

Advancements in Dental Imaging: The Role of Cone Beam Computed Tomography across Specialties

Radhika Gupta^{1*}, Saltanat Khan²

¹Department of Oral Medicine and Radiology, Index Institute of Dental Sciences, Indore, Madhya Pradesh, India.

²Department of Prosthodontics, Index Institute of Dental Sciences, Indore, Madhya Pradesh, India.

Abstract

Background: Cone beam computed tomography (CBCT) has revolutionized dental diagnostics by providing detailed three-dimensional imaging, enhancing diagnostic accuracy and clinical outcomes across multiple specialties. In endodontics, it facilitates the identification of periapical lesions, canal visualization, and detection of root fractures. In periodontics, CBCT improves the assessment of periodontal structures, aiding in the diagnosis and treatment of bone loss and furcation involvement. Orthodontists utilize CBCT for facial growth assessment, tooth eruption disturbances, and planning orthognathic surgery. In addition, CBCT is essential in evaluating cleft lip and palate deformities, and its use in oral and maxillofacial surgery aids in the precise localization of impacted teeth and assessment of proximity to vital structures, improving surgical planning and patient safety.

Keywords: Cleft lip and palate, Cone beam computed tomography, Dental imaging, Endodontics, Oral and surgical planning, Orthodontics, Periodontics.

INTRODUCTION

Cone beam computed tomography (CBCT) has become a pivotal tool in modern dentistry, offering high-resolution, three-dimensional imaging that significantly enhances dental professionals' diagnostic and therapeutic capabilities. Unlike traditional two-dimensional radiographs, CBCT provides volumetric data, allowing clinicians to accurately assess dental and maxillofacial structures. CBCT is particularly beneficial in endodontics, where it aids in diagnosing periapical lesions, visualizing complex root canal systems, and detecting root fractures, which are often missed on standard radiographs.^[1]

In periodontics, CBCT enables the detailed evaluation of periodontal structures such as the lamina dura, crater defects, and furcation involvement, improving the accuracy of diagnoses and treatment planning. Orthodontists utilize CBCT to assess facial growth patterns, manage tooth eruption disturbances, and plan orthognathic surgeries with a higher degree of confidence due to the detailed anatomical data it provides.^[1] In addition, CBCT plays a crucial role in cleft lip and palate assessment by accurately visualizing craniofacial structures, which aids in surgical planning and multidisciplinary care.^[2] Oral and maxillofacial surgeons also rely on CBCT to localize impacted teeth and evaluate their proximity to vital structures such as

the inferior alveolar canal and maxillary sinus, ensuring safer and more effective surgical outcomes.^[2]

CBCT has revolutionized the field of dentistry and maxillofacial imaging, offering high-resolution, three-dimensional imaging with a relatively low radiation dose compared to traditional computed tomography (CT) scans. CBCT provides significant diagnostic and treatment advantages across a range of dental specialties, including endodontics, periodontics, orthodontics, oral and maxillofacial surgery, and forensic odontology.^[3]

Application in endodontics

CBCT has become a vital tool in endodontics, enhancing diagnostic accuracy and treatment outcomes [Figure 1]. It allows for the detailed and three-dimensional visualization of the periapical area, improving the diagnosis of lesions caused by pulpal inflammation. In addition, CBCT offers superior visualization of the root canal system, enabling clinicians to

Address for correspondence: Dr. Radhika Gupta,
Department of Oral Medicine and Radiology, Index Institute of Dental
Sciences, Indore, Madhya Pradesh, India.
Email: drradhika1987@gmail.com

Received: Jan. 17, 2024; **Accepted:** Feb. 20, 2024; **Published:** Mar. 30, 2024

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

How to cite this article: Gupta R, Khan S. Advancements in Dental Imaging: The Role of Cone Beam Computed Tomography across Specialties. J Res Adv Dent 2024;15(6):1-4.

Access this article online

Website:
www.jrad.co.in

DOI:
<https://doi.org/10.53064/jrad.2024.15.6.586>

assess complex anatomical features such as additional canals, C-shaped canals, and root curvatures. CBCT is particularly beneficial in identifying root fractures, which may not be visible on conventional radiographs.^[1]

Application in periodontics

In periodontics, CBCT provides enhanced visualization of critical structures, including the lamina dura, crater defects, and furcation involvement. The technology allows for a more accurate assessment of bone quality and the extent of periodontal disease, supporting better treatment planning and improving clinical outcomes. CBCT's superior imaging quality contributes significantly to the precise evaluation and monitoring of periodontal disease progression and therapeutic interventions [Figure 2].

Orthodontic application

CBCT has made significant contributions to orthodontic diagnosis and treatment planning. The ability to assess facial growth patterns in three dimensions allows for more accurate treatment planning, particularly in cases requiring orthognathic surgery. In addition, CBCT is invaluable in assessing the position and orientation of impacted teeth, facilitating appropriate treatment strategies. The technology also plays a critical role in craniofacial surgery planning, particularly for complex deformities such as cleft palate.

Cleft lip and palate assessment

CBCT provides comprehensive imaging for the assessment of cleft lip and palate deformities, aiding in both surgical planning and orthodontic interventions. The three-dimensional data obtained from CBCT scans allow clinicians to visualize the extent of the deformity and associated anomalies, such as nasal cavity involvement, ensuring more precise and effective treatment planning.

CBCT in oral and maxillofacial surgery

In oral and maxillofacial surgery, CBCT is essential for localizing impacted teeth and assessing their relationship to critical anatomical structures such as the inferior alveolar nerve and maxillary sinuses. This information reduces the risk of complications during surgical procedures, such as nerve damage or sinus perforation. CBCT also aids in pre-surgical planning for craniofacial reconstructions, ensuring better surgical outcomes.

Identification of pathological conditions

CBCT's ability to provide detailed, three-dimensional imaging of the maxillofacial region makes it a valuable tool for identifying and assessing various pathological conditions, such as cysts, tumors, and lesions. In addition, CBCT combined with magnetic resonance imaging (MRI) is considered the gold standard for evaluating the temporomandibular joint, offering a detailed analysis of both hard and soft tissues. CBCT's lower radiation dose, compared to conventional CT, makes it a safer option for patients requiring multiple diagnostic images [Figure 3].

CBCT in forensic odontology

The estimation of age in both living and deceased individuals is a crucial aspect of forensic investigations. Numerous techniques have been documented in the literature for determining age through the analysis of dental structures. One promising method in dental age estimation involves examining the pulp space. While traditional techniques such as cross-sectional analysis of teeth and radiographs have been used, CBCT offers a more advanced and accurate three-dimensional view of the pulp cavity, allowing for more precise age estimations based on dental structures. CBCT is particularly effective for assessing secondary dentin deposition, which occurs as an individual

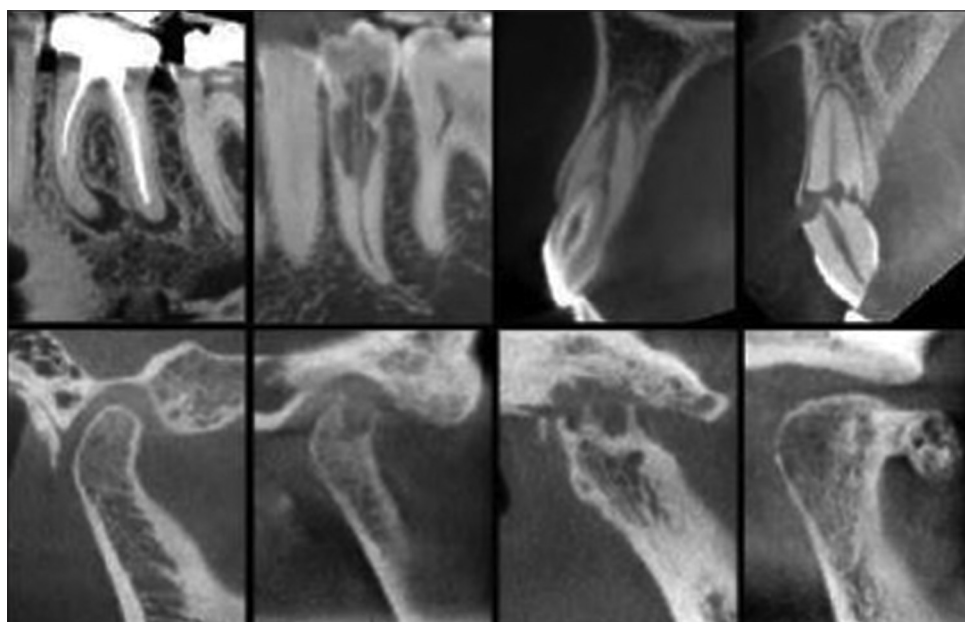


Figure 1: Application of CBCT in endodontics courtesy: UCLA CBCT radiology images. CBCT: Cone beam computed tomography

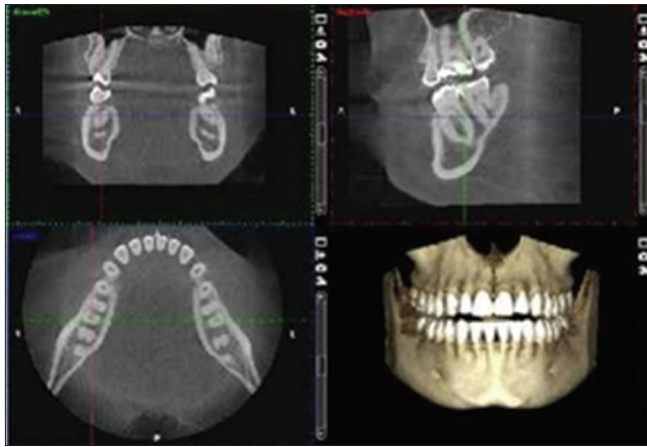


Figure 2: Application in periodontics

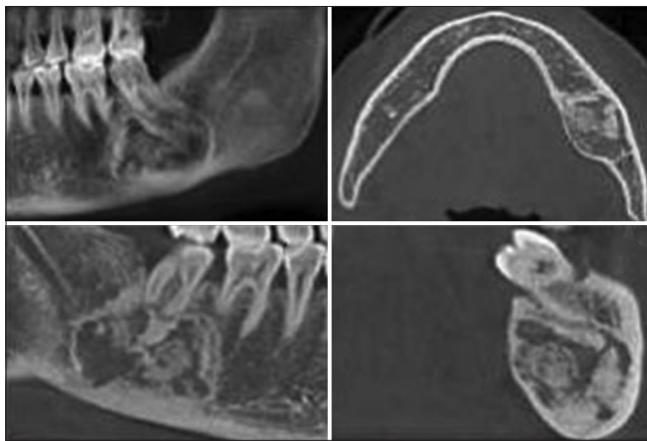


Figure 3: Identification of pathological conditions

ages, providing reliable measurements of the buccolingual and mesiodistal dimensions of the tooth.^[4]

Yang *et al.* developed voxel-counting software tailored to compute the ratio of pulp canal volume to tooth volume using CBCT images. Their research yielded positive outcomes for non-invasive dental age estimation. Furthermore, CBCT can precisely measure the thickness of soft tissues in specific facial and scalp landmarks, generating facial reconstructions with reduced exposure time and increased efficiency compared to spiral CT and other imaging methods. This reconstruction process relies on knowledge of average soft-tissue thickness, which varies among individuals from different geographic regions. Such techniques are instrumental in forensic cases involving skeletal remains, as they aim to recreate an individual's facial appearance from the skull.^[4]

CBCT is also increasingly utilized in postmortem forensic examinations and cases involving high-density metal projectiles, such as gunshot injuries. Its portability, affordability, and reduced susceptibility to metal artifacts make it a preferred choice over other imaging modalities. Studies have shown that CBCT outperforms multidetector CT in detecting structural damage to hard tissues located near high-density projectiles

and in pinpointing the precise location of these projectiles within the body.^[4]

CBCT in implant prosthodontics

CBCT plays a critical role in implant prosthodontics by providing detailed three-dimensional imaging essential for precise planning and execution. Key applications include:

1. Identification of critical anatomical structures: CBCT enables accurate visualization of vital structures such as nerves, blood vessels, and sinuses, helping to avoid complications during implant placement^[4]
2. Assessment of available bone: CBCT provides precise measurements of bone height, width, and density, which is crucial for determining implant feasibility and planning bone grafting procedures^[5]
3. Determination of optimal implant angulation: With CBCT, clinicians can plan the ideal implant trajectory to achieve optimal stability and esthetics while avoiding critical anatomical structures^[5]
4. Nerve tracing: CBCT assists in tracing the course of nerves such as the inferior alveolar nerve, which helps in preventing nerve injury and minimizing post-operative complications^[6]
5. Post-operative evaluation: CBCT is valuable for assessing bone grafts and implant positioning, enhancing post-surgical evaluation and long-term outcomes.^[6]

ADVANTAGES OF CBCT IN DENTISTRY

- Three-dimensional imaging: Provides detailed 3D views of dental and maxillofacial structures, improving diagnostic accuracy and treatment planning
- Enhanced diagnostic capabilities: Superior visualization of complex anatomical structures, such as root canal systems, bone defects, and impacted teeth
- Reduced radiation dose: Offers a lower radiation dose compared to conventional CT scans, making it safer for patients
- Precise implant planning: Facilitates accurate assessment of bone dimensions, density, and anatomical relationships for optimal implant placement and surgical planning
- Comprehensive visualization: Allows for detailed assessment of periodontal structures, craniofacial deformities, and soft-tissue thickness for better treatment outcomes
- Improved forensic analysis: Aids in accurate dental age estimation, facial reconstruction, and postmortem imaging, enhancing forensic investigations.

FUTURE PROSPECT OF CBCT IN DENTISTRY

- Integration with artificial intelligence (AI): AI algorithms could enhance image analysis, automating the detection and diagnosis of anomalies, and improving treatment planning by predicting outcomes based on vast data sets
- Enhanced imaging resolution: Advances in technology

may lead to even higher resolution images, providing greater detail and accuracy in diagnosing and planning complex cases

- **Reduced radiation exposure:** Ongoing developments aim to minimize radiation doses further, making CBCT even safer for patients without compromising image quality
- **Real-time imaging:** Future CBCT systems may offer real-time imaging capabilities, allowing for immediate assessment during surgical procedures and dynamic adjustments as needed
- **Integration with other imaging modalities:** Combining CBCT with other imaging techniques such as MRI or optical scans could provide more comprehensive diagnostic information, integrating various types of data into a unified model
- **Portable and cost-effective units:** Advances may lead to more portable and affordable CBCT units, making high-quality imaging accessible to a broader range of health-care settings, including remote or underserved areas
- **Improved software for enhanced analysis:** The development of more advanced software tools for 3D reconstruction, virtual simulations, and predictive modeling could further enhance the capabilities of CBCT in treatment planning and patient care.

CONCLUSION

CBCT has become a transformative tool in modern dentistry, offering high-resolution, three-dimensional imaging that

enhances diagnostic and treatment capabilities across various specialties. It provides detailed visualization for accurate diagnosis and planning in endodontics, periodontics, orthodontics, and oral and maxillofacial surgery. In forensic odontology, CBCT enables precise age estimation and facial reconstruction from skeletal remains. Its application in implant prosthodontics ensures optimal implant placement and assessment. Overall, CBCT significantly improves clinical outcomes and patient care through its comprehensive imaging capabilities.

REFERENCES

1. Abd El Fatah YAM, Khattab NMA, Gomaa YF, Elheeny AAH. Cone-beam computed tomography analysis of primary root canals transportation and dentin loss after instrumentation with two-pediatric rotary files. *BMC Oral Health* 2022;22:214.
2. Scarfe WC, Azevedo B, Pinheiro LR, Priaminiarti M, Sales MA. The emerging role of maxillofacial radiology in the diagnosis and management of patients with complex periodontitis. *Periodontol* 2000 2017;74:116-39.
3. Yang F, Jacobs R, Willems G. Dental age estimation through volume matching of teeth imaged by cone-beam CT. *Forensic Sci Int* 2006;159:S78-83.
4. Adell R, Eriksson B, Lekholm U, Brånemark PI, Jemt T. A long-term follow-up study of osseointegrated implants in the treatment of totally edentulous jaws. *Int J Oral Maxillofac Implants* 1990;5:347-59.
5. Borisov R. Radiological templates and CAD/CAM surgical guides. A literature review. *J IMAB* 2016;22:1285-95.
6. Nodehi D, Pahlevankashi M, Moghaddam MA, Nategh B. Cone beam computed tomography functionalities in dentistry. *Int J Contemp Dent Med Rev* 2015;2015:040515.