Applications of CBCT in Caries Detection and Endodontics – A Review

***Pavan Kumar T.[1], Sujatha S.[2], Rakesh N.[3] and Shwetha V.[1]**

*Corresponding Author E-mail: drpavant@yahoo.co.in

Contributors:

[1]Assistant Professor, [2]Professor & Head, [3]Reader, Department of Oral Medicine and Radiology, Faculty of Dental Sciences, M.S. Ramaiah University of Applied Sciences, Bangalore-560054

Abstract

In the field of dentistry, for accurate diagnosis and treatment, radiographic examination is plays a vital part. Imaging modalities have evolved over time, right from two-dimensional imaging including conventional film and digital image receptors to advanced three dimensional imaging including Computed tomography, Cone Beam Computed Tomography (CBCT), Magnetic Resonance Imaging, Nuclear Imaging and others. Among the above CBCT has become a very important part of dental imaging and the basic knowledge of this imaging modality and its application is necessary for all the dentists. In this regard, this review provides insights into the various application of CBCT in Caries detection and Endodontics.

Keywords: *Cone Beam Computed Tomography (CBCT), Caries Diagnosis, Apical Periodontitis, Vertical Root Fractures, Root Canal Anatomy, Dental Trauma.*

1. INTRODUCTION

Since the discovery of radiography in early 1895 by Roentgen, many advances have been proposed, and new devices for better imaging have been developed[1]. Radiographic examination plays an important part of diagnosis in dental practice. The ready availability of radiodiagnostic aids has led to its overuse in dental practice[2].

For many dental practitioners, the use of advanced imaging has been limited because of price, accessibility and radiation dose considerations; however, the introduction of cone-beam computed tomography (CBCT) for the maxillofacial region provides opportunities for dental practitioners to request multiplanar imaging[3].

CBCT provides accurate, high-resolution images in formats that permit three-dimensional display of the complex anatomy of maxillofacial region[4]. The main advantages of CBCT imaging are its accessibility, easy handling and that its offers a real-size dataset with multiplanar cross-sectional and 3D reconstructions based on a single scan with a low radiaton dose[5]. The progress and rapid commercialization of CBCT technology has increased dentists access to this imaging modality[4].

The results of the study by W. De Vos et.al. (2009) showed that 86 papers dealt with the clinical applications of CBCT in dento-alveolar and maxillofacial surgery, implantology, general dentistry and specialised dentistry (orthodontics, endodontics, periodontics) and otolaryngology[5]. Even in forensic odontology, CBCT imaging can provide the much-needed 3D perspective in certain cases that require more information that is beyond the scope of the traditional methods[6].

During diagnosis and treatment planning for endodontic case CBCT can be a potent tool[7]. Interpretation demands an understanding of the spatial relations of bony anatomic elements and extended pathologic knowledge of various maxillofacial structures[3].

A clinically based publication, by Cotton and co-workers, demonstrated the effectiveness of high-resolution CBCT of endodontic imaging, including identification of an untreated canal, identification of a non-displaced root fracture, identification of extent of internal resorptions, visualizing over obtrurated RCT filling material in the mental nerve canal[8]. CBCT has also been used in periradicular surgical planning, assessment of periapical pathology, and dentoalveolar trauma evaluation[9].

2. CARIES DIAGNOSIS

The ability of conventional intraoral two-dimensional methods in recognition of proximal and occlusal surface caries has demonstrated to be of low/moderate sensitivity. CBCT imaging seems to be the best prospect for improving the detection and depth assessment of caries in proximal and occlusal lesions[8].

No difference in the revealing of carious lesions was found by Kalathingal and colleagues but they did find that limited CBCT was better for caries depth calculation and specificity showed no difference, although sensitivity increased. Using 41 teeth, Akdeniz and colleagues, histologically verified using ground tooth, and all image sections for viewing, establish that caries depth calculation of storage phosphor and film was inferior when compared with limited-volume CBCT[8]. The results of a study by SM Young et al. (2009) revealed that for proximal surfaces having lesions extending into dentin, the average sensitivity score of interpretation of CBCT images was approximately twice that of the CCD images[10]. A study by Arnon Charuakkra et al. (2011) revealed that in the detection of artificial secondary caries, the diagnostic accuracy of two CBCT systems (Az values = 0.995 and 0.978) was significantly higher than that of bitewing radiography (Az value = 0.882)[11].

It is promising to use of CBCT imaging to caries detection[8]. Taking this into account and the fact that CBCT images are compromised by radiation artefacts from existing fillings or even from thick enamel, the much higher radiation dose, costs, and, last but not least, the necessity to interpret all radiologic findings for legal reasons, CBCT cannot be regarded as a recommended means for caries lesion detection[12]. In addition, with current imaging equipment, it is anticipated that teeth with radiopaque restorations or metal within, should not be considered for CBCT caries imaging[8].

3. ROLE IN ENDODONTICS

1. **Preoperative Assessment:** provides data on tooth morphology including size of pulp chamber and degree of its calcification, number and location of canals, shape root structure, curvature and direction, extent of caries, iatrogenic faults and fractures.
2. **Intraoperative:** Two IOPA radiographs may be done during treatment. First – a "working" radiograph and the second - prior to "final" obturation, to evaluate correct fitting of master cone.
3. **Postoperative:** Following obturation, a "postoperative" radiograph is done to check for accurate condensation and sealing of filling material within the root canal.

4. DETECTION OF APICAL PERIODONTITIS

Cone beam computed tomography enables periapical radiolucencies to be detected before they would be apparent on conventional radiographs[7]. Patel et al. (2012) in a clinical study, found that, in the teeth with primary endodontic pathology, the occurrence of periapical lesions, detected with CBCT and periapical radiographs was 48% and 20%, respectively[14]. The capability of digital and conventional periapical radiographic imaging and CBCT to identify artificially formed periapical defects of different dimensions in pig mandibles was compared by Stavropoulos & Wenzel (2007). In that study the sensitive CBCT imaging was double when compared with digital and conventional radiography[15].

Although there were considerable disagreements between CBCT and periapical radiographs for assessing the periapical status of molar teeth, especially for the maxillary arch, CBCT detected the periapical lesions 62% more than conventional radiographs[16].

5. ROOT CANAL TREATMENT (RCT) OUTCOME ASSESSMENT

The current evidence shows that for the recognition of periapical lesions, CBCT has increased sensitivity compared with that of IOPA radiography[7]. Liang et al. (2011) evaluated the quality of RCT by utilizing CBCT and radiographs. There was a variance in the quality of root fillings in 41% of cases, with CBCT showing increased number of poor-quality root canal fillings in comparison to IOPA radiographs.

He stated that CBCT should result in a more accurate and objective identification of the prognosis of RCT[17]. The outcome of primary RCT carried out on 132 teeth was compared by Patel et al. in the year 2012, using CBCT and periapical radiography, one-year post treatment. The cured rate (as assessed with the help of absence of radiolucency) of the treatment was 62.5% and 87% when assessed using CBCT and periapical radiographs, respectively[18].

Early endodontic treatment of teeth is needed to have more success, before obvious radiographic signs of periapical disease. Thus, earlier recognition of periradicular radiolucent changes with the help of CBCT imaging will result in earlier identification and management of endodontic disease; which in turn will result in a better outcome from endodontic treatment as teeth could be treated sooner[19].

It is not advisable to use CBCT for evaluation of all periapical pathologies before RCT. It can be advised in evaluation and diagnosis of non-odontogenic pain, especially when clear diagnosis cannot be arrived with the help of clinical examination and conventional radiography[7].

6. VERTICAL ROOT FRACTURES (VRFS)

It is very challenging to diagnose VFRs. Clinical signs and symptoms of incomplete fractures are usually not specific[7].

In 2009, Hassan et al. recognised that the precision of periapical radiographs for identifying simulated VRFs in root canal filled and non-root canal filled teeth was considerably lower than CBCT, 0.66 and 0.86, respectively. The total correctness for identifying both kinds of VRFs was 0.45 and 0.87 for root canal filled teeth and non-root canal filled teeth, respectively, with CBCT, and 0.53 and 0.63 for root canal filled teeth and non-root canal filled teeth, respectively, with conventional radiographic images[20]. It is recommended that CBCT can't be used for the diagnosis of VRFs; additional clinical studies are need to be done to evaluate and quantify the significance of CBCT in diagnosing VRFs. However, CBCT might divulge subtle signs of changes of periradicular bone loss related to an unobserved VRF[7].

7. ROOT CANAL ANATOMY ASSESSMENT

Matherne et al. (2008) found that in comparison with CBCT, Endodontists using digital radiographs and paralleling radiographic technique failed to identify at least one root canal in 40% of teeth. In a study by Ryan P. Matherne et al. (2008), endodontic evaluators only identified between 76%– 84% of RCSs with charged coupled device and photostimulable phosphor plate digital radiography when compared with the number of RCSs identified by the oral and maxillofacial radiologists with CBCT[21].

Blattner et al. 2010 assessed extracted maxillary 1st and 2nd molars for the prevalence of second mesio-buccal (MB2) canals. After imaging, the teeth were sectioned axially and the actual number of canals existing was determined. It was found that there was 80% correlation between the results from tooth sectioning and CBCT results[7].

In 2009, Filho et al. established that with the usage of CBCT and dental microscope there is improvement in the probability of canals being located[22]. For evaluating teeth having complex anatomy, such as dens invaginatus and fused teeth CBCT is useful[7].

Use of CBCT must be restricted for those clinical cases where root canal anatomy cannot be fully evaluated with current aids, such as the dental microscope and paralleling technique conventional radiographs[7].

8. PRE-SURGICAL ASSESSMENT

CBCT is an extremely useful tool in the planning of surgical endodontic treatment[16]. CBCT imaging allows the evaluation of anatomical association of the root apex of the tooth and vital adjacent structures to be visualize in any plane the clinician desires to see (Lofthag-Hansen et al. 2007, Bornstein et al. 2011)[7].

Simon and coworkers conducted a clinical study which revealed that CBCT was useful in differentiating periapical granulomas from periapical cysts by means of grayscale values in the lesions[8].

Rigolone et al. (2003) stated that for planning of periapical microsurgery on the palatal roots of maxillary first molars, CBCT might play an important role. The distance between the cortical plate and the palatal root apex could be measured, and the presence or absence of the maxillary sinus between the roots could be assessed[23].

9. ASSESSMENT OF ROOT RESORPTION AND ITS MANAGEMENT

The resorptive lesion is unnoticed, until it becomes evident on conventional images, and consequently significant damage may already have occurred to the tooth[16]. According to Estrela et al. (2009) it has also been validated, in clinical studies, that when compared with CBCT, conventional radiographic imaging clearly undervalues the range of root resorption due to inflammation[24].

The existing literature suggests the use of CBCT to evaluate whether the root resorption is present or not and thereby improve diagnosis and aid treatment[7].

10. APPLICATIONS OF CBCT FOR ASSESSMENT OF DENTAL TRAUMA (DENTO-ALVEOLAR INJURIES)

whenever the accurate identification of dental injuries and dento-alveolar root fracture cannot be assertively diagnosed from a conventional examination and radiographs CBCT has been suggested as an additional imaging modality (Cohenca et al. 2007, May et al. 2013)[7]. Bernardes et al. (2009) noted that in two dimensional imaging, the fracture line can only be seen if the X-ray beam moves straight through it. Also, the 2D nature of IOPA image restricts the diagnostic correctness of actual root fracture[25].

Velvart et al. (2001) found that the relationship of the inferior alveolar nerve canal to the apicies of root could be determined in every case when using medical CT, compared with conventional radiography, which can detect in less than 40% of cases. It is likely that comparable results could be accomplished with CBCT using significantly less radiation[19].

It is known that CBCT discloses a substantial quantity of information regarding the dento-alveolar injuries. The evidence obtained helps in both formulating a diagnosis and improved management[7].

11. LIMITATIONS OF USE OF CBCT IN ENDODONTIC APPLICATIONS

Even though CBCT provides a third dimension for evaluation, its spatial resolution is lower when compared with conventional film-based imaging or digital intraoral radiography. Nevertheless, the capability of CBCT to reveal geometrically precise three-dimensional images enables the assessment of a number of features essential in endodontic diagnosis and treatment[13].

The presence of dental restorations, in the field of view can lead to severe streaking artifacts. By avoiding the scanning structures outside the region of interest, CBCT imaging with a limited FOV may provide clearer images[13].

12. CONCLUSION

It is clear that the usefulness of the CBCT cannot be disputed. CBCT is a needful addition to the endodontist's armamentarium. It overcomes many deficiencies of conventional periapical radiography. All endodontic specialists must be acquainted with basic application of CBCT and its advantages. Before recommending the radiographic investigation, endodontic cases must be evaluated individually, CBCT has to be considered only in those circumstances when required information from other imaging systems do not yield sufficient quantity of information to permit proper treatment of endodontic problem.

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