Importance of Cone-Beam CT in Endodontics

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Abstract: Endodontic diagnosis and accomplished root canal therapy significantly related to accurate radiographic examination. Currently, intraoral periapical radiography is the first imaging choice of the management of endodontic disease. However, with the development of cone beam computed tomography (CBCT), three-dimensional imaging of the maxillofacial area can be obtained. CBCT allows the more definite diagnosis of periapical pathologies, root fractures, external and internal of root resorptions than 2-dimensional radiographs. However, CBCT imaging is not recommended in every clinical cases due to higher radiation dose than 2-dimensional radiographs. In this review article the aim was to emphasize the clinical implementations of CBCT in endodontics.

Keywords: Cone-beam computed tomography, endodontic diagnosis, endodontic problems, periapical radiography.

1. INTRODUCTION

Radiographic evaluation is extremely important for diagnosis and treatment of the endodontic diseases. The radiographic imaging is crucial not only an appropriate therapy planning but also shows endodontic complications, such as fractured files, perforations and root resorption [1-3].

Periapical radiograph (PR) is commonly used imaging method in endodontics. However, it produces two-dimensional images of three-dimensional objects, which is unavoidably accompanied by loss of information [1, 4]. In addition, the diagnostic value of PR is depend on several factores, such as exposure parameters, receptor sensitivity, processing, viewing and display conditions, superimposition of anatomic structures [5, 6]. Based on the location and dimension, detection of several endodontic complications on PR may be difficult due to the two-dimensional image created using this radiographic technique. These problems can be overcome by using small volume cone-beam computed tomography (CBCT) because it demonstrates anatomical sites or pathologies in three dimensions [1, 5-7]. CBCT is a relatively new technique to visualize dental or maxillofacial region and to compose three-dimensional images of these structures. CBCT systems use a cone-shaped beam on a two-dimensional detector that performs one pass or less around the patient's head to produce the series of two-dimensional images [5, 6, 8]. CBCT units reconstruct the projection data in the axial, sagittal and coronal planes. Most softwares provide for various nonaxial two-dimensional images in multiplanar reformation which include oblique, curved planar and serial transplanar reformation (providing cross-sections). CBCT imaging provide the clinician ability to three dimensional evaluation [6-8].

CBCT has gained importance due to advantages such as lower radiation dose, faster scan time, lower cost and smaller size compared to computed tomography [4, 8, 9].

In the recent years, CBCT has gained the popularity in the diagnosis and treatment planning of complex endodontic cases. CBCT with small field of views obtain diagnostic high resolution images of teeth and related structures in which PR has failed to provide sufficient information in these cases. However, the American Association of Endodontists (AAE) and American Academy of Oral and Maxillofacial Radiologyy (AAOMR) guidelines (published in 2015) do not recommend using CBCT as a routine diagnostic or evaluation tool, and use of it should be limited to the assessment and treatment of complex endodontic cases such as:

a Diagnosis of apical periodontitis,

b Assessment of complex root canal anatomy,

c Planning of surgical treatment,

d Complications including root fracture and resorptions,

e Diagnosis of traumatic injuries to teeth or alveolar bone.

The decision to assess with small (limited) volume CBCT is performed only after clinical examination and 2-D radiographs [1, 4-6, 10, 11].

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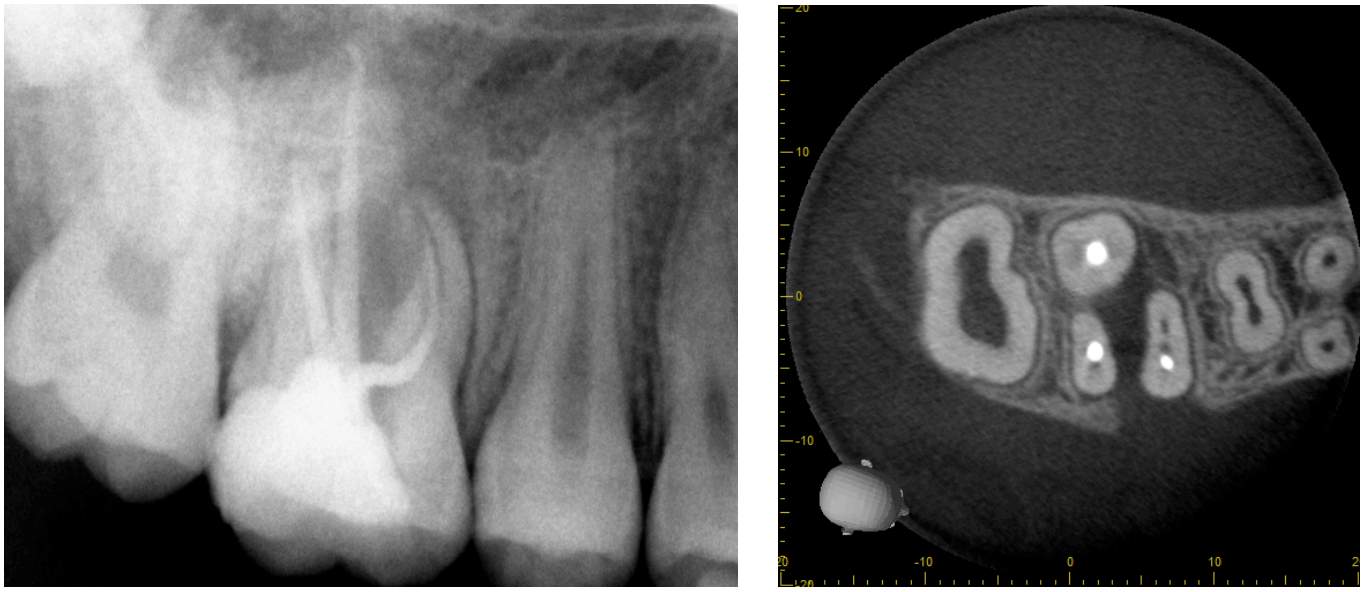


(a) **(b)**

Figure 1(a): PR of maxillary first molar tooth. **(b);** CBCT of maxillary first molar tooth - untreated second mesiobuccal canal and excessive bone lose.

2. DIAGNOSIS OF APICAL PERIODONTITIS

Apical periodontitis (AP) is an inflammatory periapical lesion arising from an endodontic infection [12]. Assessment of the location and dimension of AP can influence treatment planning and subsequent treatment outcomes. It was displayed that if a periapical lesion does not involve the buccal or lingual cortical bone, it is most difficult to detect in a PR. However, small periapical lesions can be detected by CBCT before they are apparent on PR. Studies have shown that CBCT imaging is superior for the detecton of AP when compared with PR [2,10-16] [Figure **1** (**a** and **b**)]. In a study, CBCT evaluation of periapical repair tissue after endodontic therapy showed similar results to histological assessment, whereas PR revealed the underestimation of the AP size [17].

In addition, Cotton *et al*. (2007) performed the various applications of the small volume CBCT in endodontics. It proved the usefulness of three-dimensional imaging in assessing teeth with unusual number of roots or canals, root fractures, non endodontic pathological conditions, assessment (extent, type, prognosis) of internal / external root resorptions [Figure **2**(**a** and **b**)] and determination morphology of periapical area near to root apices [18].

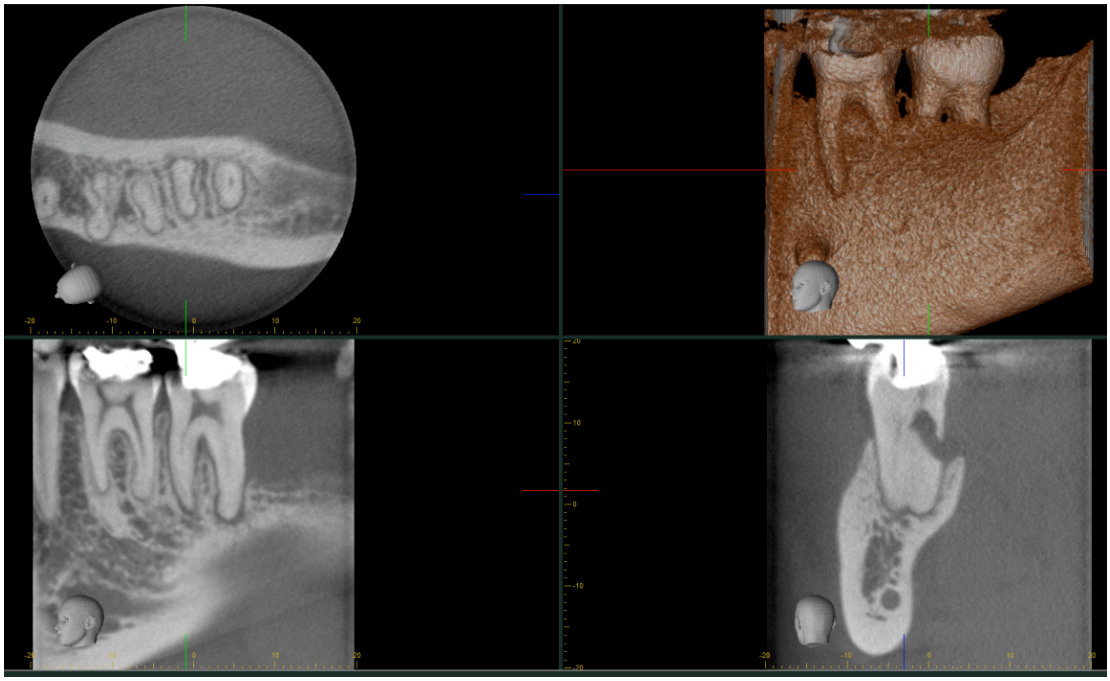
3. ASSESSMENT OF COMPLEX ROOT CANAL ANATOMY

The success of root canal therapy relies on the knowledge of the root canal anatomy and its morphological variations [5, 19]. Root morphology and bony topography, number of root canals can be clearly visualized in CBCT [4-6]. With the careful assessments of axial slices, the missed or untreated root canals which may not be observed with PR can be identified [4, 19]. Previous studies showed that small volume CBCT accurately identify the second mesiobuccal canals in maxillary first or second molar teeth [18, 20] [Figure **1**(**a**, **b**)]. Practically, the improved detection of root canals cause that more of the complex root canal is accessed, disinfected and filled, which turn improve the outcome of endodontic therapy [4]. During the radiographic assessment, proper care and attention must be given in identifying additional roots, canals [Figure **3**(**a** and **b**)], dilaceration or C-shaped canals. Mandibular premolar tooth which has complex root canal anatomy is the very difficult tooth for endodontic treatment [4, 5].

4. PLANNING OF ENDODONTIC SURGERY

CBCT assessment has been recommended before the endodontic surgery. Since the anatomical relationship of the root apices to the adjacent anatomical structures, such as the inferior alveolar canal, mental foramen and maxillary sinus, may clearly observed in the CBCT images [4, 6, 20]. CBCT plays a major role in planning for apical surgery on the palatal roots of maxillary first molars. The distance between the floor of maxillary sinus and the palatal root apex can be measured. Therefore, after the CBCT evaluation, clinician may be avoid the periapical

(a)



(b)

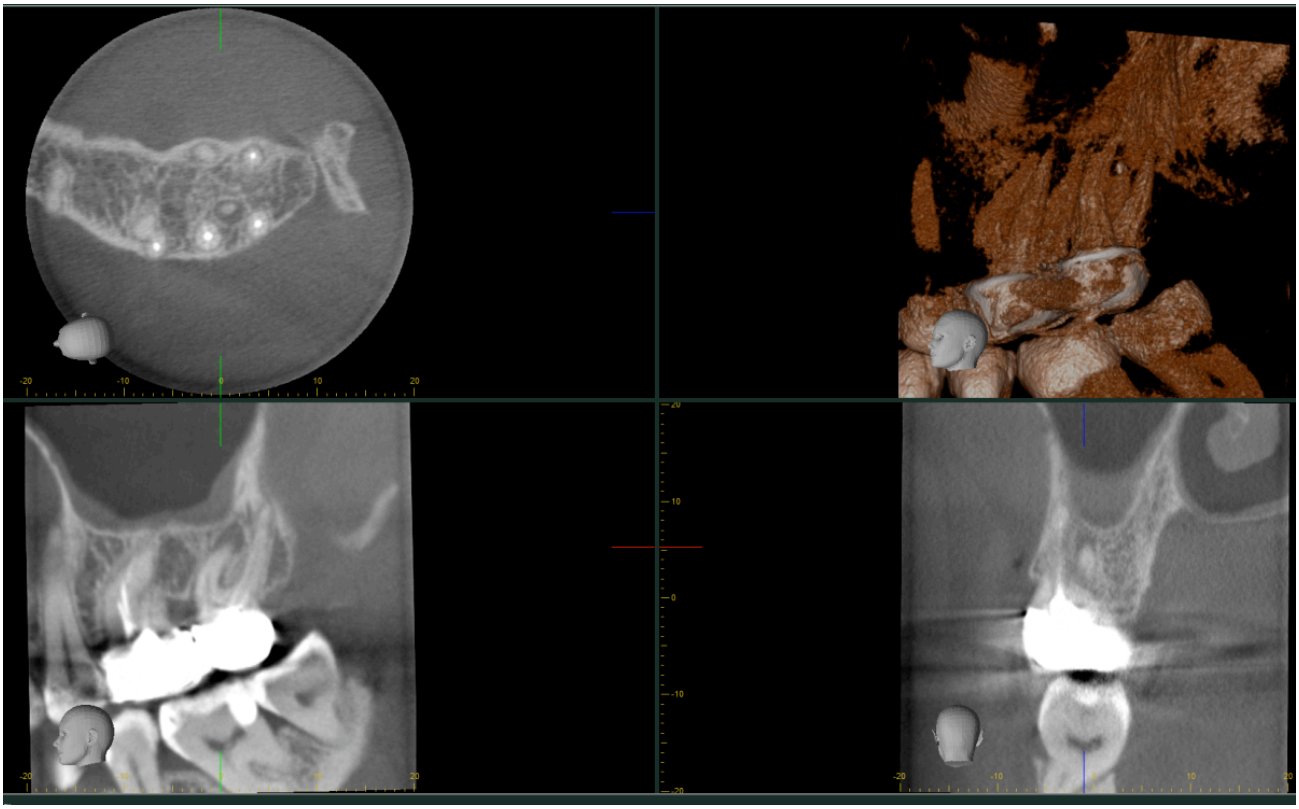
Figure 2(a): PR of mandibular second molar tooth. **(b);** CBCT of mandibular second molar tooth - the precense, location and extent of the root resorption.

surgery if the floor of the sinus has been perforated by a larger than estimated periapical lesion [21]. CBCT shows important information that cannot be obtained with PR. With the selecting appropriate imaging protocols (field of view, slice thickness and intervals), detailed evaluation of teeth and neighbouring bone, fenestration, the cortical and cancellous bone pattern, related pathologic findings can be correctly detected before the surgery [6] [Figure **1**(**a** and **b**)]. In a study, the distance between the mandibular canal and the root apices of mandibular first and second molar and second premolar teeth was measured and evaluated. The results demonstrated that the CBCT scan was an accurate imaging modality to assess location of the inferior alveolar nevre (mandibular canal) and to show its relation with teeth [22].

5. COMPLICATIONS INCLUDING ROOT FRACTURE AND RESORPTIONS

The prognosis of the tooth may be poor due to vertical or horizontal root fractures during and after endodontic treatment. The radiographic evaluation of vertical-or horizontal root fractures are important for detection of the location and severity of the fracture line. However, radiographic evaluation can be so difficult since not all the classical radiographic signs of

(a)



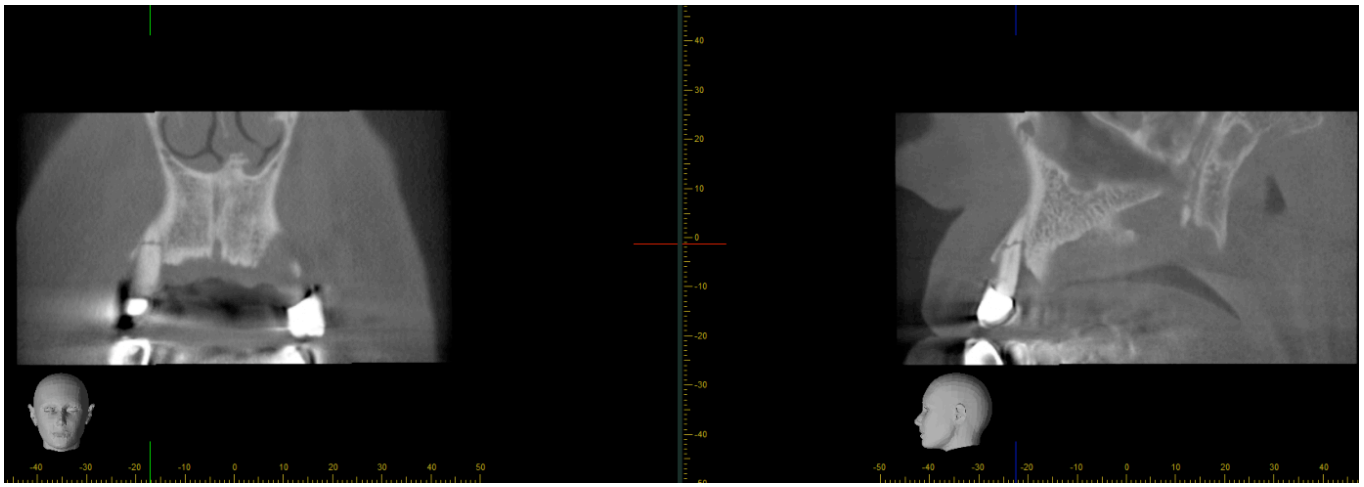
(b)

Figure 3(a): PR of maxillary second molar tooth. **(b);** CBCT of maxillary second molar tooth - extra root and canal.

root fracture may be present in every case. PR has many limitations in the detection of root fractures because of its two-dimensional nature [4, 5] [Figure **4**(**a** and **b**)]. Root fractures can be missed when the X-ray beam does not parallel to the fracture line. Therefore two or three periapical radiographs taken from different angles are recommended. In recent studies, CBCT has been suggested due to high accuracy and sensitivity to identify the fracture on root [23, 24].

The early and definitive diagnosis of the internal, external and invasive cervical root resorption, and also for the exact treatment protocols, CBCT was recommended [6, 7, 13, 25]. Today, the current technique for diagnosing root resorption is PR. Most cases are determined during routine examinations and are generally in their late periods resulting in tooth loss. Therefore, the early and accurate detection is so important. PR may not give enough information regarding location, size and extent of resorptive lesions

(a)



(b)

Figure 4(a): PR of maxillary canine tooth. **(b);** CBCT of maxillary canine tooth - root fracture.

due to superimposition of the lingual or buccal cortices, multiple roots, and neighboring anatomical structures [5, 25] [Figure **2**(**a** and **b**)]. Numerous ex vivo and clinical studies revealed that CBCT was significantly more effective than PR at determining the location of resorption defects [26-28]. CBCT is not always necessary, but in selected cases, it can be very useful [6, 7, 25].

6. DIAGNOSIS OF TRAUMATIC İNJURIES TO TEETH OR ALVEOLAR BONE

Radiographic assessment is crucial for the diagnosis and treatment planning for the traumatic injuries. PR can help to identify the location, type and severity of the traumatic injuries. However, CBCT has been recommended as an additional imaging modality when the true nature of the dento-alveolar root fracture and dental injuries cannot be confidently diagnosed from the PR [5, 29].

CONCLUSION

Periapical radiographs provide cost-effective, high-resolution imaging that continues to be the first choice for dental imaging. However, CBCT is a powerful diagnostic tool that contributes the diagnosis and treatment planning of endodontics. The dentist should be aware of CBCT imaging does not replace periapical radiograph. Effective doses with CBCT units are still

higher when compared to periapical radiograph. It is important that the guidelines of CBCT imaging in endodontics should be followed.

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