Cone Beam Computed Tomography: Adding the Third Dimension

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ABSTRACT

Cone beam computed tomography is a comparatively new three-dimensional imaging technology, which has been specially developed for imaging of the maxillofacial complex. The aim of this paper is to accustom the dental fraternity with the wide and potential applications of cone beam computed tomography in dentistry.

Keywords: Cone beam computed tomography, Impacted teeth, Dental implants, Endodontics.


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INTRODUCTION

Radiology is an important diagnostic tool and selection and application of an appropriate technique helps the dental practitioner arrive at a correct diagnosis. The conventional two-dimensional (2D) intraoral and extraoral radiographic procedures, though very routinely used for evaluation of dental or maxillofacial complex, suffer from several limitations. These limitations are magnification, distortion, superimposition and misrepresentation of structures.1-3 With the introduction of cone beam computed tomography (CBCT) in 19974,5 imaging the maxillofacial region has become much more accurate and the diagnosis much more precise.

Most of us are familiar with the thin slices which are produced by a helical fan-beam CT also known as medical computed tomography (MDCT), but CBCT allows the creation in ‘real-time’ of images not only in the axial plane but also 2D images in the coronal, sagittal and even oblique or curved image planes—a process referred to as multiplanar reformation (MPR). In addition, CBCT data are amenable to reformation in a volume, rather than a slice, providing three-dimensional (3D) information (Table 1).2

Table 1: Comparison of MDCT with CBCT3

<table>
<thead>
<tr>
<th>Point of comparison</th>
<th>CBCT</th>
<th>MDCT</th>
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<tbody>
<tr>
<td>Shape of the beam</td>
<td>Cone beam</td>
<td>Fan-shaped beam</td>
</tr>
<tr>
<td>Cost</td>
<td>Three to 5 times less than MDCT</td>
<td>Costly</td>
</tr>
<tr>
<td>Size of the equipment</td>
<td>Substantially lighter and smaller</td>
<td>Heavier and bigger in size</td>
</tr>
<tr>
<td>Radiation dose</td>
<td>Low (68 micro Sv)</td>
<td>High (600 micro Sv)</td>
</tr>
<tr>
<td>Resolution</td>
<td>Due to smaller pixel size better resolution</td>
<td>Resolution is less as compared to CBCT</td>
</tr>
<tr>
<td>Scan time</td>
<td>Faster scan</td>
<td>Long scan time as compared to CBCT</td>
</tr>
<tr>
<td>Patient position</td>
<td>Sitting/standing</td>
<td>Lying down</td>
</tr>
<tr>
<td>Patient convenience</td>
<td>The open design of the equipment along with short scan times and upright position enhances the patient convenience and acceptance</td>
<td>Patient can experience claustrophobia due to closed design of the gantry</td>
</tr>
</tbody>
</table>

APPLICATIONS OF CBCT

Oral and Maxillofacial Surgery

1. Impacted teeth: CBCT is of great use in assessing the exact position of an impacted or a supernumerary tooth and its relation to the surrounding vital structures. Most commonly impacted teeth are the mandibular third molars. While planning a disimpaction, knowledge about the relation of the tooth to the inferior alveolar nerve canal is of prime importance to avoid any intraoperative or permanent untoward complication. CBCT enables us to assess the exact relation of the tooth to the canal, giving us information of the location of the canal whether buccal/lingual in relation to the tooth and also the...
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proximity of the canal to it. CBCT examination also helps the dental practitioner know the exact number of roots of the tooth planned for extraction their precise position, presence of any dilacerations and analysis of the extent of the pathology related to them, allowing for a defined treatment plan, which would result in less invasive surgical intervention (Fig. 1).2-4,6

2. Trauma cases: Another frequent application of CBCT is in assessing fractures of the maxillofacial complex. The conventional 2D imaging has a number of limitations is assessing the exact location and extent of the fracture line, one of the major being superimpositions of the surrounding structures. Though MDCT gives accurate information but the radiation dose to the patient involved during the scan is reasonably high as is the duration of the scan and the cost. On the contrary, CBCT scanning involves low radiation dose, easy positioning of the patient, short scan time and low cost, thus increasing the patient acceptance. The resolution of the resulting CBCT images is also higher as compared to the MDCT image (Fig. 2).

3. Orthognathic surgery planning: CBCT is also largely used in planning orthognathic surgery which requires detailed visualization of the interocclusal relationship in order to augment the 3D virtual skull model with a detailed dental surface.7

4. Calcified structures in salivary glands: The maximum intensity projection (MIP) images provides valuable information on the distribution and location of soft tissue or vascular calcifications like tonsiloliths, salivary gland stones, calcified lymph nodes and carotid artery calcifications. As the voxel gray scale intensity of these calcified areas is higher than the neighboring voxels, they appear as bright spots on MIP images (Fig. 3).

PERIODONTICS

CBCT is an accurate tool in assessing the morphologic condition of bone.8,9 Many studies have proved that the measurements as performed on the CBCT were at par with the ones done by a periodontal probe.8,10 As discussed earlier the superimposition of the surrounding structures as seen on conventional 2D radiographs, hinders the assessment of furcation involvements. On the other hand CBCT specifically helps the periodontist to detect furcation bone loss, buccal lingual defects, fenestrations, dehiscence along with accurate measurement of intra bony defects and evaluate outcome of regenerative periodontal therapy (Fig. 4).8,10,11

Fig. 1: CBCT images of impacted 48. Reconstructed panoramic image and 3D reconstruction showing horizontally impacted 38 in close approximation to the inferior alveolar nerve canal. Cross section showing the nerve canal is inferior in relation to 38

Fig. 2: 3D reconstruction and the coronal section is showing discontinuity suggestive of fracture in relation to the posterolateral wall of the left maxillary sinus
ENDODONTICS

An important advantage of CBCT in endodontics is demonstration of anatomic features in 3Ds (axial, coronal, sagittal) which the routine intraoral and panoramic projections cannot. Image enhancement algorithms like zoom magnification, window/level adjustments, and text or arrow annotation can be applied and the cursor-driven measurement algorithms that make possible real-time dimensional assessment which are free from distortion and magnification (Fig. 5). The applications can be summarized as below:

- Assessing number of root canals and their curvature.
- Diagnosis of dental periapical pathosis.
- Intra- or postoperative assessment of endodontic treatment complications, such as overextended root canal obturation material, separated endodontic instruments, calcified canal identification and localization of perforations.
- Diagnosis and management of dentoalveolar trauma, especially root fractures, luxation and/or displacement of teeth and alveolar fractures.
- Localization and differentiation of external from internal root resorption or invasive cervical resorption from other conditions, and the determination of appropriate treatment and prognosis.
- Presurgical case planning to determine the exact location of root apex/apices and to evaluate the proximity of adjacent anatomical structures.

IMPLANTOLOGY

MDCT has long been used for measuring the precise height and width of bone for placement of implants. However, the ability of CBCT to provide greater accuracy in measurements at lower radiation doses has made it the preferred option in implant dentistry. The CBCT software does not only allow for measurements of the bone quantity but also helps to measure bone quality along with algorithms with help virtual implant placement. Also there are softwares to construct surgical guides which will further reduce the failure rate. CBCT is also used for bone graft assessment and evaluation of post-treatment cases (Fig. 6).

ORTHODONTICS

CBCT offers a number of advantages for imaging in orthodontics. To list some:

- Tooth position and localization
- Measuring bone dimensions for mini-implant placement
- Rapid maxillary expansion
Fig. 6: Reconstructed panoramic and 3D image showing virtual implant placement. Cross section showing height and width of the bone in this region

- 3D cephalometry
- Airway assessment
- Age assessment
- Orthognathic surgery.

As craniofacial anatomy is precisely described, this meticulous information provided about the anatomical relationships which helps tremendously in better diagnosis, treatment and prognostication.  

**BONE PATHOLOGIES**

Cysts, tumors and other bony lesions though detected on conventional radiographs, CBCT makes available information pertaining to the actual size of the lesion, its relationship with the surrounding anatomic landmarks and extension of the lesion into paranasal sinuses, orbital cavities, nasopharynx, skull, etc. This added information provided by CBCT images goes ahead in a more accurate diagnosis between inflammatory lesions of the jaws, cysts, odontogenic tumors, nonodontogenic tumors, some other benign conditions like fibrous dysplasia, thalassemia, and even malignant lesions like squamous cell carcinoma, metastatic tumors, osteosarcoma, mucoepidermoid carcinoma, malignant lymphoma, Ewing sarcoma.  

**CONCLUSION**

CBCT provides us with images with high diagnostic quality with relatively short scanning times (10-70 seconds) and at a low radiation dose, thus finding application in all the dental specialties. To maximize the clinical output further the CBCT data should undergo a thorough clinical evaluation.

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**REFERENCES**


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