SCIENTIFIC ARCHIVES OF DENTAL SCIENCES (ISSN: 2642-1623)

Volume 6 Issue 3 March 2023

Literature Review

Potential of Cone Beam Computed Tomography (CBCT) Used in the Field of Endodontics

Abir Eddhaoui*, Saad Haroon and Tarek Ezzat Aly

Dental Department, Primary Health Care Corporation, Qatar

***Corresponding Author:** Abir Eddhaoui, Dental Department, Primary Health Care Corporation, Qatar.

Received: March 13, 2023; **Published:** April 04, 2023

Abstract

CBCT is a valid reliable diagnostic devise providing high-quality, precise three-dimensional (3D) image based on the reformat of 2 D images. The scan is performed with a single 360 scan in which the x-ray source and reciprocating area detector synchronously move around the patient's head, which is stabilized by head holder. In fact, CBCT overcomes the numerous constraint and limitations of conventional radiograph such as anatomical noise, geometric distortion, and inability to detect periapical lesions restricted to cancellous bone.

Keywords: Periapical Lesion; Cone-Beam Computed Tomography; Periapical Radiography

Introduction

Endodontic assessment in detection of any suspected periapical pathosis is essential component establishing diagnosis. The diagnosis of apical pathosis represents an indispensable strategy to settle the choice of successful treatment for infection control. To guarantee a minimally distorted and reproducible image, periapical X-ray is the view of choice as it allows us to establish a proper endodontic diagnosis thus aiding towards a proper treatment plan. Intraoral radiographs are a non-invasive diagnostic method, which allows the clinician to visualize the region in question. The radiographic image will validate not only the number of root canals but as well the character or their anatomy. However, it is understood that traditional radiograph has numerous limitations such as anatomical noise and geometric distortion [1].

Furth more, the radiograph image interpretation can be mystified by several elements which involve the regional anatomical structures as well as superimposition of the teeth and surrounding dento-alveolar structures. To overcome these limitations, limited-volume cone beam-computed tomography may be used as a diagnostic imaging devise that produces precise three dimensions images. Conventional intra-oral periapical radiographs are representing a 3D object in a 2D image that is why not all endodontic lesions are detected [2]. In fact, lesions limited to within cancellous bone are not always detected, on the other hand lesions with buccal and lingual cortical involvement cause marked radiographic areas of rarefaction which are detected radiographically, a periapical radiolucency must achieve almost 30% - 50% of bone mineral loss [3].

Several clinical studies in literature compared periapical radiographs and CBCT scans have been demonstrate that CBCT significantly ameliorate the detection of periapical lesions such as Lofthag-Hansen., *et al*. 2007, Estrela., *et al*. 2008, Low., *et al*. 2008, Bornstein., *et al*. 2011.

Radiographic methods to evaluate periapical disease

Radiographic imaging is necessary for all stages of endodontic treatment, starting from establishing a successful diagnosis, endodontic access, biomechanical instrumentation, final canal obturation, evaluating the sealing condensation of the root canal filling material within the root canal system, and finally used in assessment of healing in long term [4].

Periapical radiograph

The most widely used imagery technique in dental practices is 2D Periapical radiographs, which offer adequate image quality with low radiation doses. It is a useful diagnostic tool that provides not only a detailed anatomical description of the tooth, involving position and number of canals, and dimension of the pulp cavity, in the same way details concerning the root anatomy, direction and curvature, fractures, iatrogenic defects, the extent of dental caries and the detection of new or recurrent caries, calculus deposits, the status of restorations, the presence and severity of periodontal bone loss [5]. In addition, during intraoperative endodontic therapy, periapical radiograph may be used multiple times to either measure the working length and or prior to obturation thus insuring a proper fit for the master cone. In order to perform periapical radiographs tow mains techniques are used: the bisecting angle technique, and the long cone paralleling technique. To achieve the best geometric image, periapical radiography should be performed by the paralleling technique (Manson-Hing 1980) because of its ability to minimize geometric distortion and facilitate reproducibility of repeated exposures [7].

Digital radiography in dentistry

The initial digital imaging model Radio Visio Graph (RVG) was developed by Dr. Frances Mouyens in the mid-1980s. In fact, the digital image is produced by means of small light sensitive elements or pixels rather than the silver halide granule used in film-based radiography. These pixels include a variety of grey shades dependent on the exposure and are placed in order in lattice and rows on the sensor. Compared to conventional radiography, the use of a digital imaging system can minimize the exposure.

Many investigators (Dunn and Kantor 1993; Wenzel and Grondahl 1995; Versteeg., *et al*. 1997; Wenzel 1998; van der Stelt 2005) studied the several benefits of employing digital radiography over conventional based-film radiography. The most important advantage for using digital radiography is the reduction of radiation dosage, which was reported as being about 59% and 77% when compared to using E- and D-speed films, respectively [8].

Lowering the time between exposure and image display, hurry in achieving the image, simplicity of digital storage and dispensing of both chemical processing and darkroom equipment are also notable benefits of digital techniques. Also, in order to optimize the diagnostic feature, Digital radiographs can be modified by changing the density, contrast or/and shade. There are two types of Sensors for digital radiography silicon sensors such as Charge Coupled Devices (CCD) or Complementary Metal Oxide Semiconductors (CMOS), and Storage Phosphor Plates (SPP) which are also called Photo-stimulable Phosphor Plates (PPP).

Limitations of conventional 2D imaging

Compression of three-dimensional structures

The diagnosis value of periapical radiographs is limited because it is providing a two-dimensional image of a three-dimensional object. In fact, the teeth and their adjacent anatomical structures are visualized in the vertical and horizontal plane, however, the sagittal plane (depth plane) (3D) is not visible. In addition, periapical image does not estimate accurately the spatial relationship between the roots and their surrounding structures including the periapical lesion their nature and form. In case of surgical assessment, this missing 3D information becomes necessary in order to evaluate not only the exact angulation of the roots to the cortical plate and the thickness of this cortical but also the connection between the roots and any adjacent anatomical structures such as the inferior alveolar nerve, mental foramen or maxillary sinus. Hence, there is a need to take periapical radiographs with horizontal angulation to guarantee that that at least minimum of the 3-dimensional information is available. In order to minimize the radiation dose for the patients, only two exposures from different angulations are often enough [9].

Geometrical distortion

According to Haring and Jansen 2000, radiographs for endodontic treatment must be performed using the paralleling technique instead of the bisecting angle technique because it generates more geometrically accurate radiographic images and precise reflection of anatomical structure. The receptor film or sensor should be settled parallel to the long axis of the tooth. However, the X-ray beam should be perpendicular to the receptor and the long axis of the tooth being examinate. Although, the deficiency of parallelism causes geometric distortion of the radiographic image. The positioning of hard digital sensors (receptor) may be harder since these receptors are larger in size, stiffer, and inflexible than conventional films and phosphor plate digital sensors [10].

Consequently, the radiographic root length evaluation may be decreased or increased due to over or under-angulated radiographs and as well modify the dimensions or even result in the disappearance of periapical lesions (Forsberg 1987b). Approximately about 5% of magnification on the radiograph is expected since throughout the time of performing radiographs using the paralleling technique, the tooth is separated from the film, or the sensor and the x-ray beam is divergent (Haring and Jansen 2000).

Anatomical superimposition/noise

According to Gröndahl and Huumonen 2004, interposition of anatomical structures surrounding the tooth is an important source of mal interpretation of radiographs. In fact, these anatomical structures can appear either radiopaque such as zygomatic arch or radiolucent as maxillary sinus, incisive foramen or mental foramen.

Multiple research studies have stated the complexity of detecting confined periapical lesions to the cancellous bone, without involving the overlying cortical bone (Schwartz and Foster 1971). On the other hand, the underestimation of periapical lesion size on periapical radiographs can be explained as well by the anatomical noise (Marmary., *et al*. 1999) which is based on several factors such as parallelism between the tooth and receptor, overlying anatomy, the thickness of the cortical plate, and the correlation of the root apices to the overlying cortical plate [11].

Huumonen and Ørstavik stated in 2002 that in order to overcome the anatomical noise and have a clear image of the periapical lesion additional radiographs may be required.

Temporal perspectives

One more disadvantage of periapical radiograph is the temporal or sequential viewpoint. In fact, periapical radiograph required during endodontic therapy should be standardized to the highest level regarding their radiation geometry, density, and contrast to permit authentic and reliable interpretation of any alterations in the periapical tissues that may have taken place subsequently to treatment (Gröndahl and Huumonen 2004). In fact, healing assessment can be under over-estimated in case of use of poorly standardized radiographs. In order to make sure that the tooth, receptor, and x-ray beam are appropriately aligned which permit to increase the chance to get a replica of the radiation geometry when using paralleling methods (Duckworth., *et al*. 1983), Elastomeric impression material has been employed as a mold or stent.

Even with these techniques, a set of serial radiographs will still show slight discrepancies (Duckworth., *et al*. 1983). However, on the contrary digital periapical radiographs may possibly be altered through 32 various types of image manipulation algorithms presented via software systems. Adjustment of the intensity, contrast and magnification contribute to the improvement of the quality of radiographic image which guide the practitioner not only during the establishing of diagnosis and through the endodontic treatment but also to evaluate the healing process. Unfortunately, these features are not enough to remove these drawbacks [12].

Indications for CBCT in endodontic

Endodontic use of CBCT must be restricted to the evaluation and management of complicated endodontic cases such as:

- Complex root canal anatomy and morphology.
- Clinical symptomology linked to untreated or previously treated tooth without evidence of disease on conventional radiographs.
- Diagnosis of non-endodontic origin lesion consecutively its extension and relationship with surrounding structures.
- Management of endodontic procedures complications, such as overextended root filling material, fractured endodontic instruments, calcified canals, and localization of perforations.
- Assessment of dentoalveolar trauma, especially dentoalveolar fractures, luxation and/or displacement of teeth.
- Localization and assessment of internal and external root resorption or invasive cervical resorption and the determination of prognosis and suitable treatment.
- Pre-surgical assessment to establish the exact location of the periapical lesion and to evaluate the proximity to any adjacent anatomical structures.

It should be mentioned that according to American Association of Endodontists and the American Academy of Oral and Maxillofacial Radiology the use of CBCT should be recommended only after weighing the risks of radiation with the advantage of the diagnostic data that can be achieved from the image [13,14].

Advantages of CBCT

Dimensional accuracy

One of the most important advantages of CBCT is showing anatomic structure in three dimensions (axial, coronal, and sagittal) and demonstrating volumetric image data comprises of voxels which can be selected and viewed by the operator in all planes. In fact, voxels of CBCT are isotropic (identical in height, length, and depth), generate images which are dimensional precise in any plane and free from distortion. According to Patel 2009, CBCT can reconstruct images with high accuracy since size of voxel can be as small as 0.125 mm.

Low radiation doses comparing to CT

Arai., *et al*. 1999 demonstrated that CBCT reduce patient exposure to ionizing radiation and allow a higher image quality/resolution for tooth (Hashimoto., *et al*. 2003; Hashimoto., *et al*. 2006; Hashimoto., *et al*. 2007). As well, CBCT show better bone evaluation (Bartling., *et al*. 2007) over CT.

Furthermore, CBCT units can be adjusted in order to gain smaller fields of view. These minimize the radiation exposure dosage by limiting it only to the area of interest rather than the entire face (Roberts., *et al*. 2009).

Conclusion

Careful review of literature and current evidence suggests that both conventional periapical and digital techniques have a restricted capability to visualize small bone lesions however they have a high capacity to identify normal periapical conditions. Although, CBCT had demonstrate more sensitivity to show minor bone lesions. Even so, the use of CBCT in dental practices must be considered wisely after the evaluation of numerous strict criteria. That is why routine CBCT examination of patients should be avoided in order to avoid unnecessary patient exposure to radiation especially when conventional intraoral radiography can be used.

Conflict of Interest

The authors have stated explicitly that there are no conflicts of interest in connection with this article

Bibliography

1. Arai Y, Honda K, Iwai K, Shinoda K. Practical model '3DX' of limited cone-beam X-ray CT for dental use. International Congress Series 2001:713-718.
2. Patel S, Dawood A, Ford TP, Whaites E. The potential applications of cone beam computed tomography in the management of endodontic problems. International Endodontic Journal. 40;2007:818-830.
3. Patel S, Dawood A, Mannocci F, Wilson R, Pitt Ford T. Detection of periapical bone defects in human jaws using cone beam computed tomography and intraoral radiography. International Endodontic Journal. 42;2009:507-515.
4. RE Walton. Diagnostic imaging A. endodontic radiography. In Ingles' Endodontics, J. I. Ingle, L. K. Bakland, and J. C. Baumgartner, Eds., BC Decker, Hamilton, Canada, 6th edition, 2008:554.
5. American Dental Association Council on Scientific Affairs. The use of dental radiographs: update and recommendations. Journal of American Dental Association. 2006;137(9):1304-1312.
6. Brennan J. An introduction to digital radiography in dentistry. Journal of Orthodontics. 2002;29(1):66-69.
7. Fava LR, Dummer PM. Periapical radiographic techniques during endodontic diagnosis and treatment. International Endodontic Journal. 1997;30(4):250-261.
8. K Horner, P N Hirschmann. Dose reduction in dental radiography. J Dent. 1990;18(4):171-184.
9. Essentials of Dental Radiography and Radiology results Whaites, 2003.
10. Horner K, Islam M, Flygare L, Tsiklakis K, Whaites E. Basic principles for use of dental cone beam computed tomography. Consensus guidelines of the European Academy of Dental and Maxillofacial Radiology, Dentomaxillofacial Radiology. 2009;38:187-195.
11. Julia C Schmidt, Claudia-Julie Gutekunst. Comparison of Two-Dimensional and Three-Dimensional Radiographs Using Clinically Relevant Parameters. Dent J (Basel). 2019;7(2):50.
12. Ritu Tiwari, Alfred Joseph Ravikumar. Two Dimensional Versus Three Dimensional Imaging In Endodontics-An Updated. Journal of Evolution of Medical and Dental Sciences. 2016.
13. Joint Position Statement of the American Association of Endodontists and the American Academy of Oral and Maxillofacial Radiology. Use of cone-beam computed tomography in endodontics. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics. 2011;111(2):234-237.

14. Kullendorff B, Nilsson M, Rohlin M. Diagnostic accuracy of direct digital dental radiography for the detection of periapical bone lesions: overall comparison between 66 conventional and direct digital radiography. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics. 1996;82(3);344-350.