ORIGINAL RESEARCH PAPER

Volume-7 | Issue-5 | May-2018 | PRINT ISSN No 2277 - 8179

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

APPLICATION OF CONE BEAM COMPUTED TOMOGRAPHY IN VARIOUS SPECIALITIES OF DENTISTRY-A REVIEW

Community Medicine

Dr Vidhi Patel* BDS (Karnavati School of Dentistry, Gandhinagar, India), MPH Student, St John's University, NY, USA(current student) *Corresponding author

Dr Viral Thakker Reader, Department of Periodontology, Ahmedabad Municipal Corporation Dental College, Ahmedabad, India

Dr Gaurang Thakker MDS (Oral Medicine and Radiology), Private Practitioner, Ahmedabad, Gujarat, India

ABSTRACT

Cone Beam Computed Tomography is a relatively new three-dimensional imaging technology, which can be used for imaging of the teeth and jaws. The aim of this paper is to acquaint the dental professionals with various forms of this technology and its potential applications in various specialities of dentistry.

KEYWORDS

Computed tomography, Cone-beam volumetric tomography, Dental radiography

Introduction:

For diagnosis and treatment planning in dentistry radiographic examination is essential. The amount of information gained from conventional film and digitally-captured periapical radiographs is limited by the fact that the three-dimensional anatomy of the area being radiographed is compressed into a two-dimensional image. Due to superimposition, periapical radiographs has limited capacity to show the three-dimensional anatomy. CT imaging in dentistry is limited due to the high radiation dose, cost, availability, poor resolution and difficulty in interpretation. But with cone-beam computed tomography (CBCT) imaging these problems can be avoided.

Cone Beam Computed Tomography (CBCT) used for the three-dimensional imaging of the teeth and jaws is a relatively new technology in dentistry. CBCT technology is becoming more widely available and less costly and have less radiation exposure than conventional CT scan. CBCT scanners are available from most dental X-ray equipment manufacturers in a wide variety of formats with various different applications in dentistry.

CBCT in oral and maxillofacial imaging [1,2]

In April 2001, NewTom (Quantitative Radiology, Verona, Italy) was the first commercially distributed CBCT system for head and neck imaging. Subsequently, several other systems have been sanctioned or are in development. These systems can be broadly classified into three groups: (1) CBCT systems capable of imaging a large portion of the maxillofacial and cranial complex with one exposure (large FOV); (2) dedicated CBCT systems with a smaller FOV; and (3) hybrid digital panoramic/CBCT systems which have separate mechanisms for the two functions. Some of the latter systems also provide a 2D digital cephalogram option.

The captured volume of data is called the 'field of view' (FOV). Scanners are available to image volumes ranging from the whole skull to just a small volume incorporating a few teeth. X-ray dose and size of digital files will increase as larger volumes are exposed, or resolution is increased.[3]

Field of view [3,4,5]

To reduce the radiation exposure to the patient, the FOV should be adjustable in height and width to limit radiation exposure to the area of interest only. The capacity to control the FOV is exceptionally important in terms of limiting X-ray dose. In selection of a CBCT scanner it is important to choose equipment with FOV appropriate to the intended usage.Smaller FOV reduces the amount of data produced, as fewer voxels are recorded and has a positive impact on the need for data storage capacity and the speed of data processing and onscreen data manipulation. It is therefore recommended to use high-resolution on small FOV only.

Radiation exposure of CBCT [4,6-9]

Various reports have described the radiation exposure associated with CBCT scans. In 2003, it was reported that only a 20% reduction in the total radiation dose associated with cone beam CT compared with conventional CT. However, In 2004, Schulze et al. had reported that 3D volumetric images obtained with cone beam technology produces four times less radiation than conventional CT. The factors which affect the effective radiation dose are peak kilovoltage (kVp) and milliampere (mA). The use of lower mAs and/or collimation can reduce the patient's radiation exposure, but it can also reduce image quality.

The effective exposure dose for a patient from a CBCT machine has been reported to range from 45 microsievert (μSv) to 650 μSv. The reported doses for an analog full mouth series and an analog panoramic radiograph are 150 μSv and 54 μSv respectively.

Indications/Applications in Dentistry [10-11]

Grondahl (2007) reported that in Sweden in 2007 the relative frequency in the use of CBCT between different oral specialties was:

Table 1: Use of CBCT in various specialities

Speciality	Use of CBCT(%)
Implantology:	40%
Oral surgery:	19%
Orthodontics	19%
Endodontics	17%
Temporomandibular joint (TMJ)	1%
Otorhinolaryngology: (ENT)	2%
Otherinvestigations (periodontology, forensic dentistry, research).	2%

CBCT in oral and maxillofacial surgery [12-28]

CBCT with 3D images have been used to investigate the exact location and extent of jaw pathologies. or supernumerary teeth and the relationship of these teeth to vital structures.

1) CBCT images are used for pre- and postsurgical assessment of bone graft recipient sites and to evaluate osteonecrosis changes of the jaws (such as those associated with bisphosphonates) and paranasal sinus pathology and/ or defect.

2) CBCT technology has also been used for thorough pretreatment evaluations of patients with obstructive sleep apnea, to determine an appropriate surgical approach (when necessary).

3) As CBCT units become more widely available, dentists have increasingly utilized this technology to evaluate maxillofacial trauma. Used widely for investigating and managing midfacial

and orbital fractures, postfracture assessment, interoperative visualization of the maxillofacial bones, and intraoperative navigation during procedures involving gunshot wounds.

CBCT in IMPLANTOLOGY [10,23,24]

1. For planning and in designing a surgical guidance template.
2. To assess the quantity and quality of bone in edentulous ridges
3. Before bone reconstruction and sinus lifting
4. To assess the relation of planned implants to neighboring structures
5. To provide information on correct placement of implants
6. To assess the success of implant osseointegration
7. Before ridge augmentation in anodontia

CBCT in MAXILLOFACIAL PROSTHODONTIC[25]

·Cone beam computed tomography has now replaced the standard CT in imaging and planning craniofacial defect reconstruction. From CBCT DICOM data three-dimensional augmented virtual models of the patient's face, bony structures, and dentition can be created out by software volume rendering for treatment planning.

·Virtual planning of the shape of the graft and a virtual reconstruction of the defect prior to the actual surgery is possible. In addition, implant placement (if required) onto the graft can also be planned.

·With the help of larger CAD/CAM units ,Obturators for cleft closures can be precisely milled in and thereby can eliminate the entire tiresome clinical process of obturator construction.

CBCT in TMJ DISORDERS [26-35]

Diagnostic imaging of the TMJ is crucial for proper diagnosis of diseases and dysfunctions associated with joint conditions. Due to its high cost and the high dose of radiation involved, CT is is not very popular in dentistry. CBCT is useful in following:

- Examination the joint space and the true position of the condyle within the fossa.
- Diagnosis of dislocation of the joint disk.
- Measurement of the roof of the glenoid fossa and visualize the location of the soft tissue around the TMJ.
- Imaging for various cases involving trauma, fibro-osseous ankylosis, pain, dysfunction, and condylar cortical erosion and cysts in TMJ region.

CBCT in Orthodontic [2]

In general, orthodontics has relied on 2D X-rays to assess 3D structures. However, CBCT provides a 3D visualization of the craniofacial skeleton

In diagnosis,

1. Skeletal jaw relation
2. Symmetry/asymmetry
3. 3D evaluation of impacted tooth position and anatomy
4. Growth assessment
5. Pharyngeal airway analysis
6. Assessment of the TMJ complex in three dimensions
7. Cleft palate assessment
8. Assessment of skeletal structures and dental structures

In Treatment planning

1. Orthognathic surgery treatment planning in true 1:1 imaging
2. Planning for placement of temporary anchorage devices
3. Accurate estimation to space requirement for unerupted/ impacted teeth
4. Used in association with CAD/ CAM technology for construction of custom appliances. (Lingual orthodontic appliance)

CBCT in ENDODONTICS [36-41]

CBCT is useful in following:

1. Very useful tool in diagnosis of apical lesions.
2. Useful tool to assess whether the lesion was of endodontic or non-endodontic origin.
3. Detection of fractured roots both vertical and horizontal root fracture[2] and bucco-lingual or mesiodistal.
4. Early Detection of cases with inflammatory root resorption,
5. In diagnosis and extension of other cases, such as external root resorption, external cervical and internal resorption,

CBCT in PERIODONTICS[42-47]

1. CBCT can be used in assessment of bone and bone loss
2. CBCT also aids in assessing furcation involvements.
3. CBCT can be used to detect buccal and lingual defects, which was previously not possible with conventional 2-D radiographs.
4. Intra-bony defects can accurately be measured and dehiscence, fenestration defects and periodontal cysts assessed in CBCT.
5. CBCT has also proved its superiority in evaluating the outcome of regenerative periodontal therapy.

CBCT in FORENSIC DENTISTRY [48]i

Age estimation is an important aspect of forensic dentistry. It is imperative that clinicians are able to estimate the age of the individuals placed in the legal system (and those who are deceased) as accurately as possible. Typically, extraction and sectioning are required to quantify these morphological changes, which is not always a viable option. CBCT, however, provides a non-invasive alternative.

Conclusion

The role of CBCT in the field of dentistry have been demonstrated in several studies due to the usefulness of CBCT images for diagnosis, treatment planning, and treatment outcome. Recent evidences continues to demonstrate that CBCT is a valuable tool, and it is particularly important in cases where conventional radiography cannot provide adequate diagnostic information. Cone-beam computed tomography (CBCT) is a diagnostic imaging technology that is changing the way dental practitioners view the oral and maxillofacial complex as well as teeth and the surrounding tissues. CBCT has been specifically designed to produce undistorted three dimensional images similar to computed tomography (CT), but at a lower equipment cost, simpler image acquisition and lower patient radiation dose.

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