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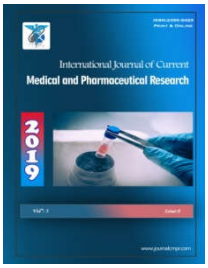

ROLE OF CBCT IN PERIODONTICS AND IMPLANT DENTISTRY

Kompal Gautam[1], Anjali Kapoor[2], A.Rizwan Ali[3], Aparna Choudhary[4], Divya Agrawal[5] and Mohit Singh[6]

[1]Periodontics Kompal
[2]Dept of Periodontics, RUHS College of Dental Sciences, Jaipur.
[3]Graduate Periodontics
[4,5]MDS Pedodontics
[6]MDS Conservative Dentistry & Endodontics

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ABSTRACT

Aim: To review the role of CBCT in Periodontics and Implant Dentistry
Method of literature search: Research of the dental literature regarding CBCT in Periodontics and Implant Dentistry. Was performed in Medline, PubMed, Ebsco and Google databases, including manuscripts, original articles, reviews, case reports and published thesis from 1990 to 2018.
Conclusion: CBCT through its high spatial resolution, affordability, smaller size, lower acquisition and maintainence in periodontal imaging have allowed the Periodontist to enhance clinical outcomes thus providing ultimate patient satisfaction and a improved quality of life.

INTRODUCTION

Periodontitis, one of the most common oral inflammatory infectious diseases and the leading cause of tooth loss, is characterized by the destruction of tooth-supporting tissues, including alveolar bone, periodontal ligament, and cementum.[1]It is generally widely accepted that radiographs supplement clinical examination in establishing the diagnosis and guiding the treatment plan for a patient affected by periodontal disease. Radiographs can provide key information of relevance in periodontal decision making which can not be known by clinical examination, such as length of root(s) with remaining bony support.[2]

Two -dimensional (2D) imaging techniques in dentistry have been employed since the first intraoral radiography created in 1896. Since then, dental imaging techniques have evolved enormously. While tomography makes it possible to divide the desired levels from an X-ray range, panoramic imaging provides a comprehensive observable image of maxillofacial structures. Recent developments of digital diagnostic imaging provided us with lower radiation doses and faster processing times, without affecting the diagnostic quality. 2D images, however, have their own natural limitations (including enlargement, distortion, and folding images), which cause the structures to appear erroneously.5Cone-beam computed tomography (CBCT) is capable of producing three-dimensional (3D) images, which leads to effective diagnosisand treatment. By introducing dento alveolar imaging in 1998, CBCT produced cost effective and lower absorbed dose 3D data in comparison to conventional CT. [3]

CBCT imaging technique is based on a cone-beam X-ray, gathered on a 2D recognizer, with the privilege of achieving less radiation. Compared to a 2D radiography, CBCT has various advantages, including no folded images, measuring ratio of 1:1, no geometric distortion, and 3D demonstration. By using a relatively low ionic radiation, CBCT provides a 3D representation of hard tissues along with little information from soft tissues.[3]

Role of CBCT in Periodontal Diagnosis

Periodontal disease is characterized by periods of disease activity, followed by periods of latency ultimately leading to Periodontal attachment loss, alveolar bone loss, and consequent tooth mobility. These complex nature of the disease, thus grant importance to use of imaging in the detection of such alterations.

Radiographs reveal the amount and type of damage caused to the alveolar bone.[4] Unfortunately, 2d radiographic methods are severely limited by the inherent overlay of anatomic structures, difficulty to reproduce angles over time, bone loss detected

Corresponding author:* **Kompal Gautam
Periodontics Kompal

after loss of 30 to 50% of mineralized tissue.[8] Bone resorptions limited to the spongy portion are appreciated where there is cortical bone erosion and prejudice image interpretation.[5]

Extent of periodontal disease involvement of alveolar bone and furcation areas leading to progressive bone loss always poses a difficult in its determination and visualization. CBCT not only provides better diagnostic but also provides accurate quantitative information on periodontal bone levels and furcation defects in 3d than conventional radiography. Whenever buccal and lingual walls masks the defect with conventional 2d radiography, CBCT analysis proves to be superior.[6,7]

Role of CBCT in Evaluation of Bony Defects, Furcation & Craters

Earlier studies with computed tomography (CT) have shown that assessment of periodontal bone height and intrabony defects is reasonably accurate and precise. However, the higher radiation exposure was a major limitaion.[8]

Noujeim *et al*. In a study where he created periodontal lesions of different depths in dried human hemimandibles and compared them using intraoral radiography and CBCT. They found that CBCT being more accurate in detecting defects than the conventional intraoral radiograph.

Stavropoulos and Wenzel evaluated the accuracy of CBCT scanning for the detection of periapical bone defect and found CBCT to have better sensitivity compared to intraoral radiography.

One author assessed the accuracy and reliability of CBCT in the diagnosis of naturally occurring bone defects by comparing it to measurements made directly on the skulls. There study reported a certain degree of discrepancy between direct measurement and estimated measurement on Radiograph. A recent study revelleda improved quantification of Bone defects by CBCT using a new software. These studies provide Promising data promoting the use of CBCT for detection of Periodontal Bone defects.[9]

A study by Vandenberghe *et al*. concluded that the intraoral radiography was significantly better for contrast, bone quality, and delineation of lamina dura, but CBCT was superior for assessing crater defects and furcation involvements. [10] These studies together with a handful of invitro study reports higher precision in diagnosis of periodontal bone defects using CBCT.

Role of CBCT in Evaluation of Soft Tissue Changes

According to Glickman a certain sequence of early radiographic changes occur in periodontitis which begins as crestal irregularities leading to triangulation and interseptal bone changes. Initially crest of the interdental bone becomes rough and irregular along with indistinctness and disruption in continuity of lamina dura along mesial or distal aspect of interdental alveolar crest. Widening of periodontal membrane space along mesial or distal aspect of the interdental crestal bone, as a result sides of the triangle are formed by lamina dura and the root with base toward the crown, this process is called as Triangulation.

Januário Al *et al* described a novel, non-invasive, CBCT-based technique to visualize, measure and analyze the relationship of several structures of the periodontium and dentogingival attachment apparatus. This method with ample applications in several field of dentistry is called ST-CBCT. With soft tissue CBCT (ST-CBCT) we are able to determine the relationships between: Gingival margin and the facial bone crest, Gingival margin and the cemento-enamel junction (CEJ), CEJ and facial bone crest. It precisely visualises soft tissue of Periodontium only when soft tissues of the lips, cheeks and tongue are properly retracted. [11]

When tissue biotypes of 22 fresh cadaver heads were assessed radio graphically with CBCT it was found that the measurements were an accurate representation of the clinical thickness of both labial gingiva and alveolar bone.

CBCT precision in alveolar bone density measurement

CBCT, offers an opportunity to clinician to see inside the bone, pinpoint and measure densities in small localized areas such as a vertical periodontal defect, or an alveolar bone graft. This precision allows CBCT to reproducibly quantify Bone density and bone remodeling after bone grafting.

CBCT in Evaluation of Periodontal Ligament Space

Periodontal disease in radiographs are recognised by earliest signs as Fuzziness, disruption in continuity of lamina dura and wedge shaped radiolucency at distal and mesial aspect of pdl. Widening of pdl at apical and inter-radicular areas may provide significant information regarding effects of occlusal trauma and systemic disease on Periodontium.[17]

Lamina dura (LD) which is a thin layer of dense cortical bone lining the roots of sound teeth. It is a radiographic landmark viewed largely on periapical radiographs as a thin radiopaque line around the length of root. The space occupied between lamina dura and adjacent tooth is termed as PDL space.

Conventional radiographs poses potential hurdles in assessment of lamina dura and pdl space. variations in the angulation of X-ray beam, convexity or concavity of proximal tooth surfaces, curvature of the roots, level of the CEJ and the thickness of the alveolar bone may produce significant alterations in visualising thickness and clarity of the LD.[12]

Only a sensitive imaging technique like CBCT could be able to detect such earliest changes thus overcoming the above mentioned hurdles. Invitro studies by Hasimoto *et al* clarified the superiority of CBCT over CT. Loubele *et al*. Concluded that in terms of visualization and delineation of the LD and PDL space the subjective image quality of CBCT was significantly better than for CT.[13]

Role of CBCT in Evaluation of Alveolar Bone Height around Bone Defects

Accurate assessment of severity (amount of bone loss) and extent (percentage and number of affected sites) plays a major pivotal role in Diagnosis and treatment of periodontal diseases. Radiographs both 2d and 3d can reveal the amount and nature of Bone loss. Information from probing the gingival tissues together with diagnostic radiographs provides guidelines for assessing alveolar bone height and checking for presence of bone defects.[14,15]

Certain limitations to 2d radiography being superimpositions of adjacent anatomical structures, lack of standard projection geometry in evaluation of bone craters, lamina dura and periodontal bone level, in modern days have been very efficiently eliminated by 3d radiographs like CT and CBCT. However certain authors feel that CBCT is still underused for

Periodontal diagnosis despite having a higher sensitivity of 80-100 in detection and classification of bone defects, while intraoral radiographs having a sensitivity of 63-67%. Moreover absence of distortion and overlapping presents image compatible with the actual size.

Earlier studies by Persson *et al* however reported better resolution of bone levels by conventional radiographic than computer screen images.[16] Mol and Balasundaram in there study found that CBCT provided slightly better diagnostic and quantitative information on periodontal bone levels than conventional radiography. However accuracy in anterior aspect of the jaws is limited by both means.[17] A more potential morphological description of bone defects by CBCT than digital radiography was described by Vandenberghe *et al*.[10] A study by Grimard *et al*. who compared direct clinical, periapical radiograph, and CBCT measurement for assessing bone level changes following regenerative periodontal therapy concluded that CBCT was more precise and accurate than periapical radiograph and it may obviate surgical re-entry as a technique for assessing regenerative therapy outcomes. Improved visualization of morphology of the defect in a study by de FariaVasconcelos *et al*. [18]

CBCT in Evaluation of Regenerative Periodontal Therapy and Furcation Involvement

Furcation Involvement still remains a challenge for examiner. Improper treatment mostly due to misdiagnosis and misclassification can lead to progressive bone destruction followed by tooth loss. A study by Walter *et al*. reported precise extent and categorization of furcation involvement together with visualization of the root morphologies, root proximities and root fusions by CBCT[25]. A present day study was conducted with transgingival method as clinical and CBCT for Radiographic Furcation Analysis further supported the precision of CBCT suggesting it as a potential replacement to surgical re-entry.

Thus in Conclusion, It is evident that CBCT provides a wide array of benefits and application in the field of Periodontology. While studies in present day regarding this topic is still in progress need for authenticated evidences remain as need for the hour.

CBCT in implant dentistry

Improving Modern day standard health care of patients is one the main aspects of Implant Dentistry. CBCT proves to a be a useful and remains a widely available tool in implant dentistry. With emerging new software applications and optimized algorithms an enhanced user-friendly interaction with the volumetric data can be achieved which can thus be used for virtual treatment planning to simulate the ideal implant placement by considering both surgical and prosthetic aspects.

Evidences from several observational studies (cohort and case series),suggest that CBCT can be exploited to its fullest in management of implant patients, this includes: Evaluation of Root morphology and pathologies, sinus grafting evaluation, bonedonar site evaluation, to locate relevant anatomical structures, Post agumentation implant planning and to assess complications related to previous implants placed. It can also be used to fabricate surgical stents and in real time navigation. CBCT is of at most value in evaluation of following relevant anatomical structures:

Mandibular Lingual Undercut: A lingual undercut in mandibular posterior region and associated lingual plate perforation is difficult to manage. CBCT in such cases is preferred for evaluation of surgical site and to bypass the possible complications with it.[19]

CBCT crossectional imaging at first molar area shows essentially three type of morphologies: it can be an undercut type of ridge(type u 66%) with a wider crest and a lingual undercut, Parallel type (Type P,20.4%) or Convergent type (type c,13.6%). The later two has no lingual undercuts. Watanabe *et al*. Also classified the mandibular cross-sectional morphology based on the outlines of the lingual and buccal plates into three: Round on buccal side and concave on the lingual side possessing a lingual concavity(type A) with incidence of (59-61%) , Concave on buccal side and round on the lingual side (type B) and Round shape on both sides (type C).[20]

Accessory mental foramen

CBCT images most of times frequently ruled out presence of Bifid mandibular canal in 65% of cases in comparsion to rotational panaromic radiography which detected only in 0.08-0.95 % of cases. Thus potential surgical complications regarding anterior looping of mental nerve and mandibular incisive canal can be avoided by CBCT and a safer treatment plan can be fabricated.

Nasopalatine morphology

Incisive foramen located in the midline of the palate, posterior to the central maxillary incisors leads to nasopalatine canal which divides into two canaliculi and terminates at nasal floor on either side of septum. This canal consists of nasopalatine (incisive) nerve and branches of descending nasopalatine artery. Thus contact of these neural tissues with Dental implant can cause serious sensory dysfunction with failure of osseointegration. CBCT can be used to determine various variants of these canal which can possibly being from either a single canal morphology to parallel or y shaped canal morphology.

Alveolar Process

Outcome of extraction socket healing can lead to marginal bone loss of entire facial aspect than lingual aspect and loss of additional 2mm or one third of initial socket dimensions causing significant dimensional alterations. These alterations could very well be appreciated on CBCT then routine radiography for dental implant planning .[21]

AAP 2017 Consensus statement supports that whenever clinician is facing difficulties regarding selection of implant sites, number, diameter, length, or loading strategy or when patient presents with a compromised phenotype or esthetics, CBCT can be used in such clinical scenarios.[22]

Reinhilde *et al* (2018) presented that CBCT can be used presurgical in identifying critical anatomic boundaries which can possibly prevent neurovascular trauma. It can be used to combat challenges posed for implant placement in anterior aestheticzone, evaluation for border line cases with inadequate bone morphology and volume which requires agumentation. Evaluation of incidence of trauma to jaws and teeth which present with doubtful progonis. CBCT acts in many aspects as a virtual patient. Some special techniques such as planning for grafting, distraction and zygoma implants can also be done.[29]

Available literature supports the accuracy of CBCT in measuring following parameters: Ridge height, width, bone quality, 3d assessment of alveolar topography, vital anatomic structure characterization and identifying incidental pathologies.

AAP 2017 devised an Cone beam commuted tomography Implant Planning protocol which states Patient immobilization followed by orientation of occlusal plane parallel to horizontal. A thin sheet of wax can be used to separate maxillary teeth from mandibular, we should always limit the scanning field of view with arches including crowns of opposing archs. Small volume element (voxel) size (0.20mm 0r 0.25mm) with low attenuation value is to be selected. An intraoral laser is used to scan stone models or teeth to create an image portfolio. Image portfolio consists of reconstructed panaromic projections of alveolar process with teeth, other with nerves marked on it and a final one with proposed implant sites. These are ultimately combined by a software to create multiobject 3d model.[31]

Though CBCT is inherently valuable because of its advantages which leads to most efficient usage in Implant dentistry it has got some limitations too. Additional research and development is required to reduce artifacts, beam hardening and scatter to improve resolution and quality of image. This will lead to increase in accuracy to quatify bone densisty and to detect remodelling changes over time. Increased cost and increased amount of radiation presents as a financial and radiation hazard obstacle. Further research is required for usage in field of 3d printing for static guide prepration and also for Biological tissue engineering applications.

Thus the clinical Bottom line is that CBCT in Implant dentistry offers both a patient significant and clinician oriented benefits which renders a better patient care and improved clinical outcomes with a higher level of safety. However Improved judgement of operator and its specific benefits outweighs the risks associated, CBCT should always be used as an adjunt to 2d dental radiology.

CONCLUSION

Application of CBCT to Dentomaxillofacial Radiology is increasing day by day. However amidst in the field of imaging in Periodontolgy and oral implantology CBCT truly stands as a privileged one. Recent CBCT machines very efficiently produce an affordable, low radiation high quality 3d image which plays vital role in detecting alveolar bone changes and 3d architecture of osseous defects. With current advancements in research modalities and increasing sophisticated operator skills every efforts are being made from reducing radiation exposure to patients to early diagnosis and treatment planning for a healthier and better well being of patients. CBCT through its high spatial resolution, affordability, smaller size, lower acquisition and maintainence in periodontal imaging have allowed the Periodontist to enhance clinical outcomes thus providing ultimate patient satisfaction and a improved quality of life.

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