, efficient patient care and education, improved treatment outcomes, and increased patient satisfaction, the use of CBCT is strongly advised. Because of how complicated the craniofacial complex, teeth, and airway are, it is challenging to conveniently acquire conventional images. Compared to conventional imaging, CBCT offers higher picture fidelity, which can improve vision. The use of CBCT in clinical patient evaluation is revolutionising orthodontics. In terms of diagnostic, clinical techniques, and result, it is likewise evolving. The purpose of the current literature review is to discuss the use of CBCT in orthodontics.

KEYWORDS

CBCT, Orthodontics, Application of CBCT

INTRODUCTION:

A remarkable period in the history of medicine was the 1895 discovery of X-rays by Sir Wilhelm Conrad Roentgen. Due to the introduction of many imaging technologies with intricate physical principles, diagnostic imaging has been much more polished during the past few decades. Three-dimensional imaging developed to fulfil the requirements of cutting-edge technologies in the delivery of the therapy, and it was also instrumental in the development of novel treatment modalities. Two-dimensional (2D) radiography, which for many years served as the foundation of diagnostic imaging, has limitations (superimpositions, distortions, etc.) and it is doubtful that it will continue to play a role in the future. In 1972, G.N. Hounsfield created computerised transverse axial scanning, which paved the way for the development of computed tomography (CT).[1]

Cone-beam computed tomography is a cutting-edge imaging technique with numerous clinical uses in dentistry. CBCT has been employed for dental and maxillofacial imaging and has proven to be a successful investigative method. The radiation exposure dose from CBCT during maxillofacial exposure is ten times lower than that from traditional CT scans. Additionally, CBCT has a high degree of accuracy and can deliver volumetric data in three dimensions in the axial, sagittal, and coronal planes.[2,3]

A radiographic imaging technique called cone beam computed tomography enables precise three-dimensional (3D) imaging of hard tissue structures. The most important of the recently developed medical diagnostic imaging modalities is CBCT. With quicker scanning times (60 s), this imaging technique can produce pictures with sub-millimeter resolution (2 line pairs/mm) and greater diagnostic quality. In terms of radiation exposure dose during maxillofacial exposure, CBCT scans are 10 times less harmful than traditional CT scans (68 Sv vs. 600 Sv), and they also have excellent dimensional accuracy (only 2% magnification).[4]

The use of CBCT is highly recommended for accurate diagnosis, more reliable treatment planning, effective patient care and education, enhanced treatment outcomes, and increased patient satisfaction. Conveniently collecting conventional pictures is difficult due to the complexity of the craniofacial complex, teeth, and airway. CBCT provides higher picture integrity than traditional imaging, which can enhance vision. When it comes to clinically evaluating patients, CBCT is revolutionising orthodontics. It is also evolving in terms of diagnosis, clinical procedures, and outcome.[5,6] Present review of literature aims to discuss role of CBCT in orthodontics.

Principles of CBCT Imaging:

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 programme 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 impinge on the detector. Even though they provide images that are similar, CBCT imaging and multidetector computed tomography (MDCT) imaging technology are two different evolutionary branches of CT imaging.[7,8]

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 centre serves as the rotation 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.[8]

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. These projection data are processed by software using complex methods, such as filtered back projection, to create a volumetric data set that may be utilised to produce primary reconstruction images in three orthogonal planes (axial, sagittal, and coronal).[9]

Application of CBCT in Dentistry:

There are many clinical uses for CBCT imaging in the oral and maxillofacial area. For the identification of any bone pathology and developmental abnormalities in the orofacial region, multiplanar imaging in CBCT has offered an extremely helpful tool for oral and maxillofacial radiologists. CBCT is preferred for object localization, impacted teeth, supernumerary teeth and to assess their relation to vital structures, osteomyelitis, soft-tissue calcifications, cleft palate, developmental anomalies, and presurgical plan in cases of cysts and tumours in the orofacial region. This technique is beneficial for diagnosis and the evaluation of fractures in the oral and maxillofacial region.[10,11]

Application of CBCT in Orthodontics

Assessment of Skeletal and Dentofacial Structures:
As mentioned earlier, CBCT imaging is more accurate for landmark identification as it eliminates superimposition in the images. The values obtained from CBCT images are more accurate than conventional imaging techniques.[12]

Periago et al. conducted an observational cross-sectional *ex vivo* experiment. The group measured the accuracy of linear measurements on 23 human skulls, comparing the direct measurements on the skulls to the measurements made on CBCT images. They concluded that although most linear measurements between cephalometric points from the 3D volumetric surface renderings generated from CBCT scans may be statistically significantly different from the anatomic dimensions, they are clinically accurate for craniofacial diagnostic purposes.[13]

Localization of Impacted Teeth:
CBCT is frequently used to assess the location of impacted teeth. Three-dimensional CBCT scans can be used to precisely localise impacted teeth. Additionally, CBCT is a useful tool for detecting disease and root resorption, which simplifies diagnosis and treatment planning.[14]

Evaluation of Asymmetry:
A three-dimensional image of the patient enables a more precise assessment of both dental and skeletal Asymmetry. By seeing and measuring the maxillary and mandibular bones in three dimensions, it is easier to distinguish between the presence of a really unilateral crossbite and one brought on by a movement of the mandible into centric occlusion.[15,16]

Assessment of the Temporomandibular Joint:
Conventional tomography has been utilised extensively for TMJ evaluation, but due to its method sensitivity and lengthy exams, it has become a less desirable diagnostic tool for dentists. It has been demonstrated that CBCT scans of the TMJ are more reliable and accurate at spotting condylar erosions than tomographic or panoramic views. Temporomandibular dysfunction can make orthodontic treatment more difficult, thus it's important to carefully check the TMJ before, during, and after orthodontic treatment. The orthodontist may find it helpful to review subsequent CBCT pictures taken over an extended period of time in assessing the progression of any potential degenerative changes.[17,18]

Orthognathic Surgery:
Numerous CBCT applications for treatment simulation, direction, and result evaluation in orthognathic surgery have been established. In patients with injuries and skeletal abnormalities, CBCT 3D surface reconstructions of the jawbones are employed for preoperative surgical planning and simulation. With the aid of specialised software tools, it is now possible to successfully conduct simulations of virtual jaw displacement, osteotomies, distraction osteogenesis, and other procedures.[16]

Orthodontic Implants Placement:
The likelihood that orthodontic implants will be successfully placed and positioned can be significantly increased with understanding of the root positioning.[19]

Orthodontic Treatment for Cleft Patient:
Both preoperative and postoperative follow-up examinations for patients with cleft lip and palate benefit from using CBCT. It is helpful for determining volume, the precise location of a bone defect, the placement of extra teeth, the condition of permanent teeth, and alveolar bone morphology. A cleft palate patient's rehabilitation and treatment planning are made easier with the help of CBCT imaging.

Cephalograms produced by CBCT:
Cephalograms produced by CBCT: The CBCT data set can be reorganised to produce a CBCT reconstructed lateral cephalogram, allowing for the taking of standard measures and comparison with existing 2D norms. These CBCT-reconstructed lateral cephalograms have the benefit of allowing the patient's head position to be digitally adjusted in circumstances when the patient was not properly positioned during scanning. Additionally, by virtually removing unnecessary superimposing skeletal components, the image quality can be improved. Additionally, separate photographs of the left and right sides can be made to assess asymmetries.[20]

Fabrication of Custom Orthodontic Appliances: The fabrication of custom lingual orthodontic appliances has been demonstrated using CBCT image data with existing technology to virtually plan a patient's treatment and therefore the manufacturing of custom appliances with 3D printing technology. Such advances appear to be rapid, and that they also promise efficient and effective patient-specific treatments.[20]

Limitation of CBCT:
Due to intrinsic "noise," CBCT pictures are less clear and have a lower soft tissue contrast resolution Due to inherent spatial resolution limitations and high areas of attenuation (like metallic restorations), CBCT image quality is also impacted by image artefacts like streaking, shading, rings, and distortion. These effects can make it difficult to see structures in the dento-alveolar region clearly. Ionizing radiation, which has the potential to cause cancer, is used in CBCT imaging.[20]

Advantages of CBCT[21]
- Low radiation (much less than traditional CT scan)
- Convenient and painless for patients
- Aid in the diagnostics, development of treatment plan and procedure.
- Assess risk.
- Better analyze position and orientation of surrounding structures(sinuses,roots,and nerves)
- Cost effective
- Safe for patients of all ages.

Disadvantages of CBCT[21]
- Limited contrast resolution
- Emits radiation
- Streaking and motion artifacts are possible

Future Scope of CBCT in Orthodontics:
New applications for technology are developed almost every day. The CBCT technology's subsequent uses provide a preview of what might soon be made available. simulated models Without the need for alginate impressions, 3D digital study models are frequently created using CBCT data. It reduces patient discomfort and frees up the crucial chair time of the orthodontist. Since these models incorporate not only the dental crowns but also the roots, impactions, developing teeth, and alveolar bone, they have a higher diagnostic utility than other digital models.

Aligner for Invisalign In the future, it will be feasible to carry out the entire manufacture of the aligners utilising CBCT digital data. It may be feasible to generate virtual models using only the CBCT pictures, eliminating the need for bite registration and impression collection. Since laboratories frequently get this information electronically, the needed virtual tooth movement is frequently achieved through e-mail exchanges between the orthodontist and the laboratory. The information contained in the electronic database of the final tooth placements in the laboratory may even be used to produce retainers. Bracket Indirect Bonding Indirect bonding laboratory procedures frequently use the creation of "hardcopy" models from the CBCT picture.

CONCLUSION:
In compared to older methods like radiography, modern advancements in dentistry have shown to be quite beneficial. Cone Beam Computed Tomography, a medical imaging method using X-Ray computed tomography, is one such development. For patients needing orthodontic treatment, this imaging modality is incredibly helpful as an advanced and currently popular tool for comprehensive diagnosis and treatment planning. Both the patient and the doctor can benefit from CBCT. There is less radiation exposure and less scanning time needed. Additionally, it offers high resolution photos, which helps with accurate diagnosis and effective treatment planning. It is useful mainly in orthodontics because to its capacity to capture the whole anatomy. The data obtained is more accurate than other imaging modalities when properly documented. Following confirmation of a positive effect, CBCT imaging may also be used in other sorts of instances where it is expected to offer helpful diagnostic information.

REFERENCES
1. Goldman LW. Principles of CT and CT technology. *J Nucl Med Technol*. 2007. September;35(3):115–28. 10.2967/jnmt.107.042978
2. Loubele M, Bogaerts R, Van Dijck E, Pauwels R, Vanheusden S, Suetens P, et al. Comparison between effective radiation dose of CBCT and MSCT scanners for dentomaxillofacial applications. *Eur J Radiol*. 2009;71(3):461–8.]
3. Howerton WB, Jr, Mora MA. Use of conebeam computed tomography in dentistry. *Gen*

Dent. 2007;55(1):54–7.
4. Kumar M, Shanavas M, Sidappa A, Kiran M. Cone beam computed tomography - know its secrets. J Int Oral Health. 2015 Feb;7(2):64-8. PMID: 25859112; PMCID: PMC4377156.
5. Agrawal JM, Agrawal MS, Nanjannawar LG, Parushetti AD. CBCT in Orthodontics: The Wave of Future. J Contemp Dent Pract 2013;14(1):153-157.
6. Walker L, Enciso R, Mah J. Three-dimensional localization of maxillary canines with cone-beam computed tomography. Am J Orthod Dentofacial Orthop 2005; 128(4):41823.
7. Abramovitch K, Rice DD. Basic Principles of Cone Beam Computed Tomography. Dent Clic North Am. 2014;58:463–84.
8. 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.
9. Kapshe N, Pujar M, Jaiswal S. Cone beam computed tomography: A review. Int J Oral Health Dent 2020;6(2):71-77.
10. Shukla S, Chug A, Afrashtehfar KI. Role of cone beam computed tomography in diagnosis and treatment planning in dentistry: An update. J Int Soc Prev Community Dent 2017;7:S125-36.
11. Hegde S, Ajila V, Kamath JS, Babu S, Pillai DS, Nair SM. Importance of cone-beam computed tomography in dentistry: An update. SRM J Res Dent Sci 2018;9:186-90.
12. Fernandes, Akshata Gailot and Vinita Ved. "The application of cone beam computed tomography in orthodontics", International Journal of Development Research. 2018;08;01
13. Periago DR, Scarfe WC, Moshiri M, Scheetz JP, Silveira AM, Farman AG. Linear accuracy and reliability of cone beam CT derived 3-dimensional images constructed using an orthodontic volumetric rendering program. *Angle Orthod.* 2008;78:387–95.
14. Katheria BC, Kau CH, Tate R, Chen JW, English J, Bouquot J (2010). Effectiveness of impacted and supernumerary tooth diagnosis from traditional radiography versus cone beam computed tomography. Pediatric dentistry 32(4):304-309.
15. Hechler SL. Cone beam CT: Applications in orthodontics, Dent Clin N Am 52(2008):809-23.
16. Agrawal JM, Agrawal MS, Nanjannawar LG, Parushetti AD. CBCT in Orthodontics: The Wave of Future. J Contemp Dent Pract 2013;14(1):153-157.
17. Honey O, Scarfe W, Hilgers M, et al. Accuracy of the cone-beam computed tomography imaging of the temporomandibular joint: Comparisons with panoramic radiology and linear tomography. Am J Orthod Dentofacial Orthop 2007;132(4):429-38.
18. Tsiklakis K, Syriopoulos K, Stamatakis H. Radiographic examination of temporomandibular Joint using cone beam computed tomography. Dentomaxillofacial Radiol 2004;33:196- 201
19. Kuroda S, Yamada K, Deguchi T, et al. Root proximity is a major factor for screw failure in orthodontic anchorage. Am J Orthod Dentofacial Orthop 2007;131(4 Suppl):S68-73
20. Prateeksha Bora, Poonam Agrawal, Dinesh Kumar Bagga, Sakshi Tiwari, Aartika Singh. Applications of Cone Beam Computed Tomography in Orthodontics: An Overview. Biosc.Biotech.Res.Comm. Special Issue Vol 13 No 15 (2020) Pp-168-172
21. Fathima S. Cbct In Dentistry-An Overview. *European Journal of Molecular & Clinical Medicine*, 2020; 7(5): 1403-1408