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MINI REVIEW

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Role of cone beam computed tomography in ENT: A mini review

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ABSTRACT

Cone Beam Computed Tomography (CBCT) is a three-dimensional imaging modality that has evolved beyond its original dental and maxillofacial applications to gain increasing relevance in Otorhinolaryngology (ENT). The technique provides high resolution isotropic voxel imaging of osseous structures with substantially lower radiation exposure compared to conventional multi detector computed tomography (MDCT). These characteristics make CBCT particularly suitable for imaging fine bony anatomy of the temporal bone, paranasal sinuses, skull base, and facial skeleton. This mini review aims to evaluate the current role of CBCT in ENT practice, focusing on its principles, technical advantages, and major clinical applications. The review highlights three key domains where CBCT demonstrates relative superiority: otology (temporal bone and cochlear implant planning), rhinology (paranasal sinus evaluation and functional endoscopic sinus surgery planning), and maxillofacial–facial trauma assessment. The limitations of CBCT, particularly its restricted soft tissue contrast and susceptibility to artifacts, are also critically discussed in the context of the review objective. Despite these limitations, CBCT serves as an effective adjunct or alternative to MDCT in selected ENT indications where high resolution bone imaging is paramount. With ongoing technological advancements and integration with image guided surgical systems, CBCT holds significant future potential as a point of care imaging tool in ENT practice.

KEY WORDS

Cone beam computed tomography; Otorhinolaryngology; Temporal bone; Paranasal sinuses; Image-guided surgery

ARTICLE HISTORY

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Introduction

Imaging plays a pivotal role in the diagnosis, treatment planning, and postoperative assessment of diseases involving the ear, nose, throat, and related craniofacial structures. Traditionally, multi detector computed tomography (MDCT) has been considered the gold standard for evaluating bony anatomy of the temporal bone, paranasal sinuses, and facial skeleton, while magnetic resonance imaging (MRI) remains superior for soft tissue and neural assessment. However, concerns regarding radiation dose, accessibility, and cost have driven the exploration of alternative imaging modalities [1].

Cone Beam Computed Tomography (CBCT) was initially introduced in the late 1990s for dental and maxillofacial imaging. Over the past two decades, its application has expanded into ENT owing to its ability to generate high resolution volumetric datasets of osseous structures using a cone shaped X ray beam and flat panel detector. Unlike MDCT, CBCT acquires the entire volume in a single rotation, resulting in faster acquisition and reduced radiation exposure [2].

The sub millimetre spatial resolution of CBCT enables detailed visualization of delicate anatomical structures such as the ossicular chain, cochlear turns, semicircular canals, lamina papyracea, and skull base bony corridors. Additionally, the compact design and open configuration of CBCT scanners improve patient comfort and facilitate installation in outpatient ENT settings. These features have positioned CBCT as a valuable adjunct imaging modality in modern ENT practice [3,4].

Review Methodology

A narrative mini review methodology was adopted for this article. A literature search was conducted using electronic databases including PubMed, Scopus, Google Scholar, and ScienceDirect.

- **Keywords used:** "Cone Beam Computed Tomography", "CBCT in ENT", "Temporal bone CBCT", "Paranasal sinus CBCT", "CBCT otology", "CBCT rhinology".
- **Timeframe:** Articles published between January 2015, and December 2024 were considered to ensure contemporary relevance.
- **Inclusion criteria:** Peer reviewed articles published in English focusing on CBCT applications in ENT, comparative studies between CBCT and MDCT, and review articles discussing technical aspects and clinical indications.
- **Exclusion criteria:** Case reports with limited clinical relevance, non-English publications, dental only CBCT studies without ENT correlation, and articles published before 2015.

Indications of CBCT in ENT

Otology

CBCT has gained significant importance in otology due to its superior spatial resolution for detailed assessment of the temporal bone. It enables precise visualization of the ossicular chain, otic capsule, cochlea, vestibule, and semicircular canals, which are often inadequately demonstrated on conventional radiography [5-9]. In cases of cholesteatoma, CBCT is particularly useful for postoperative surveillance, allowing detection of residual or recurrent disease by identifying subtle bony erosions of the scutum, ossicles, and mastoid cortex [10].

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In otosclerosis, CBCT effectively demonstrates fenestral and retrofenestral involvement, including stapes footplate thickening and pericochlear lucency. CBCT also plays a crucial role in cochlear implant planning, where accurate measurement of cochlear duct length, assessment of cochlear patency, identification of round window anatomy, and detection of congenital anomalies or labyrinthine ossification are essential for optimal surgical outcomes [11].

Furthermore, superior semicircular canal dehiscence syndrome can be reliably diagnosed using high-resolution CBCT, owing to its ability to depict very thin bony structures. Temporal bone fractures, particularly those involving the otic capsule, facial nerve canal, and ossicular chain, can also be delineated with excellent clarity, aiding surgical decision-making [12].

Rhinology

In rhinology, CBCT provides comprehensive evaluation of paranasal sinus anatomy and the ostiomeatal complex with high spatial accuracy. It is particularly valuable in chronic rhinosinusitis, where identification of bony obstructions, mucociliary drainage pathways, anatomical variants such as concha bullosa or Haller cells, and sinus wall integrity is critical for treatment planning [13].

CBCT plays a central role in preoperative planning for functional endoscopic sinus surgery (FESS) by offering high-resolution datasets compatible with image-guided surgery (IGS) systems, thereby enhancing surgical precision and safety. The modality is also beneficial in assessing post-traumatic sinonasal bony defects, skull base integrity, and barotrauma-related conditions such as vacuum headache [14].

Owing to its lower radiation dose compared to MDCT, CBCT is increasingly preferred for follow-up imaging in chronic sinonasal disease and postoperative assessment, particularly in younger patients and those requiring serial imaging [15].

Skull base surgery

CBCT contributes to skull base surgery primarily as a preoperative planning and adjunct imaging tool, where precise delineation of osseous anatomy is essential. It enables accurate mapping of critical bony corridors for endoscopic transnasal and endonasal approaches, including the sphenoid sinus, sellar floor, clivus, cribriform plate, planum sphenoidale, and skull base foramina. This detailed visualization assists surgeons in understanding individual anatomical variations, which is particularly important in minimally invasive skull base procedures [16].

CBCT is especially useful in the evaluation and localization of cerebrospinal fluid (CSF) leaks, where identification of focal skull base defects, bony dehiscence, or thinning is required for targeted surgical repair. In benign skull base lesions such as osteomas, fibrous dysplasia, and other fibro-osseous conditions, CBCT provides high-resolution assessment of cortical integrity, lesion extent, and involvement of adjacent bony structures. When integrated with image-guided navigation systems, CBCT datasets enhance intraoperative orientation, improve surgical precision, and help minimize complications related to adjacent critical neurovascular structures. Although CBCT does not replace MDCT or MRI for comprehensive skull base tumour evaluation, it serves as a valuable complementary modality for osseous-focused surgical planning [17].

Laryngology

The role of CBCT in laryngology remains limited due to its inherent poor soft tissue contrast; however, it has selective applications in specific clinical scenarios. CBCT can be useful in the detection and precise three-dimensional localization of radio-opaque foreign bodies within the upper aerodigestive tract, particularly when conventional radiography is inconclusive. It also allows accurate assessment of calcified lesions such as sialoliths involving the submandibular or parotid glands, aiding in treatment planning [17].

In selected airway assessments, CBCT permits evaluation of the bony and cartilaginous framework of the larynx, including ossification patterns of the thyroid and cricoid cartilages, the hyoid bone, and congenital or post-traumatic skeletal abnormalities. These applications are particularly relevant in cases of airway compromise related to structural deformities. Despite these advantages, CBCT remains an adjunct imaging modality in laryngology, with MDCT and MRI continuing to be preferred for comprehensive evaluation of soft tissue lesions, inflammatory conditions, and laryngeal neoplasms [18].

Trauma

CBCT is highly effective in the assessment of facial and midfacial trauma, offering excellent spatial resolution for accurate depiction of fracture lines, displacement, and comminution. It is particularly useful in the evaluation of midfacial fractures, including Le Fort I, II, and III fracture patterns, where detailed understanding of fracture anatomy is crucial for surgical planning and reconstruction [19].

In cases of orbital blow-out fractures, CBCT enables precise assessment of orbital floor and medial wall defects, fracture extent, and bony discontinuity, assisting in identifying patients at risk for enophthalmos or muscle entrapment. Zygomaticomaxillary complex and zygomatic arch fractures can be accurately assessed for displacement and rotational deformity, while nasal bone fractures can be evaluated efficiently, especially in complex or recurrent trauma [19].

CBCT also has utility in selected temporal bone and skull base trauma, allowing visualization of fracture patterns involving the otic capsule, facial nerve canal, and ossicular chain. Compared to MDCT, CBCT offers the advantages of lower radiation dose, faster acquisition, and high diagnostic accuracy for osseous injuries, making it particularly suitable for outpatient evaluation and follow-up of maxillofacial trauma [19].

Advantages of CBCT

CBCT offers several advantages that make it particularly suitable for ENT imaging, especially in clinical scenarios where detailed assessment of osseous anatomy is essential. One of its primary strengths is its high spatial resolution with isotropic voxels, allowing precise visualization of fine bony structures such as the ossicles, otic capsule, lamina papyracea, skull base foramina, and delicate fracture lines that may be inadequately depicted on conventional imaging.

A major advantage of CBCT is its significantly lower radiation dose, with studies reporting up to a 40–60% dose reduction compared to MDCT for comparable examinations. This dose efficiency is particularly beneficial in ENT practice, where imaging is frequently performed in younger patients, benign conditions, and cases requiring repeated follow-up, such as chronic rhinosinusitis and postoperative otologic surveillance [20].

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CBCT also features short acquisition times, often achieved in a single gantry rotation, which minimizes motion artifacts and improves image quality in uncooperative or paediatric patients. The open gantry design enhances patient comfort and reduces claustrophobia compared to conventional CT scanners.

From a practical standpoint, the compact footprint and lower infrastructure requirements of CBCT systems allow installation in outpatient ENT clinics, dental–ENT hybrid imaging units, and even operating room environments. This facilitates point-of-care imaging, improves workflow efficiency, and reduces patient transfer time between imaging and clinical areas.

Additionally, CBCT images are fully DICOM-compatible, enabling seamless integration with picture archiving and communication systems (PACS) and image-guided surgical navigation platforms. This capability is particularly valuable in functional endoscopic sinus surgery, cochlear implantation, and minimally invasive skull base procedures, where real-time anatomical correlation enhances surgical accuracy and safety.

Overall, these advantages position CBCT as a cost-effective, patient-friendly, and diagnostically robust adjunct imaging modality in modern ENT practice, particularly when high-resolution bone imaging is the primary diagnostic requirement [21].

Limitations and Future Scopes

The primary limitation of CBCT is its poor soft tissue contrast, which restricts its utility in evaluating soft tissue lesions, tumours, neural structures, and intracranial pathology. Beam hardening and metallic artifacts may degrade image quality in the presence of dental restorations or implants. Additionally, some CBCT systems have limited fields of view, which may not encompass extensive pathology [22].

These limitations justify the selective use of CBCT in accordance with the review objective, emphasizing its role as a complementary rather than replacement modality to MDCT and MRI.

The future role of Cone Beam Computed Tomography in ENT is expected to expand significantly with ongoing technological innovations and interdisciplinary integration. Advances in detector sensitivity and spatial resolution are likely to further enhance image quality while simultaneously reducing radiation dose, making CBCT safer for repeated use in chronic ENT conditions requiring long-term follow-up, such as chronic rhinosinusitis and postoperative otologic cases [23].

Development of advanced artifact reduction algorithms, particularly for metallic dental restorations and implants, will improve diagnostic confidence in the maxillofacial and skull base regions. Additionally, expansion of larger and adjustable fields of view will allow comprehensive assessment of complex anatomical regions, bridging the gap between CBCT and MDCT in selected clinical scenarios [24].

Integration of CBCT with artificial intelligence (AI)–based image analysis holds promise for automated detection of anatomical variations, fracture patterns, and subtle bony erosions, thereby reducing observer variability and reporting time. Furthermore, the incorporation of CBCT data into real-time image-guided navigation systems is expected to enhance surgical precision in functional endoscopic sinus surgery, cochlear implantation, and minimally invasive skull base procedures.

With increasing emphasis on point-of-care imaging, compact CBCT units installed within ENT outpatient departments and operating rooms may transform workflow efficiency, reduce patient waiting times, and optimize resource utilization. These advancements collectively suggest that CBCT will continue to evolve as a critical component of precision imaging and personalized surgical planning in ENT practice [25].

Conclusion

Cone Beam Computed Tomography has established itself as a valuable and increasingly indispensable imaging modality in contemporary ENT practice, particularly for clinical scenarios requiring detailed evaluation of osseous anatomy. Its strengths are most evident in otology, where precise depiction of temporal bone microanatomy is essential; rhinology, especially in preoperative planning and navigation for functional endoscopic sinus surgery; and facial and midfacial trauma, where accurate fracture delineation guides surgical management. The advantages of high spatial resolution, reduced radiation exposure, rapid acquisition time, and compatibility with image-guided surgical systems position CBCT as an effective adjunct to conventional MDCT. Although limitations related to soft tissue contrast and susceptibility to artifacts persist, these constraints do not undermine its clinical utility when used judiciously and in appropriate indications. In conclusion, CBCT should be regarded not as a replacement but as a complementary imaging modality within the ENT diagnostic armamentarium. With continued technological refinement, expanding clinical evidence, and integration with advanced surgical and computational tools, CBCT is poised to play a progressively significant role in improving diagnostic accuracy, surgical outcomes, and patient safety in ENT practice.

Statement and Declarations

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Consent for Publication: Not applicable.

Availability of Data and Material: Not applicable.

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Authors' Contributions:

1. Dr. Navendra Jha: Conceptualized the Topic, Designed the Study Framework, Reviewed the Literature, And Finalized the Manuscript.
2. Dr. Fatima Injela Khan contributed to literature collection, analysis, and drafting of the manuscript.

Both authors read and approved the final manuscript.

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