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A Review on Cone Beam Computed Tomography (CBCT) in Oral and Maxillofacial Surgery

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Abstract

Maxillofacial practice has become easier now days with the arrival of Cone Beam Computed Tomography (CBCT). There are numerous applications for CBCT in dentistry. The amount of information one can obtain from a 3 D image over a 2D image is considerable. This review speaks the best part of CBCT in clinical applications in oral and maxillofacial diagnosis.

Keywords: Cone Beam Computed Tomography, Computed Tomography, Radiography, Maxillofacial Surgery, Maxillofacial Imaging.

Abbreviations

CBCT: Cone Beam Computed Tomography; CT: Computed Tomography; MARPE: Mini-Screw Assisted Rapid Palatal Expansion; TMJ: Temporomandibular Joint; OMS: Oral and maxillofacial surgery.

Introduction

Cone Beam Computed Tomography (CBCT) is a three dimensional view radiographs and used vastly in the field of oral and maxillofacial surgery through its valuable applications in dental diagnosis and effective maxillofacial treatment planning.

History of X ray

In 1800s, Wilhelm Rontgen discovered X rays[1.]Initially two-dimensional radiographs were developed for the purpose of supporting the physician to arrive a diagnosis along with their clinical findings. But the dental tissues and its structure are three dimensional, they could not project the three-dimensional view. This was the limitations of two-dimensional radiographs. A revolution is happened on the account of 3 D images, CT was developed by Sir God Frey N. Hounsfield in1967.since its available in 1970s ,CT has become one of the commonly used imaging methods[2.]when compare to Two dimensional radiographs, in CT there was no superimposition and distortion. But CT has some limitation like high cost, limited access, and mainly higher radiation to the patient[3].To Overcome these limitations, CBCT has emerged in the field.

An early volumetric CT predecessor of CBCT, the dynamic spatial reconstructor, was developed in the late 1970s by the Biodynamics Research Unit at the Mayo Clinic (Rochester, MN, USA). The first CBCT scanner was constructed for angiography [4.] In 1997, the department of radiology

of the Nihon University School of Dentistry developed a new technology- limited cone-beam computedtomography[5.]CBCT was developed by Arai et al[6] in Japan (1999) and Mozzo et al (1998)[7]. The first commercial CBCT was introduced in Europe in 1999[4.]It has variousnames such as dental volumetric tomography (DVT), cone-beam volumetric tomography (CBVT),

dental computed tomography (DCT), and cone-beam imaging (CBI), the most preferred name is cone-beam computed tomography(CBCT)[8].

Principles of Cone Beam Computed Tomography (CBCT) :

CBCT is recorded with cone-shaped beam of Xrays and a reciprocating solid state flat-panel detector. The detector rotates around the patient either by 180^0 or 360^0 once and records the field of view rather a slice by slice imaging Performed in conventional CT[9].In a single rotation, the region of interest (ROI) is scanned by a cone-shaped X ray beam around the vertical axis of the patient's head. Digitized information of the objects in the ROI such as shape and density are acquired from multiple angles. These imaging data are then processed by Speciality software that ultimately constructs the tomographic images of the ROI in multiple anatomical planes, namely the standard coronal, axial and sagittal anatomical planes[10].

Clinical application of CBCT in Oral and Maxillofacial surgery

Dental Implantology

To evaluate bone quality and bone quantity CBCT is the most following method nowadays. It seems to be possible to predict bone density, initial implant stability, and possibility of immediate or early loading using CBCT scan prior to implant surgery[11].CBCT enables the identification of nerve structures such as inferior alveolar nerve course through the mandible[12].CBCT is also a useful source for bone grafting used in dental implants. With the help of CBCT scan and computer aided design, surgical guides can be fabricated. These surgical guides are used by the implantologist to place the planned implants in the patient's mouth in the same position as in the virtual treatment plan, allowing for more accurate and predictable implant placement and reduced patient morbidity[13].

The European association for Osseo integration suggests CBCT might be required for treatment planning in the following clinical situation[14]

1) where clinical examination and conventional radiography have failed to demonstrate

the relevant anatomy, to help reduce the risk to important anatomical structures; (2) in borderline situations where there is limited bone available to place dental implants; and (3) where implant positioning can be improved to optimize biomechanical, functional, and aesthetic results. Examples include computer-assisted planning and the construction of surgical guides.

Impacted and Supernumerary teeth

Impaction surgery is the most common minor oral surgery performed in dental clinics and hospital. The intra oral periapical radiographs and panoramic radiographs are the widely used choice for impaction surgery. CBCT assesses the risk of treatment or non-treatment based on more accurate 3 Dimensional analysis[15].The relationship of impacted third molars to the mandibular canal ,adjacent teeth, sinus walls, and cortical border is important diagnostic information that can directly impact the outcome of surgery[16].Tantanapornkal et al [17] concluded that 3DX-rayCBCT(J Morite USA, Inc, Irvine, CA, USA) was significantly more accurate when compared with panoramic radiography in predicting IAN exposure during third molar removal with sensitivity of 93% and specificity 77%..Using CBCT to locate and evaluate impacted cuspids and supernumerary teeth seem to make the surgical procedure more efficient and less invasive[18].Jawad et al [19] reported that CBCT provided improved detection rate of root resorption associated with impacted canines. He also introduced a new root

resorption scale for CBCT imaging. CBCT proved to be a most reliable in determining the number of roots than did panoramic radiography[20].

Oral And Maxillofacial Pathology

Usually CT is taken for diagnosis of maxillofacial pathology. But with the help of CBCT exact size of the defect and its relative density (radiolucent or radiopaque or a combination of the two) are determined[21].CBCT is recommended when there is a need to diagnose a cyst ,tumor,or infections in the alveolar process and jaw bone [22].CBCT can also be teamed with stereo lithographic model construction ,which is used for dental implant placement or in the reconstruction of jaws resected due to pathology[21].CBCT is helpful for presurgical planning of aggressive benign cysts and tumor as well as the monitor the progression of pathology with the use of multiple scans. CBCT also monitor skeletal changes ,airway changes and healing responses[23].CBCT shows very little soft tissue details. In that situation either CT or MRI is indicated. It should not use in suspected malignancy. It is inferior to CT as it cannot distinguish solid and cystic leisions[24].Finally CBCT was shown to increase confidence of the surgeon, but did not change proposed management [25].

Maxillofacial Traumatology

Trauma patients can be assessed with CBCT for treatment planning. CBCT can be used in combination with specific computer software for preoperative virtual planning and fabrication of patient-specific reconstruction plate for mandibular fractures[26].When comparing CT and CBCT in the diagnosis of midface one study shown that CBCT provide better image quality at lower doses, and superior spatial resolution in standard and reduced dose settings[27].However one recent study said that CBCT was not optimal for postoperative facial imaging in terms of maxillofacial bony structure in the vicinity of osteosynthesis materials[28].

TMJ Disorders

MRI is the gold standard for articular components of TMJ usually. Though Panoramic radiographs give a basic idea of the joint, it has low sensitivity in evaluating changes in the condyle ,poor reliability and low accuracy in evaluating the temporal components of the joint[29].CBCT provides information of condyle, glenoid fossa, joint space and surrounding structures. As CBCT allows the location of mandibular condyle, we can diagnose the potential problems associated with and dislocations of joint[30].CBCT is used to compare the right TMJ with the left TMJ. By the use of CBCT we can assess the orthodontic expansion in mini implant supported rapid palatal expansion (MARPE) cases[31].Therefore CBCT is useful imaging device for assessment of developmental anomalies of condyle, trauma of mandible and TMJ ,ankylosis, cortical erosion and osteoarthritic changes in the condyle[32].At last, CBCT may soon become the investigational tool of choice for evaluating bony changes of the TMJ[30].

Orthodontics & Orthognathic surgery

CBCT is useful for diagnosis treatment planning and treatment outcome in orthodontics. We can study about the hard and soft tissue wit this. When using aligners ,before starting the treatment we can predict root and bone structure and design treatment with the help of CBCT[33].Because some authors have doubt on root movement in aligner treatment[34].Additionally CBCT can be used in association with CAD/CAM technology for production of custom-made orthodontic appliances[35].It can also be used for evaluation of facial growth and its discrepancies with class III malocclusion and orthodontic treatment[36,37].CBCT is used for virtual surgical treatment planning in maxillary and mandibular advancement,

rotation and jaw correction[38] .A computer designed splint is prepared with CBCT and can be used in maxillary down fracture and mandibular setback[39].Katkar et al [40]shows CBCT was reliable in demonstrating cephalometric landmarks accurately. CBCT is a effective tool to identify the vital structures related to impacted teeth which could interfere the orthodontic movement[41].Airway measurement technique are possible with CBCT[42,43].These data is useful for surgical orthodontic cases as well as sleep apnea patients[44].CBCT is reliable tool in craniofacial surgery also.

Conclusion

CBCT is used widely now a days in OMS offices. It is a valuable tool for diagnosis, treatment planning and treatment outcome and research purpose. These are several studies says about the clinical applications of CBCT. our study was focusing its usage in oral and maxillofacial surgery.

References

1. White SC, Pharoah M (2014) Oral radiology principles and interpretation. St.Louis: Mosby Elsevier 199-212.
2. Brenner DJ, Hall EJ. Computed tomography—An increasing source of radiation exposure. The NewEngland Journal of Medicine. 2007;357:2277-2284.
3. Hatcher DC, Dial C, Mayorga C. Cone beam CT for pre-surgical assessment of implant sites. Journal of the California Dental Association. 2003;31:825-833
4. Tyndall DA, Rathore S. Cone-beam CT diagnostic applications: caries, periodontal bone assessment, and endodontic applications. Dent Clin North Am. 2008;52(4):825–841.
5. Karjodkar FR. Textbook of Dental & Maxillofacial Radiology. 2nd ed. New Delhi: Jaypee Brothers Medical Publishers; 2009. p. 279-282
6. Arai Y, Tammisalo E, Iwai K, Hashimoto K, Shinoda K (1999) Development of a compact computed tomographic apparatus for dental use. DentomaxillofacRadiol 28: 245-248.
7. Mozzo P, Procacci C, Tacconi A, Martini PT, Andreis IA (1998) A new volumetric ct machine for dental imaging based on the cone-beam technique: Preliminaryresults. EurRadiol 8: 1558-1564.
8. Scarfe WC, Farmen AG. What is cone beam CT and how does it work. Dent Clin North Am 2008;52:707-30.
9. Nimeshkumar P, Ekta M (2021) A review on Cone Beam Computed Tomography in dentistry. Int J Oral CraniofacSci 7(2): 003-007.
10. Kenneth Abramovitch,Basic Principles of Cone Beam ComputedTomographyDent Clin N Am 58 (2014) 463–484
11. UfukTatli and BurcuEvlice. Cone-Beam Computed Tomography for Oral and Maxillofacial Imaging :http://dx.doi.org/10.5772/intechopen.69282
12. Almog DM, LaMar J, LaMar FR, LaMarF (2006) Cone beam computerizedtomography-based dental imaging for implant planning and surgical guidance,part 1: Single implant in the mandibular molar region. J Oral Implantol 32: 77-81.
13. Orentlicher G, Abboud M. Guided surgery for implant therapy. Dent Clin North Am. 2011;55(4):715–744.
14. Harris D, Horner K, Grondahl K, et al. E.A.O. Guidelines for the use ofdiagnostic imaging in implant dentistry 2011. A consensus workshop organized by the European Association for Osseointegration at the Medical University of Warsaw. Clin Oral Implant. Res 2012; 23:1243e53.
15. J Sakabe, Y Kuroki, S Fujimaki, I Nakajima and K Honda. Reproducibility and accuracy of measuring

unerupted teeth using limited cone beam X-ray CT. Journal of Dentomaxillofacial Radiology (2007) 36, 2–6.

16. Danforth RA, Peck J, Hall P: Cone beam volume tomography:An imaging option for diagnosis of complex mandibular third molar anatomical relationships. J Calif Dent Assoc 31:847, 2003
17. Tantanapornkul W, Okouchi K, Fujiwara Y, et al. A comparative study of cone-beam computed tomography and conventional panoramic radiography in assessing the topographic relationship between the mandibular canal and impacted third molars. Oral Surg Oral Med Oral Pathol Oral RadiolEndod. 2007;103(2):253–259.
18. Walker L, Enciso R, Mah, J: Three-dimensional localization ofmaxillary canines with cone-beam computed tomography.Am J OrthodDentofacOrthop 128:418, 2005
19. Jawad Z, Carmichael F, Houghton N, Bates C. A review of cone beam computed tomography for the diagnosis of root resorption associated with impacted canines, introducing an innovative root resorption scale. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology. 2016;**122**:765-771. DOI: 10.1016/j.oooo.2016.08.015
20. Suomalainen A, Ventä I, Mattila M, Turtola L, Vehmas T, Peltola JS. Reliability of CBCT and other radiographic methods in preoperative evaluation of lower third molars.Oral Surg Oral Med Oral Pathol Oral RadiolEndod. 2010;109(2):276–284.
21. Guttenberg SA. Oral and maxillofacial pathology in three dimensions.Dent Clin North Am. 2008;52(4):843–873
22. Marques YM, Botelho TD, Xavier FC, Rangel AL, Rege IC, Mantesso A. Importance of cone beam computed tomography for diagnosis of calcifying cystic odontogenictumour associated to odontoma. Report of a case.Med Oral Patol Oral Cir Bucal. 2010;15(3):e490–e493.
23. Mansur Ahmad and Earl freymiller. Cone Beam Computed Tomography: Evaluation of Maxillofacial Pathology. 2010 CDA Journal, Vol 38
24. Boeddinghaus R, Whyte A. Trends in maxillofacial imaging. ClinRadiol 2018;73:4e18.
25. Santos AA, Yamamoto-Silva FP, Torres EM, et al. Contribution of conebeamcomputed tomography in the decision of surgical management for bone lesions of the maxillofacial region. J Craniomaxillofac Surg2019;47:87e92.
26. Thor A. Preoperative planning of virtual osteotomies followed by fabrication of patient specific reconstruction plate for secondary correction and fixation of displaced bilateral mandibular body fracture. Craniomaxillofacial Trauma and Reconstruction. 2016;**9**:188- 194.
27. Veldhoen S, Schöllchen M, Hanken H, Precht C, Henes FO, Schön G, Nagel HD, Schumacher U, Heiland M, Adam G, Regier M. Performance of cone-beam computed tomography and multidetector computed tomography in diagnostic imaging of the midface: A comparative study on phantom and cadaver head scans. European Radiology. 2017;**27**:790-800.
28. Peltola EM, Mäkelä T, Haapamäki V, Suomalainen A, Leikola J, Koskinen SK, Kortesniemi M, Koivikko MP. CT of facial fracture fixation: An experimental study of artefact reducing methods. Dentomaxillofacial Radiology. 2017;**46**:20160261.
29. Dahlstrom L, Lindvall AM: Assessment of temporomandibularjoint disease by panoramic radiography: Reliability and validity in relation to tomography. DentomaxillofacRadiol 25:197, 1996

30. Tsiklakis K, Syriopoulos K, Stamatakis HC (2004) Radiographic examination of the temporomandibular joint using cone beam computed tomography. DentomaxillofacRadiol 33: 196-201.
31. Mehta S, Chen PJ, Vich ML, Upadhyay M, Tadinada A, et al. (2021) Boneanchored versus tooth-anchored expansion appliances: Long-term effects on the condyle-fossa relationship. J World Fed Orthod S2212-4438: 31-X.
32. Honda K, Larheim TA, Johannessen S, Arai Y, Shinoda K, et al. (2001) Ortho cubicsuperhigh resolution computed tomography: A new radiographic technique with application to the temporomandibular joint. Oral Surg Oral MedOralPathol Oral RadiolEndod 91: 239-243.
33. T, Jiang YN, Chu FT, Lu PJ, Tang GH (2021) A cone-beam computed tomographic study evaluating the efficacy of incisor movement withclear aligners: Assessment of incisor pure tipping, controlled tipping,translation, and torque. Am J OrthodDentofacialOrthop 159: 635-643.
34. .Haouili N, Kravitz ND, Vaid NR, Ferguson DJ, Makki L (2020) Has Invisalign improved? A prospective follow-up study on the efficacy of tooth movement withInvisalign. Am J OrthodDentofacialOrthop 158: 420-425.
35. Kwon SY, Kim Y, Ahn HW, Kim KB, Chung KR, Kim Sunny SH. Computer-aided designingand manufacturing of lingual fixed orthodontic appliance using 2D/3D registration software and rapid prototyping. International Journal of Dentistry. 2014;**2014**:164164.
36. Kapila S, Conley RS, Harrell WE (2011) The current status of cone beamcomputed tomography imaging in orthodontics. DentomaxillofacRadiol 40:24-34.
37. Mehta S, Chen PJ, Upadhyay M, Yadav S (2021) Intermaxillary elastics on skeletal anchorage and MARPE to treat a class III maxillary retrognathicopen bite adolescent: A case report. IntOrthod S1761-7227: 107-108.
38. Alkhayer A, Piffkó J, Lippold C, Segatto E (2020) Accuracy of virtual planning inorthognathic surgery: a systematic review. Head Face Med 16: 34.
39. Zinser M, Zoeller J (2015) Computer-Designed Splints for SurgicalTransfer of 3D Orthognathic Planning. Facial PlastSurg 31: 474-490.
40. Katkar RA, Kummet C, Dawson D, et al. Comparison of observer reliability of three-dimensional cephalometric landmark identification on subject images from Galileos and i-CAT cone beam CT. DentomaxillofacRadiol. 2013;42(9):20130059.
41. Erickson M, Caruso JM, Leggitt L. Newtom QR-DVT 9000 imaging used to confirm a clinical diagnosis of iatrogenic mandibular nerve paresthesia. J Calif Dent Assoc. 2003;31(11):843–845
42. Sears CR, Miller AJ, Chang MK, Huang JC, Lee JS. Comparisonof pharyngeal airway changes on plain radiography and conebeamcomputed tomography after orthognathic surgery. J OralMaxillofacSurg 2011;69:e385–e394
43. Hong JS, Park YH, Kim YJ, Hong SM, Oh KM. Three-dimensionalchanges in pharyngeal airway in skeletal Class III patientsundergoingorthognathic surgery. J Oral MaxillofacSurg 2011;69:e401–e408.
44. Abramson Z, Susarla SM, Lawler M, Bouchard C, TroulisM,Kaban LB. Three-dimensional computed tomographic airwayanalysis of patients with obstructive sleep apnea treated by maxillomandibular advancement. J Oral Maxillofac Surg2011;69:677–686.