REVIEW ARTICLE

POTENT UTILITY OF DENTAL CONE-BEAM COMPUTED TOMOGRAPHY IN ROUTINE EXTRACTIONS DUE TO ITS DIAGNOSTIC ACCURACY OVER CONVENTIONAL RADIOGRAPHS – A REVIEW

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ABSTRACT:

Since ages conventional radiography was the worldwide standard for diagno- sis and treatment planning of extraction of teeth. Much help was also attained from medical computed tomography for a period of time, but with the advent of cone-beam computed tomography, dental practice entered into a paradigm shift. Efforts have been further made in this review article about areas of po- tential applications and limitations of cone-beam computed tomography and the necessity to use it as a mainstream aid in the field of exodontias. The need to prefer cone beam computed tomography over conventional radiographs is because of the established fact that it is diagnostically more accurate than conventional radiographs, which have also been further focused on. (2017, Vol. 01; Issue 01: Page 83 - 88)

Keywords: Cone Beam Computer tomography, Computed tomography, Diag- nostic accuracy, Panoramic radiography.

INTRODUCTION

Cone-beam computed tomography (CBCT) is a relatively new diagnostic tool that has provided a new dimension to diagnosis and treat- ment planning in the dental field. CBCT has been made available as the separate C-arm to medical computed tomography (CT) imaging (1). The dynamic spatial reconstructor which was an early volumetric CT predecessor of CBCT, was devel- oped in the late 1970s by the Bio- dynamics Research Unit at the Mayo Clinic (Rochester, MN, USA) (2). Initial interest was focused primarily on applications in angi- ography in which soft-tissue resolu- tion could be sacrificed in favour of high temporal and spatial-resolving capabilities. The CBCT then devel- oped, provided an alternate method of cross-section image production to fan-beam CT using a compara- tively less expensive radiation de- tector than conventional CT (1). The idea to use CBCT in dentistry and the technology to use it first oc- curred in 1995. The Italian co in¬ventors, Tacconi and Mozzo, de- veloped a CBCT system for the max- illofacial region that was designed and produced by QR Srl of Verona, Italy. This unit, the NewTom QR-DVT 9000, became the first com- mercial CBCT unit marketed specif- ically to the dental market and it was initially introduced in Europe in 1999 (2). At present there are nu- merous manufacturers who have introduced CBCT machines as per clinical practice requirements. Though CBCT was introduced for usage exclusively in implant dentis- try, it has been expanding its re- quirements in almost many fields of dentistry and the head and neck re- gion. Reasons for the need of CBCT usage in routine extraction has been looked into in this article.

REVIEW LITERATURE

The CBCT imaging provides three-dimensional volumetric data con- struction of dental and associated maxillofacial structures with iso- tropic resolution and high dimen- sional accuracy (3). There are two types of beams commonly used in CT: fan beam and cone beam. In fan beam scanners, a narrow fan- shaped ray passes through the ax- ial plan of the body contiguously. The final 3D images are produced by stacking all the 2D axial slices together. The cone beam CBCT uses a cone-shaped beam and a re- ciprocating detector, which rotates around the patient 360 degrees and acquires projected data which us- ing sophisticated com-puter soft- ware along with a back-filtered pro- jection, a 3D image is produced that can be viewed in axial, coronal, and sagittal planes. All CBCT units pro- duce 3D images although each manufacturer uses slightly differ- ent parameters and viewing soft-ware. The software reconstructs the sum of the exposures via algo- rithms specified by the manufac- turer into as many as 512 axial slice images. These images are in the Digital Imaging and Communica- tions in Medicine (DICOM) data for- mat. DICOM data enables the den- tist to telecommunicate the imaging information. The images can be viewed and measured in a volumet- ric fashion as well as in all three planes (axial, sagittal and coronal). Some of the features in favour of CBCT are its accuracy which can generate a size of voxel (a 3D cuboid unit of images) as small as 0.125 mm in dimension which was found in a study done by Razavi et al. in 2010, using Accuitomo CBCT. CBCT's volumetric data is isotropic, which means all three dimensions of the image voxels are the same. This makes it possible to reorient the im¬ages to fit the patient's anatomic features and perform real- time measurements.

Various CBCT units provide choices for field of view (FOV), which allows irradiation of particular area of in- terest to dentists, while limiting ir- radiation of other tissues. This function contributes to excellent resolution and minimal radiation risk for patients. Compared to con- ventional CT, the compact size and affordability of CBCT makes it suit- able for the dental office setting. Moreover, a CBCT image can be re- constructed in many formats. For instance, a CBCT image can be reformatted to panoramic, cephalo- metric or bilateral multiplanar pro- jections of the temporomandibular joint (4).

CBCT IN EXODONTIAS

Dental extractions are the most commonly performed procedures by all dentists on a routine basis amongst all other procedures. Though all other teeth are ad- dressed in various ways, third mo- lars are always extracted if found offending. Thus third molar extrac- tions are the majorly common per- formed procedure nowadays and amongst young adults. Position of the third molars in the maxillofacial regions poses a lot of complications. The lower molars suffer a great risk of injury to the inferior alveolar nerve (IAN) which often lies in close proximity to the tooth. The overall risk of temporary IAN injury associ- ated with third molar removal ranges from 0.4%–6%. Thus it is very important to pre¬operatively assess the position and establish the relationship of the third molar with the mandibular canal to minimize the risk of nerve injury (5, 6).

CBCT's prove to be a beneficial help in dealing with the challenge by us- ing various radiographic markers like colour coding and nerve tracing applications in their software (Fig 1) to indicate a relationship between the third molar and the mandibular canal (6).

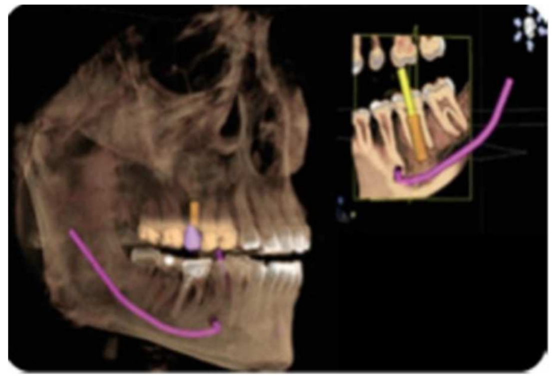

Fig 1: Colour coding of the mandibular nerve on Sirona software (Sirona Dental GmbH, Salzburg, Austria). Courtesy: Jaju and Jaju. CCID, 2014; 6: 29- 43.

Conventional radiographs like panoramic and intraoral periapical radiographs are generally sufficient to diagnose the preoperative status in most cases where there is no over- lap between the IAN and the lower third molar but where there are ra- diographic signs of an overlapping impacted tooth with the mandibu- lar canal, panoramic radiographs provide limited information. The buccolingual relationship between the IAN and the lower third molar cannot be evaluated from pano- ramic radiographs. Also the pres- ence or absence of cortication around the IAN and the detailed anatomy of the third molar cannot be accurately diagnosed using con- ventional radiography (6). With all teeth, the root angulations, curva- ture, accurate position of the tooth within the bony socket and rela- tionship with other important prox- imal maxillofacial structures can- not be clearly understood with con- ventional radiographs. Several studies have shown that panoramic radiography has only limited diag- nostic accuracy in determining the number of roots and in describing root morphology. CBCT proved to be more reliable in determining the number of roots than did pano- ramic radiography (5). A study con- ducted by Kamrun et al showed that the visibility of the superior border on panoramic images was very poor, except for the most pos- terior area, which clearly confirmed the decreased accuracy of pano- ramic radiography. The poor visual- ization of the canal on panoramic images was considered to be re- markably improved by the use of CBCT (7). Tantanapornkul et al fur- ther demonstrated that the 3D X- Ray CBCT (J Morita USA, Inc., Ir- vine, CA, USA) was significantly more accurate when compared with panoramic radiography in predict- ing IAN exposure during third mo- lar removal with a sensitivity of 93% and a specificity of 77% (8).

Other teeth requiring extraction can be more or less diagnosed using conventional radiographs but im- pacted teeth be it third molars or canines or any other teeth needs the utmost aid of CBCT. After third molars the maxillary canine is the second most frequently impacted tooth (9, 10). Factors like location of the impaction, prognosis of inter- vention on the impacted tooth and adjacent teeth, surgical accessibil- ity, impact of treatment on the final functional occlusion and possible surgical morbidity forces to choose the more accurate CBCT (5, 6).

Though all tooth buds appear labi- ally some may form lingually as well (11). Almost all teeth are able to be diagnosed using radiographs but for altered situations CBCT is needed, which is not produced in radiographs (Fig 2).

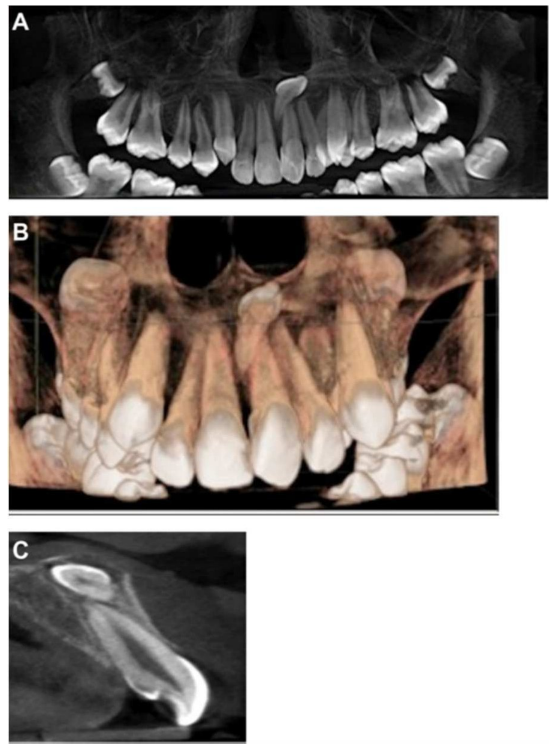

Fig 2 CBCT images (panoramic/3D reconstruction/cross-sectional) eases treatment planning for im- pacted mesiodens. (A) Panoramic radiograph showing mesiodens. (B) 3D reconstruction showing im- pacted mesiodens. (C) Cross sec- tional view showing relation of im- pacted mesiodens with central in- cisor. Courtesy: Jaju and Jaju. CCID, 2014; 6: 29- 43.

Ericson and Kurol in a study stated that impacted maxillary canines could not be accurately localized in the labio-palatal dimension with periapical radiographs (12). CBCT with its 3D orientation on the other hand can precisely locate the posi- tion of the impacted canine and thus assist the oral surgeon in plan¬ning the treatment (13). Due to a the unique combination of low radiation dose, high-quality bony definition and a compact design re- quiring minimum space, though CBCT has been made desirable as an in-office imaging system for the examination of pathologies in the head and neck, extracranial, para- nasal, and temporal bone regions, the utility presently holds true for areas with known complications and is used along with radiographs. CBCT holds a lot of potential in fur- ther expanding its horizons (13, 14).

CBCT is costlier both in terms of purchase and operations than con- ventional radiographs. To operate, CBCT needs better skilled techni- cians which are also costlier to train. A marked disadvantage is that, CBCT demonstrates limited contrast resolution, so if hard tis- sue is viewed it is not a problem as it cannot interpret soft tissues well. One aspect is that CBCT has higher radiation dosage than panoramic radiography but significantly lower dosage than medical CT, but these doses also vary widely according to the device used, x-ray energy and filtration, tolerance for image noise and motion artefacts, and the size of the imaging (3, 15). The benefits though include massive area of use in the entire Oral and Maxillofacial region and usage in extractions not only involving impacted teeth and third molars but also as an aid in routine dental office extractions to complicated extractions executed under sedation. CBCT can therefore be used to replace radiographs while performing the procedures and this can ultimately result in driving down the amount of time needed to have an accurate diagno- sis and preoperative assessment (15). Thus patient hassles and com- plications faced by the operator in maintaining a detailed record can also be tackled. Though, methods and detailed studies on ways to in- corporate into daily practice, train- ing staff and driving down cost needs to be looked into to justify the need.

CONCLUSION

With all the review literature in hand, it is seen that not only CBCT has numerous areas of application in the field of exodontia but it is also much more accurate. Few studies highlighted above shows that CBCT is much superior and has diagnos- tic accuracy both over radiographs and medical CT. The current CBCT technology has limitations already discussed in relation to projection geometry, detection sensitivity and contrast resolution (1). Despite, all the limitations, the surgical plan- ning and assessment is very smooth and without conflict. Addi- tionally, streaking and motion arte- facts are next to minimum with CBCT. Thus the benefits are more to risks and manufacturers have al- ready taken several measures to re- duce and solve the manufacturing problems (15). One such is that of software improvements which with further improvements could bring down the limitations and along with innovating to lowering the radiation dosage concept by abiding by the ALARA (As Low As Reasonably Achievable) principle, it could pave great ways to incorporate it into daily practice in the future (1, 3).

REFERENCE

1. Prashant P Jaju, Shushma Jaju. Clinical utility of dental cone-beam computed tomography: current perspectives. Clin Cosmet Investig Dent, 2014; 6: 29-43.
2. DA Tyndall, S Rathore. Cone- beam CT diagnostic applications: caries, periodontal bone assess- ment, and endodontic applications. Dent Clin North Am, 2008; 52 (4): 825–841.
3. The American Dental Association Council on Scientific Affairs. The use of cone-beam computed tomography in dentistry. JADA, 2012; 143 (8). 899- 902.
4. Shaun Adibi et al. CBCT in den- tistry: What dental educators and learners should know? J Dent edu- cation, 2012; 76(11): 1437-1442.
5. A Suomalainen et al. Reliability of CBCT and other radiographic methods in preoperative evaluation of lower third molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010; 109(2): 276–284.
6. H Ghaeminia et al. Position of the impacted third molar in relation to the mandibular canal. Diagnostic accuracy of cone beam computed tomography compared with pano- ramic radiography. Int J Oral Max- illofac Surg, 2009; 38(9): 964–971.
7. N Kamrun et al. Visualization of the supe¬rior and inferior borders of the mandibular canal: a compar- ative study using digital panoramic radiographs and cross-sectional computed tomography images. Oral Surg Oral Med Oral Pathol Oral Ra- diol, 2013; 115(4): 550–557.
8. W Tantanapornkul et al. A com- parative study of cone-beam com- puted tomography and conven- tional panoramic radiography in as- sessing the topographic relation- ship between the mandibular canal and impacted third molars. Oral Surg Oral Med Oral Pathol Oral Ra- diol Endod, 2007; 103(2): 253–259.
9. S Leifert, IE Jonas. Dental anom- alies as a microsymptom of palatal canine displacement. J Orofac Or- thop, 2003; 64(2): 108–120.
10. DG Liu et al. Localization of im- pacted maxillary canines and ob- servation of adjacent incisor resorp- tion with cone-beam computed to- mography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod, 2008; 105(1): 91–98.
11. A Fournier, JY Turcotte, C Ber- nard. Orthodontic considerations in the treatment of maxillary im- pacted canines. Am J Orthod, 1982; 81(3): 236–239.
12. Ericson S, Kurol J. Radio- graphic assessment of maxillary ca- nine eruption in children with clin- ical signs of eruption disturbance. Eur J Orthod, 1986; 8(3):133–140.
13. L Walker, R Enciso, J Mah. Three-dimensional localization of maxillary canines with cone-beam computed tomography. Am J Or- thod Dentofacial Orthop, 2005; 128(4): 418–423.
14. AC Miracle, SK Mukherji. Cone- beam CT of the head and neck, part 2: clinical applications. AJNR Am J Neuroradiol, 2009; 30(7): 1285–1292.
15. S Adibi, W Zhang, T Servos, P O'Neill. Cone beam computed tomogra¬phy for general dentists. Open Access Scientific Reports, 2012; 11(1): 519- 523.