Review Article

JRAD Journal of Research and Advancement in Dentistry

J Res Adv Dent 2016;5:1:279-284.

CBCT Imaging in Orthodontics

Sreevalli S[1*] K. Srinivasa Rao[2]

[1]Reader, Department of Orthodontics, Drs. Sudha & Nageswara Siddhartha Institute of Dental Sciences, Vijayawada, India.
[2]Associate Professor, Department of Orthodontics, Government Dental College and Hospital, Vijayawada, India.

ABSTRACT

Background: The application of innovative diagnostic technologies in dentistry and in orthodontics has been very interesting to observe. The use of Cone Beam computed tomography (CBCT) as one of the investigative procedure for the comprehensive orthodontic treatment especially in Canine impaction, Orthognathic surgeries, Airway obstructions, cleft lip and palate, temporomandibular disorders helps the clinician to diagnose a case with great accuracy. The purpose of this article is to provide a detailed overview of CBCT imaging, its technique, advantages, disadvantages and its clinical applications.

Keywords: Cone beam computed tomography, Orthodontic diagnosis, Clinical applications.

INTRODUCTION

Since 1980's dental computer supported tomography instruments have been developed continuously on an international scale. Almost all systems available today are based on the "cone beam" technique, in which the objects detected in the path of the cone beam are converted mathematically into a digital image by means of algorithms. Cone-shaped X-ray beam that is directed through the patient and the remnant beam is captured on a flat two-dimensional (2D) detector. These 2D images are then converted into a 3D image using computer software. The rapid movement of the X-ray tube and digital detector through 180°, or more frequently through 360°, produces essentially instantaneous and precise 2D and 3D radiographic images of an anatomical structure. Furthermore, these images are only restricted by the system's distinctive field-of-view (FOV).

There are three types of scanners to describe the anatomy of the site interested.

1. Scanners using flat panel detector's (FPD) describe the dimensions of their cylindrical FOV as height/width (HxW).

2. Scanners using image intensifiers and charged couple devices (CCD) as their detectors describe the dimensions of their spherical FOV's as cm.

Large FOV's usually FOV heights equal to or greater than 16cms are used for cephalometric analysis and traditional orthodontic surveys. Medium FOV scanners are used for Implant surveys. Scanners with smaller FOV's capture a user defined region, usually symmetrical in shape and these are used for temporomandibuar surveys and localization of impacted teeth. After capturing the image it is displayed with the help of DICOM (Digital imaging and communications in medicine).The DICOM that is used currently for communication is 3.0 versions[1].

Advantages of CBCT over conventional CT

1. As Conventional CT scanners are large and very expensive, CBCT is less expensive and involves a smaller system.

Received: July. 23, 2015: **Accepted:** Nov. 11, 2015
*Correspondence Dr. Sreevalli S.
Department of Orthodontics, Drs. Sudha & Nageswara Siddhartha Institute of Dental Sciences, Vijayawada, India.
Email: srivallimohan@gmail.com

pISSN 2278-0076
eISSN 2321-9270

2. High speed is required to minimize the artifacts like sinuses, whereas CBCT have fewer imaging artifacts and scan time is rapid.

3. Collected image data is anisotropic and are very accurate from CBCT'S.

4. Display modes are exclusive to dentofacial imaging in CBCT. In Conventional Scan is not necessarily limited to the jaws; the patient can be exposed to more radiation than a panoramic survey.

5. As compared to CBCT Conventional CT machines are expensive to purchase and maintain.

6. Lower radiation dose is used for CBCT'S.

CBCT In Orofacial Imaging

Three dimensional craniofacial imaging have changed professional approach towards diagnosis in dentistry as well as in orthodontics. Although Computed tomography (CT) is still used in many clinical situations, when 3D information is needed, its use has been limited in dentistry because of its high cost, low vertical resolution, and high doses of radiation. CBCT scanners are intrinsically three dimensional in its acquisition of anatomic sites of interest and provide usable images[2]. It produces images of high contrast structures, especially suited for bone and teeth, and also for assessing the rate of tooth movement during orthodontic treatment and also in evaluating the position of impacted, supernumerary teeth, implant planning(temporary anchorage devices), preoperative and postoperative assessment of Orofacial structures and after orthognathic and cleft lip and palate surgeries. The dosage that is absorbed by the patient is drastically reduced compared to conventional CT. Another important application of CBCT in maxillofacial region is production of laser generated study models, which are from VTO to digital casts and 3D cephalometric analysis useful for distraction osteogenesis and dental implant placement.

Radiation exposure of CBCT

Initially many studies have proved that there is only 20 percent reduction in the total radiation dose in conventional CT. But studies done by Schulze et al proved that change in the settings like use of lower collimation can reduce the amount of radiation the patient is exposed. Required effective exposure dose for a patient from a CBCT ranges from 45 to 650 microsievert. For a full mouth orthopantomogram the required dose is 150 microsievert[3].

Applications in orthodontics and Dentofacial Orthopaedics:

1. CBCT helps us to assess treatment outcomes and bone remodelling changes after orthodontic and Orthognathic surgical procedures.

2. Location and position of impacted canines in both the arches, amount of bone covering over the tooth, labial and lingual position, resorption of the overlying teeth due to impacted teeth can be assessed. Involved teeth show series of cross-sectional images.

3. Thickness and morphology of bone can be determined for the placement of micro implants and for skeletal expansion by using rapid maxillary expansion screws.

4. Facial asymmetries and TMJ abnormalities can be better examined by cone beam images

5. Pre and post orthodontic changes in hard and soft tissues facial structures can be assessed without any magnification and superimposition of the anatomical structures.

6. Size and shape of the pharynx can be measured before planning any treatment procedures to correct obstructive sleep apnea disorder.

7. CBCT images provide clear picture regarding root angulations and resorptions occurred during the course of orthodontic treatment.

Evidence based diagnosis and treatment planning

In the present scenario, CBCT plays an important diagnostic tool for evidence based diagnosis and treatment planning that is to be done.

Diagnosis

Assessment of anatomic structures for cephalometric ananlysis:

Conventonal cephalometric radiography is a two dimensional representation of a three dimensional object. Because of this, landmark identification is difficult due to superimposition of anatomical structures on the opposite side. CBCT imaging in association with the computer soft ware helps us to view the image in all three planes of space. Landmark identification and reproducibility of measurements on cephalometric tracings obtained from CBCT is much better in clarity than conventional CT'S [4, 5].

Role in Growth Assessment

CBCT plays an important role in assessing the skeletal growth that occurred during the treatment of CL-II and CL-III malocclusions using functional appliances, facemasks and headgears. Positional changes of maxilla and mandible can be compared with the anterior cranial fosse with the help of the 3-D analysis. CBCT scan in the orofacial region also helps us to view the cervical vertebra which provides a constant evaluation of skeletal maturation of the patient which is useful for growth modulation.

3D visualizing of the occlusal arch forms helps orthodontist to measure tooth size and arch length discrepancy and plan quickly for extractions in minimum, moderate, and maximum anchorage requirements cases. Some non extraction treatment procedures like, expansion, uprighting of buccal and anterior segments interproximal stripping to gain arch length,visualization of"dark' buccal corridors for expansion are evaluated using the diagnostic image slice in a coronal section of the CBCT scan[6].

Role in impactions

Normal conventional radiographs offer a 2D representation of a 3D object. Localization of these teeth is usually done using the buccal object rule as well as taking two radiographic images at right angles to one another, usually a periapical radiograph. All the above techniques do not provide information like amount of bone and tissue that is covering the impacted teeth. CBCT helps the clinician to locate the impacted teeth, any associated pathology, as well as their relationship and effect on the surrounding dentition. Area of interest can be reconstructed three dimensionally and Levelling and aligning of impacted canine can be done. Assessment of force to be used and force vector/directions and bracket positioning without applying any force on the adjacent teeth can be checked by CBCT images**.** Root resorption caused by impingement of the impacted tooth on the adjacent teeth can also be assessed [7,8].

Temporomandibular joint disorders

The end goal of the orthodontic treatment is not only moving the teeth to class-I molar and canine positions along with cusp to fossa relation but also to obtain well balanced soft tissues and TMJ joints. As TMJ is a complex entity with hard and soft tissue component any derangements in the articular disc, different ramal heights which causes open bite in the posterior segments can be better visualized by 3D images than panoramic films. In patients with asymmetry of the jaws and Class-II Div2 malocclusions where TMJ abnormality is expected imaging of TMJ complex plays an important role in treatment planning of a particular case. The time required to capture images bilaterally by conventional tomography is more than the CBCT. 3D CBCT requires less time for both right and left TMJ's from a single 360^0 rotation scan around the pts head. Only in cases like TMJ erosion, remodeling or structural deformities CBCT is a useful diagnostic aid since it reduces the radiation dose and the possibility of multiplanar views and image manipulation in the form of rotated views[9].

Obstructive sleep apnea

Tongue position has a lot of effect on airway. Lateral cephalograms are very useful in analyzing the upper airway passages in adenoid patients. Some lateral cephalometric analysis have also taken upper and lower airway measurements to derive the correlation between adenoids and Class-II malocclusions. Use of cone beam CT has opened up new dimensions for understanding the upper airway anatomy and physiology. It also analyses the airway volume, area and the distance in obstructive sleep apnea and in enlarged adenoid cases. This technology enables complete, fast, and detailed upper airway images at a relative low cost. Any abnormalities like can be cheked deviated septae, maxillo-mandibular hypoplasia,

displacement of the hyoid bone relative to the mandible.3D images can be used to accurately measure both cross sectional area and airway volume allowing narrowest part of the airway, so a useful tool in diagnosis of sleep apnea. And enlarged adenoid cases, since these cases showed significant decrease in airway volume thus enabling the clinician for evidence based treatment[10].

Cleft lip and palate

Usually cleft lip and palate patients have alveolar bone defects, hypodontia, supernumerary and impacted teeth. Reconstruction of cleft palate by surgical method requires volumetric assessment and its location of bone defect. CBCT gives exact information regarding the number and orientation of teeth, amount and quality of bone available in the cleft region. Even though panoramic radiograph gives us the information regarding the number of teeth but amount and quality of the remaining bone can only be assessed with the help of CBCT.3D CBCT reconstructions of the skin surface of the face for cleft lip patients are also available [11,12].

Treatment planning

Estimation of space accurately for unerupted teeth

CBCT imaging to locate the exact position of the impacted teeth and transposed teeth gives precise dimensions of the unerupted teeth so that clinician can caluculate space required for alignment. Extraction and nonextraction procedures can be planned depending upon the space available. Because of accuarate diagnosis surrounding anatomic structures are not disturbed during extrusion into the oralcavity.

Sure Smile system using custom made appliances

CBCT images help the clinician to make custom made lingual braces for the patients undergoing lingual orthodontic treatment. Rapid advances promise efficient and effective patient specific treatments. Orametrix is a company that uses sure smile lingual custom made braces to provide treatment for lingual patients[13].

Orthognathic surgeries

CBCT imaging in combination with appropriate software and virtual models enables the examination of hard and soft tissues in the orofacial region and their relationship in three planes of space that is saggital, vertical and tranverse. Virtual anatomic models can be fabricated in tandem with CT volumes and 3Dimage data. Virtual models that are generated can be used to recreate treatment options, to create anatomically correct substitute grafts and be an important aid during the surgical procedure. Effects of different treatment regimens on the facial profile can be evaluated by using this 3D imaging. Data bases may be overlapped with the anatomic models to provide features of the displayed tissues, to reproduce tissue reactions to development, treatment, and function. Replicated manipulation of the hard tissues like teeth and skeleton produces a correct deformation reaction in the attached soft tissues. This method offers a more accurate depiction of predicted changes subsequent to surgical treatment. since more rotations and displacements in the condyles occur during orthognathic surgery, a quantitative assessment of condylar rotation/displacement can be checked with the help of CBCT. Cross sectional cuts in axial, coronal and sagittal planes permit access to the internal morphology of soft tissues and skeletal structures. CBCT is an ideal diagnostic VTO which we can communicate with the patient with different treatment options. It gives the patient a reasonable preview of the outcome [14,15].

Microimplant placement

Mini implants have been widely used in orthodontics as temporary anchorage devices (TAD). They are placed in dense bony areas of maxilla and mandible. Cortical bone thickness and bone pattern are important criteria in mini implant p;acemnt, therefore it is crucial to identify the ideal site before insertion of the miniimplant . CBCT provides ideal information regarding the bone thickness, extent of maxillary sinus, exact location of the roots and the interroot distance.3Dimensional CBCT image based stereo lithographic surgical stent guides have been more accurate than 2D surgical guides in mini implant placement [16,17].

Limitations in Orthodontics:

1. Identification of cephalometric land marks especially sella, porion is difficult with some cone beam units due to lack of fine detail

2. Artifacts from dental restorations and implants compromise image quality in the plane of occlusion[18].

CONCLUSION

The use of CBCT is expanding in dental & maxillofacial imaging. The 2D and 3D reconstruction which are possible with this imaging techniques supplements the clinical decision with respect to the anatomic site of interest.3D treatment planning can be made on digital computer models of the patient's anatomy which contains teeth, skeletal and soft tissue structures. All these anatomic sites can be viewed by the orthodontist from any angle, sliced and made transparent. These structures can be adjusted by the doctor for the treatment planning purposes. Accumulating evidence continues to demonstrate that CBCT is a valuable tool.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. LudlowJB, Davies-Ludlow LE, Brooks SL: Dosimetry of two extraoral direct digital imaging devices: NewTom Conebeam CT and Orthophos Plus DS panoramic unit Dentofacial Radiol 32:229-234, 2003.

2. Ngan DC, Kharabandha OP, Geenty JP,Darendeliler: Comparison of radiation levels from computed tomography and conventional dental radiographs Aust Orthod J 19:67-75,2003.

3. Visser H, Rodig T, Hermann KP: Dose reduction by direct-digital cephalometric radiography. Angle orthodont 71:159-163,2001.

4. Luke LS, Atchison KA, White SC: Consistency of patient classification in orthodontic diagnosis and treatment planning, Angle Orthod 68;513-520,1998.

5. Harrell WE:Three-dimensional diagnosis and treatment planning: the use of 3D facial imaging and 3D cone beam Ct in orthododntics and dentistry. Austral Asian Dent Pract J July/August, 2007.

6. Joshi V., Yamaguchi T., Matsuda Y., Kaneko N., Maki K., Okano T. Skeletal maturity assessment with the use of cone-beam computerized tomography. Oral Surg. Oral Med. Oral Pathol. Oral Radiol. 2012;113(6):841–849.

7. Walker L, Enciso R, Mah J:Three-dimensional localization of maxillary canines with cone beam computed tomography.Am J Orthod Dentofacial Orthop 128:418-423,2005.

8. Ericson S, Kurol PJ: Resorption of incisors after ectopic eruption of maxillary canines: a CT study Angle Orthod 70 :415-423,2000.

9. Hintze H., Wiese M., Wenzel A. Cone beam CT and conventional tomography for the detection of morphological temporomandibular joint changes.

10. Schwab RJ, Pasirstein M, Pieeson R, Mackley A, Hachadoorain R, Arens R et al: Identification of upper airway anatomic risk factors for obstructive sleep apnea with volumetric magnetic resonance imaging Am J Respir Crit Care Med 168:15220-530,2003.

11. Scarfe W.C., Farman A.G., Sukovic P. Clinical applications of cone-beam computed tomography in dental practice. J. Can. Dent. Assoc. 2006; 72(1):75–80.

12. Albuquerque M.A., Gaia B.F., Cavalcanti M.G. Comparison between multislice and cone-beam computerized tomography in the volumetric assessment of cleft palate. Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod. 2011;112(2):249–257

13. Ye N., Li J., Zhang K., Yang Y., Lai W. Computer-aided design of a lingual orthodontic appliance using cone-beam computed tomography. J. Clin. Orthod. 2011;45:553–559.

14. Sarti A, Gori R, Lamberti C: A physically based mode to simulate maxillofacial surgery from 3D CT images. Future generation computer systems 15:217-221, 1999.

15. Schendel S.A., Lane C., Harrell W.E., Jr. 3D orthognathic surgery simulation using image fusion. Semin. Orthod. 2009;15:48–56.

16. . Kim S.H., Choi Y.S., Hwang E.H., Chung K.R., Kook Y.A., Nelson G. Surgical positioning of orthodontic mini-implants with guides fabricated on models replicated with cone-beam computed tomography. Am. J. Orthod. Dentofacial Orthop. 2007;131:S82–S89

17. Temporary anchorage devices in orthodontics-Ravindra nanda-2008.

18. Kapila S., Conley R.S., Harrell W.E., Jr. The current status of cone beam computed tomography imaging in orthodontics. Dentomaxillofac. Radiol. 2011;40(1):24–34.