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Review Article

The Visual Funnel: Cone Beam Computed Tomography

Ayeesha Urooge[1], Shafiullah Khan[2], Khizerulla Sharief[3], Manjunath Venkatappa[4], Bintee Koirala[5] and Karthik D Yadav[4]*

[1]Master of Dental Surgery, Mak Multi-Speciality Dental Care, Kadapa, India

[2]Bachelor of Dental Surgery, Mak Multi-Speciality Dental Care, Kadapa, India

[3]Associate Professor, Paediatrician, Akash Institute of Medical Sciences and Research Centre Bangalore, India

[4]Master of Dental Surgery, Professor, Dept of Oral Medicine and Radiology, KGF College of Dental Sciences, India 5Bachelor of Dental Surgery, Consultant at Dental Enclave, India

***Corresponding Author:** Karthik D Yadav, Master of Dental Surgery, Professor, Dept of Oral Medicine and Radiology, KGF College of Dental Sciences, India.

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Abstract

With time lapse, imaging modalities has been progressed to 3D imaging from the primitive 2D imaging structure like CBCT in the field of dentistry. CBCT provides us with a 3D image and structural configuration of the disease process which helps us to provide a precise understanding of the borders, degree of disease severity and their progress with their anatomical relations. The use of CBCT in the field of dentistry has been proven and finds its applications in the medical field nowadays. However, the lack of knowledge and availability has limited its usage and requires constant update for the clinicians. It is important to provide the clinician with a sound database at the time of their training with regards to the use of CBCT and keep them updated with the newer advances to diagnostic modality to make maximum use of it and reduce the patient discomfort or complications arising out of the same.

Keywords: Cone Beam Computed Tomography; Imaging; Dentistry; Treatment; Anatomy; Radiation

Introduction

X – rays came into existence in the year 1895, coined by Sir Wilhelm Conrad Roentgen which laid the landmark of radiology in the era of medicine with progressive development observed over the years and still the search for naiver diagnostic modalities down the line [1].

Imaging modalities has been progressed to 3D imaging from the primitive 2D imaging structure, which not only helps to diagnose the disease process but also helps to plan the treatment and at the same time predicts the prognosis of the disease process. CBCT machine uses a cone-shaped beam with a reciprocating solidstate flat panel detector, which revolves around the object of interest at the time of image acquisition (whilst covering the anatomical segment of interest) in a volumetric form than the conventional slice form that is acquired by the conventional CT. The image acquired may be confined into a definitive 3D volumetric data of significance which is diagnostically relevant and reduces the absorbed x-ray dose from 6 to 15 times in comparison to CT [2].

Procedure protocol

Initially the patient is given the instructions, followed by patient positioning under the following parameters [2]

- mA - 1-15
- kVp - 90-120
- Time - 5-40 seconds (Depending on the manufacturer and area of interest)

The acquired images are transmitted to the computer and analyzed by the software using modified Feldkamp algorithm and reconstructed to form the anatomical volume for viewing at 1:1 ratio in all the planes like axial, coronal, and sagittal planes. Further, the image is stored in the particular format of Digital Imaging and Communications in Medicine (DICOM), which serves as a standardized format for the purpose of telecommunication and compatibility with other third party imaging software.[2]

Advantages [3]

- Less radiation
- Better image quality
- Non-invasive diagnostic procedure
- Painless
- 3D volumetric data
- Helps in diagnosis
- In scheduling and forecasting treatment plan
- Assess the degree of risk
- To analyze position
- Positioning of the surrounding structures (sinuses, roots, and nerves)
- Cost effective
- Provides complete data for analysis

Disadvantages [3]

- Limited contrast resolution
- Decreased radiation
- Artifacts
- Limited availability
- Requires interpretation by a specialist
- Requires special machinery
- Provides a 1:1 ratio

Applications of CBCT in dentistry

Diagnosis

Radiographic examination forms an integral part of diagnosis apart from clinical and other laboratory investigations for diagnosis and treatment planning in the field of dentistry. CBCT provides us with a 3D image and structural configuration of the disease process which helps us to provide a precise understanding of the borders, degree of disease severity and their progress with their anatomical relations. CBCT helps in diagnosis and assessment of disease severity, planning and delivery of treatment, and follow-up [4].

Cleft lip and cleft palate

CBCT provides a clear idea of the structural deformities as well as the ideology with respect to the timely intervention with reconstructive procedures which will provide a favorable outcome [5].

Oral and maxillofacial surgery

Due to the availability of the volumetric data of the disease process in amalgamation with the surrounding structures be, it vital/non-vital in nature [6,7]. Surgical procedures may involve basic extraction procedures to impactions, cyst or abscess, fractures involving the maxillofacial region, TMJ abnormalities and any other procedures requiring surgical intervention [8,9].

CBCT serves as a third eye to increase the visibility as well as the accessibility of the disease process which encompasses diagnosis (via imaging, exploration and navigation), treatment planning and delivery trailed by continuous follow-up; to predict and evaluate the treatment outcome [10,11].

The following observations can be observed in CBCT for a detailed analysis [6-9,12].

- Unerupted/impacted or supernumerary teeth odontogenic and non-odontogenic tumors, cysts) of the jaws
- Mandibular fracture
- Pathologic calcifications
- Carotid artery calcifications
- Pre- and post-surgical bone graft evaluation
- Para nasal air sinus evaluation

TMJ disorders

CBCT provides multi-planar three-dimensional images of the condyle and its surrounding structures. It also provides data with regards to the joint space and the factual position of the condyle within the fossa, which is of diagnostic relevance in assessment of TMJ dislocation [13].

CBCT is also efficient in detection of developmental anomalies, trauma, fibro-osseous ankylosis, dysfunction, and condylar cortical erosion, rheumatoid arthritis and cysts [14,15].

Endodontics

Endodontic treatment forms an essential part of the day-to-day dental treatment which helps in detection of tooth structure including the size, root form with the canals and deviations apart from the normal structures, tooth fractures, periapical lesions, root resorption, maxillary sinus involvement, and mandibular canal proximity. It can also be used to establish working lengths, alongside the type and degree of root angulation and assessment of the root canal obturation [16-18].

Periodontics

Periodontal bone loss affects patients across all age groups, however the intensity is more rapid in adulthood which remains a matter of concern and requires attention. Conventional radiographs provide only a 2 dimensional view of the tooth with its surrounding structure, however periodontics requires a 3 dimensional view to understand the tooth and its relations (bony structures, vascular and nerve supply. CBCT provides the required volumetric data which plays a role in diagnosis, treatment planning and determining the treatment outcome.

CBCT is capable of providing diagnostic data of significance in visualization of buccal and lingual defects, cysts, intra-bony defects, furcation involvement, dehiscence and fenestration defects, and periodontal cysts [18-20].

Orthodontics

CBCT provides volumetric data of anatomic landmarks as well as its associated structures, which delivers information with respect to the alveolar bucco-lingual width, palatal bone thickness as well as skeletal growth patterns [21-24]. They also provide vital information in regard to the stages of teeth and provide an idea of their eruption rime period along with an idea of dental age estimation and the status of impacted teeth. CBCT also provides an idea about the inclination angle of tooth inclination and the torque required for the same which would provide maximum treatment benefit for the patient. Further CBCT acts as a pre-guidance and a post-guidance in interpreting the orthognathic as well as facial orthomorphic changes that have taken place [25,26].

Implantology

CBCT provides information with respect to the bone height, width and the type of bone which represents the density and helps in selection of the size, shape and contour of the implant with the angulation and the type of implant required for the individual during a prosthesis construction [12,27,28]. Further, it also helps to plan the surgical procedure which would provide the maximum beneficial results for the patient.

Advances in CBCT

Over the years, there has been enormous research analysis with respect to the development in the field of diagnostic armamentarium, however the lack of knowledge and availability has limited its usage and requires constant update for the clinicians.

The use of CBCT for CADCAM procedures have lately gained popularity especially in the 3D printing aspect, but the availability in the rural areas of all these equipment still remains a delusion, which has to be fulfilled.

Further, the use of CBCT in multi-detector form is the newest advancement which is most commonly used to assess the TMJ and sinus in the field of dentistry. However, it remains available in certain centers only as they cost a fortune and burns a financial burden initially but provides the best volumetric data with minimal radiation as well as distortion, which provides the perfect image for analysis, planning and execution of treatment.

Future prospects

Artificial intelligence and robotics have revolutionized the planning and operating protocols as they follow the minimal damage protocol and conserve the tissue/structure and obtain the maximum favorable results which is the aim of each clinician/physician.

Image guided approach not only helps to understand the anatomy, but also helps to operate in the dynamic situation to provide the best results with minimal complications. However, these ideologies have not been applied vastly and require a positive reinforcement in the field of CBCT in amalgamation with these techniques.

Conclusion

CBCT is the most cost-effective treatment modality with minimal patient intervention/rejection but due to the limited avail-

ability and the lack of knowledge in interpretation and software operating protocol its use is still not a viable option amongst the day-to-day clinicians/physicians.

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