Review Article

Application of Cone Beam Computed Tomography in Endodontics: An Updated Review

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ABSTRACT

Early diagnosis and timely treatment of endodontic illness are crucial since it can negatively influence quality of life. Radiology is crucial for planning treatments, monitoring diseases, and evaluating how well treatments are working. The maxillofacial skeleton's osseous components can be visualized in three dimensions (3D) using cone-beam computed tomography (CBCT), a diagnostic imaging technique. There are CBCT systems available that can deliver low dose, limited field of view (FOV) pictures with adequate spatial resolution for use in endodontic diagnosis, treatment planning, and post-treatment evaluation. The physician can gain a deeper understanding of the anatomy being evaluated, improving the ability to detect endodontic illness and enabling more efficient treatment planning. The aim of this paper is to review current literature on the endodontic applications of CBCT.

Key words: 3 Dimensional, cone-beam computed tomography, endodontics, radiology

INTRODUCTION

For reasons of diagnosis, treatment planning and execution, and assessment of the efficacy of therapy, radiology is crucial in endodontics.[1] Conventional radiography has remained the primary imaging method in endodontics since its introduction. But in recent years, several dental specialties have attempted to use medical imaging advancements, with varying degrees of success.[2] The operator must perform multiple X-rays with various projections in numerous cases to gain a thorough presentation of the teeth and adjacent tissues because traditional radiography only produces a two-dimensional image anatomy.[3] Some anatomical structures may block the region of interest (ROI), making radiological interpretation of the image challenging. Therefore, there are some instances where standard radiography in ordinary clinical practice does not provide enough information about pathological states, anatomical forms of the structures, and positional relations.[4] As a result, traditional radiography, despite its inherent drawbacks, continues to be the industry standard imaging system. Cone-beam computed tomography (CBCT), on the other hand, has brought to light the shortcomings of traditional radiography when evaluating the specific anatomy of the maxillofacial skeleton.[2] The CBCT in endodontics provides a complete investigation of the tooth and surrounding alveolar structure in addition to providing a 3D evaluation of the ROI. Consequently, CBCT can be an effective tool for endodontic diagnosis, treatment planning, and follow-up.[5] The present review will highlight the fundamentals of CBCT and upheld the applications of this imaging system in endodontic practice.

LIMITATIONS OF CONVENTIONAL RADIOGRAPHIC IMAGING

Three-dimensional structures are compressed into a two-dimensional image via conventional radiography. The mesiodistal plane of the radiograph allows for visibility of the anatomy being examined, but the third (buccolingual) dimension of the radiograph allows for very little understanding of the structures.[6]

If more accurate imaging is not used, anatomical complexity, disorders affecting the dental hard tissues, such as resorption, as

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CBCT

A modern, three-dimensional diagnostic imaging system created expressly for use on the craniofacial skeleton is CBCT.[9] A new tomographic scanner known as "CBCT" or "digital volume tomography" was created in the late 1990s by two different Italian and Japanese organizations with the goal of using it for maxillofacial and dental procedures. CBCT has been utilized for oral and maxillofacial surgery, implantology, endodontics, orthodontics, periodontics, and temporomandibular disorders since it has the benefit of a reduced radiation dose.[10]

An X-ray source and detector, or sensor, installed on a rotating gantry make up the CBCT hardware. A revolving gantry with an attached X-ray source and detector is used to perform CBCT. On the patient's other side, an area X-ray detector is pointed through the center of the area of interest at a divergent source of ionizing radiation in the shape of a pyramid or cone.[11] The X-ray source and detector rotate around a fixed fulcrum within the ROI. During the exposure sequence, a large number of planar projection images with a FOV of at least 180° are taken. The 3D radiography pictures produced by CBCT are crisp, practically immediate, and accurate.[12]

CBCT pictures that have been reconstructed can be shown in many different ways. The three orthogonal planes (axial, sagittal, and coronal) of the pictures of the ROI can be displayed simultaneously as a common option to give the clinician a genuinely three-dimensional representation of the area of interest.[13]

CLASSIFICATION OF CBCT

The dimensions of the scan volume or FOV, which are primarily dependent on the size and shape of the detector, the geometry of the beam projection, and the capability to collimate the beam, are how CBCT systems are most frequently categorized.[14]

Based on available or selected scan volume height, the use of units can be classified as follows: Small volume or localized region; also called as focused, small field, limited field or limited volume, Single arch; CBCT scans have a FOV height ranging from 5 to 7 cm within one arch, Inter arch; CBCT scans have a FOV height ranging from 7 to 10 cm, maxillofacial; CBCT scans have a FOV height ranging from of 10 to 15 cm and craniofacial; CBCTs have a FOV height greater than 15 cm.[15] Small volume CBCT scanners are well suited for use in Endodontics as the area of interest can easily be captured by their smaller FOV.[14]

EFFECTIVE DOSE OF CBCT

The amount of radiation emitted by a specific CBCT system depends on a number of variables. The radiation dose will depend on the type of X-ray beam, such as whether it is continuous or pulsatile, the degree of rotation of the X-ray source and detector, and the size of the FOV. The radiation dosage generated by the imaging device and the radiation sensitivity of the tissues that the X-ray beam is travelling through during the exposure sequence are both factored into the effective dose. Due to the small amounts of data involved, effective dose is typically stated in micro Sieverts (Sv).[16]

ADVANTAGES OF CBCT

By generating 3D pictures that provide a thorough understanding of the anatomy and the spatial relationships between the pathosis and anatomical components, CBCT overcomes the limits of conventional radiography. Because CBCT voxels are isotropic, they guarantee that the images that are produced are geometrically exact and that image measurements, in any plane, are distortion-free.[17] The key benefits of CBCT over CT are less ionizing radiation exposure for patients and better image quality for assessing oral hard tissues and bone. In addition, the X-ray source can be collimated to focus the radiation just on the desired region. The ability to view anatomical details in three dimensions is CBCT's most significant benefit in endodontics. The projection data are reconstructed by CBCT units to create images in three orthogonal planes (axial, sagittal, and coronal).[18]

APPLICATION OF CBCT IN ENDODONTICS

For endodontic CBCT imaging to fully capture the intricate details of the root canal system and periodontium, it must have extraordinarily high detail and resolution. It is only advised to use narrow FOV CBCT scans to diagnose and treat endodontic issues. A tiny FOV scan minimizes the amount of exposed tissue and, hence, the effective radiation dose; nevertheless, this has the advantage of reducing scatter, which enhances image quality.[19]

DETECTION OF APICAL PERIODONTITIS (AP)

Inflammatory lesions of the pulp and periapical regions are the most frequent pathologic disorders affecting the teeth. In this sense, CBCT is substantially more sensitive and accurate than conventional radiography in identifying AP in people, and it can detect the deterioration of periapical bone caused by endodontic infection before conventional radiographs show any signs of it.[20] Conventional radiography missed the periapical lesions 62% more often than CBCT, and even the latter technique's parallax views improved the assessment of the subject teeth. In addition, CBCT revealed a considerable number of other findings, including the growth of lesions into the maxillary sinus, thickening of the sinus membrane, and missing canals. In addition, CBCT can show

discrete cancellous bone and cortical bone abnormalities.[21] Using CBCT imaging as the gold standard, Ma *et al.* evaluated the effectiveness of periapical radiography in identifying the lesions of AP of posterior teeth. Eighty patients had their one hundred and six posterior teeth analyzed using periapical radiography and CBCT. Of them, 58 were healthy, 11 had chronic pulpitis, 34 had chronic AP, and the remaining teeth had normal apical imaging following root canal therapy (3 teeth). Radiography and CBCT detected AP in 39.6% and 59.4% of 106 patients, respectively; this difference was significant ($P = 0.01$).[22]

ASSESSMENT OF POTENTIAL SURGICAL SITES

A very helpful tool for surgical endodontic treatment planning is CBCT. It is possible to carefully examine the spatial relationship between the specific tooth root(s) undergoing surgery (and the related bone destruction) and surrounding anatomical structures such the maxillary sinuses, the inferior oral nerve canal, and the mental foramen. The cortical plate's distance from the palatal root apex and the presence or absence of the maxillary sinus between the roots could both be presented and assessed. Anatomical planning for apicoectomy using the vestibular technique was evaluated in a study by Rigolone *et al.* Mean distance between root apex and vestibular cortex was 9.73 mm. The maxillary sinus recessus was located between the vestibular and palatine roots in 25% of patients. In terms of accuracy and avoiding complications, CT may be crucial for palatine root apicoectomy through vestibular access.[22]

ASSESSMENT OF TRAUMATIC DENTAL INJURIES

CBCT is a useful tool for identifying the kind and extent of traumatic dental injury. The benefits of CBCT have been highlighted in the literature for the assessment and treatment of dentoalveolar trauma. In addition, CBCT has been demonstrated to be significantly more sensitive than several periapical radiographs (PRs) in the diagnosis of horizontal root fractures. In addition, the use of CBCT as an extra-oral imaging modality increases patient comfort throughout the imaging procedure.[23] In a case of lateral luxation of the maxillary central incisor, Soares *et al.* used a new CBCT reconstruction program (e-Vol DX) to confirm the luxation after a conventional exam failed to definitively define the dental trauma damage.[24]

DETECTION OF DIFFERENT TYPE OF ROOT RESORPTION

External root resorption (ERR) is a frequent consequence following dental luxation and avulsion injuries. Before the resorption becomes visible on conventional radiographs, severe hard tissue damage to the affected tooth may have already occurred, as conventional radiography is far less sensitive than CBCT in detecting ERR in its early stages. At present, CBCT is frequently used to determine the severity of specific forms of ERR and the outlook for the impacted tooth.[25] In a study, Durack *et al.* compared the capacity of CBCT and digital intraoral radiography (DIOR) to identify simulated external inflammatory root resorption lesions in an *ex vivo* model. Whether 180° or 360° scans were performed, small volume CBCT had the same ability to identify simulated EIR. Compared to PRs, CBCT considerably improved the ability of the examiners to pinpoint the precise location of the fake resorption lesions ($P = 0.001$).[6]

ASSESSMENT OF ROOT CANAL ANATOMY AND MORPHOLOGY

Identification, cleansing, shape, and obturation of all accessible parts of the root canal system are essential for the effectiveness of endodontic treatment. Preoperative access to this information lowers the likelihood of developing the above aberrations because CBCT is a dependable instrument for precisely assessing the degree of curvatures associated with tooth roots. In addition, it has been demonstrated that CBCT is a valuable assessment and treatment planning tool when endodontic therapy for teeth with anatomical and morphological anomalies, such as dens invaginatus and tooth fusion, is necessary.[26] In order to determine whether CBCT might be used to evaluate the variance in the number and shape of the root canals of the primary molars, Ozcan *et al.* conducted a study. The number of roots and root canals varied among the primary molars in all four groups. There were more one-canal roots than two-canal roots in the maxillary molars.[27]

DETECTION OF VERTICAL ROOT FRACTURE

While root fractures are less frequent than fractures of the crown and only make up 7% of dental injuries, they are challenging to adequately diagnose with traditional radiography. According to studies, CBCT is more accurate than traditional radiography at detecting vertical root fractures (VRF). However, when evaluating root filled teeth for VRF with CBCT, it should be kept in mind that scatter created by the root filling or other high-density intraradicular materials may mistakenly suggest the existence of a fracture. In a study, Hassan *et al.* examined the efficacy of PRs and CBCT scans for identifying VRFs. The findings revealed that CBCT scans had a generally greater overall accuracy for detecting VRF (0.86) than did PRs (0.66).[28]

CONCLUSION

Conventional intraoral radiography offers doctors a readily available, reasonably priced, and high-resolution imaging modality that is still useful in endodontic treatment. However, there are some unique circumstances, both pre- and post-operatively, when the diagnosis and therapy are influenced by the understanding of spatial correlations provided by CBCT. It is now impossible to refute the value of CBCT imaging. CBCT is a crucial tool in a thorough endodontic examination and a valuable task-specific imaging modality.

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