The benefits and limitations of CBCT

Dr. Alix Davies discusses the use of CBCT in endodontics

Cone beam computed tomography (CBCT) is one of the most significant advances in endodontics in the last decade. When used appropriately, it can greatly enhance the diagnosis and treatment planning of a variety of endodontic cases. However, it is important that each case is considered individually to ensure that the benefits provided by the scan outweigh the risks of the additional radiation.

Recent European Society of Endodontology (ESE) guidelines (Patel, et al., 2014) on the use of CBCT in endodontics suggest scenarios where a scan may be useful (Table 1). This article aims to explore these scenarios, discussing situations where CBCT would be useful, and those where it would provide no additional benefit to management of the case.

Educational aims and objectives

This clinical article aims to explain the benefits and limitations of CBCT and digital imaging in endodontics.

Expected outcomes

Endodontic Practice US subscribers can answer the CE questions on page XX to earn 2 hours of CE from reading this article. Correctly answering the questions will demonstrate the reader can:

- Identify some differences in the diagnostic abilities of 2D- and 3D-imaging technologies.
- Identify the technology behind CBCT imaging.
- Realize the management of CBCT in endodontics.
- Recognize the benefits and limitations of CBCT.
- Recognize the importance of assessing patients on an individual basis.

CBCT technology

Radiographic examination is essential in the diagnosis and management of endodontic problems and is performed with a periapical radiograph. However, a single periapical has limited diagnostic ability due to anatomical noise from superimposed structures, such as the maxillary sinus, zygomatic arch, and inferior dental nerve (Huumonen, Ørstavik, 2002; Patel, et al., 2009). The three-dimensional anatomy is compressed into a two-dimensional image, which will result in superimposition of the roots and prevent full appreciation of the root canal anatomy. Apical periodontitis is also difficult to diagnose in periapical radiographs when the lesions are confined to cancellous bone, especially when covered by a thick cortical plate (Bender, Seltzer 1961; Huumonen, Ørstavik, 2002).

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A CBCT is an extraoral imaging technique involving a cone-shaped beam and radiographic detector, which orbit around the patient. The data that is collected is reconstructed to produce three-dimensional scans of the maxillofacial region. These can be viewed in multiple planes to assess the presence of periapical lesions, root canal morphology, and the surrounding dentoalveolar anatomy. This increased knowledge may influence management decisions and treatment approaches (Davies, et al., 2015; Davies, et al., 2016; Patel, et al., 2009).

The effective dose of a periapical radiograph is 1-5µSv (Gijbels, et al., 2002) while the dose of CBCT with the Accuitomo (J. Morita USA) (4x4 cm field of view) ranges from 13µSv to 44µSv (Loubele, et al., 2009). The radiation dose received by the patient varies depending on the field of view (FOV), exposure time, tube current and potential, and the region of the jaw that is undergoing the scan.

Clinicans who order CBCT scans must have appropriate training (Brown, et al., 2014) and must ensure that radiation doses to patients are as low as reasonably achievable (ALARA). The need for a CBCT must be justified, due not only to the additional radiation that the patient will be exposed to, but also to the extra cost, and possibly travel time required for the patient to undergo the scan. Increasing numbers of dental practices have in-house CBCT scanners. However, many of these were designed for implant and oral surgery assessment, producing larger volume, lower resolution scans that are unsuitable for endodontic cases. Recent models have an endodontic function that enables a small volume higher resolution (75-125µm) scan to be taken. This is necessary to maximize the information gained while minimizing the dose to the patient.

Table 1: European Society of Endodontology guidelines recommending potential situations when CBCT would be beneficial (Patel, et al., 2014)

Diagnosis of radiographic signs of periapical pathosis when there are nonspecific signs and/or symptoms
Confirmation of non-odontogenic causes of pathosis
Assessment and management of complex dentoalveolar trauma, which may not be readily evaluated with conventional radiographic views
Appreciation of extremely complex root canal anatomy prior to endodontic treatment or retreatment
Assessment of endodontic treatment complications when existing conventional views have yielded insufficient information
Assessment and management of root resorption in cases that appear potentially amenable to treatment
Presurgical assessment prior to complex periradicular surgery

The applications of CBCT in endodontics

Diagnosis of periapical pathology

CBCTs are more specific and sensitive in the diagnosis of periapical pathology than periapical radiographs (Stavropoulos, Wenzel, 2007; Özen, et al., 2009; Patel, et al., 2009). They may, therefore, assist in locating an offending tooth when signs and symptoms are inconsistent (Figures 1A-1C). They may also be used to confirm the absence of an odontogenic etiology and therefore assist in the diagnosis of non-odontogenic causes of pain (Patel, et al., 2015).

Diagnosis of vertical root fracture

CBCT scans cannot reliably detect small cracks or incomplete vertical root fractures (Chang, et al., 2016). Larger fractures are likely to be evident clinically or on periapical radiographs, and a CBCT would therefore not be indicated. CBCT is particularly unreliable in detecting vertical root fractures in root-filled teeth, as the image scatter produced by the root filling will mask the area of the root that needs to be assessed (Patel, et al., 2013). However, the J-shaped radiolucencies that often indicate a root fracture may be more clearly visible once superimposed structures, such as roots, are removed, thus assisting the clinician in reaching a diagnosis (Figures 2A-2E).

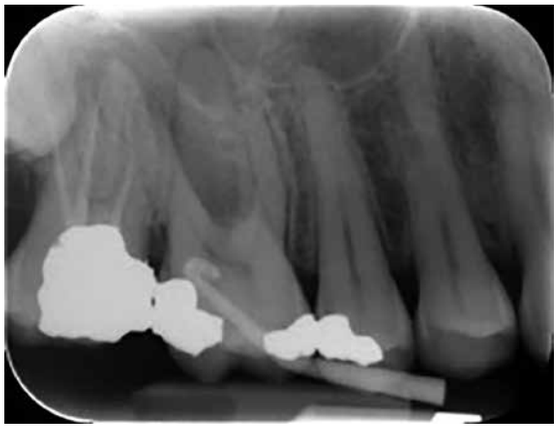
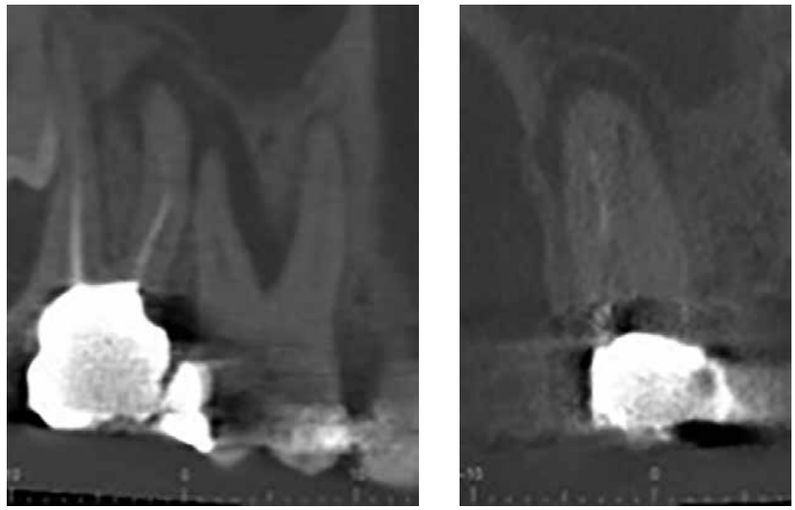


Figure 1A: This patient was referred for root canal treatment of his UR6. At presentation, he complained of a recurring abscess adjacent to this tooth. However, the UR6 was not tender to percussion or palpation, and despite having a deep distal filling, it gave a positive response to Endo-Frost. The periapical radiograph showed a radiolucency on the distal root of the UR6. The UR7 had poorly filled root canals, but due to the superimposition of the UR8, UR6 distal root, and proximity of the sinus floor, it was difficult to accurately assess for periapical pathology



Figures 1B and 1C: The sagittal reconstructed CBCT section with removal of the overlying anatomy (B) and coronal section through the mesial root of the UR7 (C) clearly show a periapical area associated with this root due to a poorly filled mesial canal and unfilled separate MB2. Due to the lack of signs and symptoms from the UR6, it was decided that the bone loss around the distal root was likely to be from pus discharge from the UR7. The patient elected to have the UR7 extracted, and the abscess resolved immediately

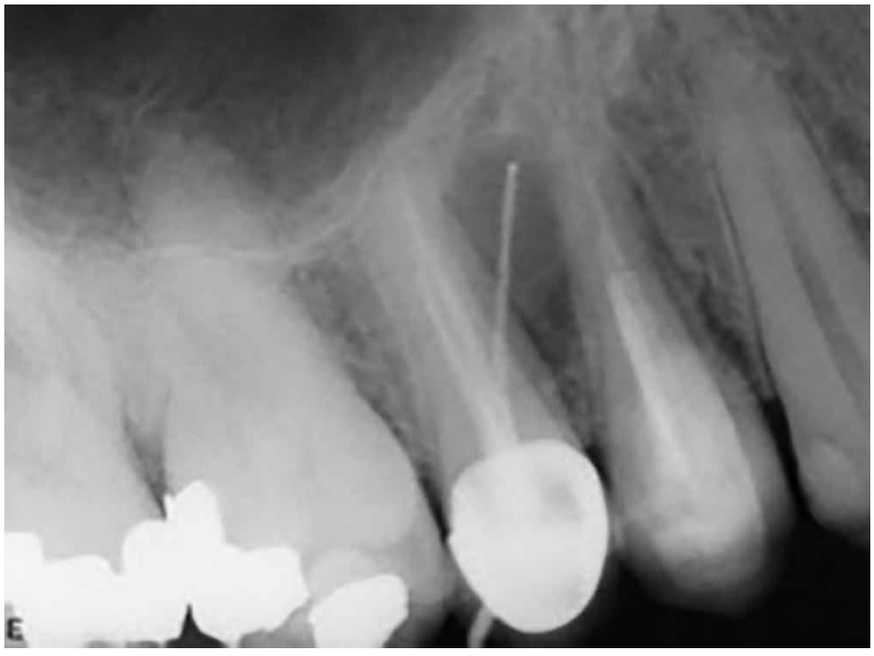
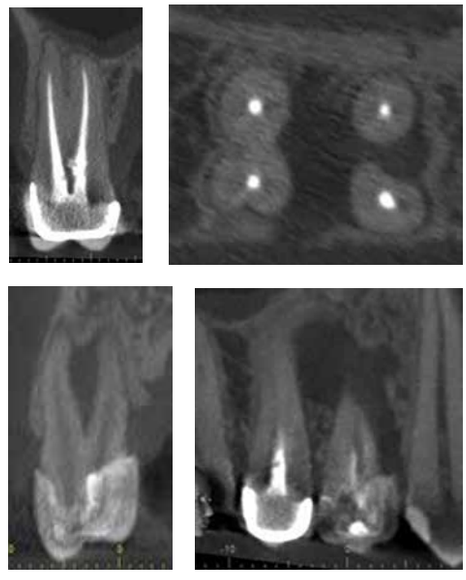


Figure 2A: This patient had root canal treatments completed on both the UR4 and UR5. He subsequently developed swelling and pus discharging from a sinus tract between the two teeth. Clinical tests assessing tenderness to percussion and palpation, and assessment for localized deep probing depths, failed to identify the problematic tooth. The periapical with gutta percha in the sinus tract also failed to localize the tooth



Figures 2B-2E: Coronal reconstructed sections of the UR5 (B) and UR4 (D) fail to show an area around the UR5, but there is a clear area of interproximal bone loss in the UR4 furcation area. The axial reconstructed section (C) also shows this clearly. A sagittal reconstructed section through the furcation shows the bone loss around the UR4, which tracks down the mesial aspect of the root. This J-shaped lesion is often indicative of a root fracture

Dentoalveolar trauma

CBCT may be used to assess dentoalveolar trauma in cases where clinical and conventional radiographic assessments are inconclusive (Patel, et al., 2015). Multiple periapicals are currently recommended to assess for fractures (Diangelis, et al., 2012), but these may still fail to show a horizontal fracture if the radiographic beam does not pass directly through the fracture line (Orhan, Aksoy, Kalender, 2010). The exact location of oblique fractures may, in particular, be more clearly diagnosed with CBCT and therefore more appropriately managed (Bornstein, et al., 2009). Patients are likely to find the extraoral CBCT imaging technique far more comfortable than tolerating intraoral beam holders, especially when teeth are mobile or fractured, or there are soft tissue lacerations. Nonetheless, it is important that the request for a CBCT does not delay emergency treatment if the facilities are not immediately available.

Assessment of complex root canal anatomy

Each tooth demonstrates a variety of canal configurations that must be thoroughly disinfected to maximize success rates of root canal treatment. An experienced clinician working with a microscope would be expected to identify the canals in the majority of cases, and therefore routine use of CBCT for every case is not justified. However, cases with unusual root formations, such as dens in dente (tooth within a tooth) (Durack, Patel, 2011), multi-rooted lower premolars, C-shaped molars, or cases with excessively curved canals, may benefit from a CBCT scan. A case where the root treatment was performed to a good standard and has still failed may also require additional imaging to assess for unfilled canals (Figures 3A-3F).

CBCT has been shown to identify significantly more canals in root-filled teeth than periapicals alone (Davies, et al., 2015). However, scans should not be taken to compensate for lackadaisical diagnostic or clinical skills. It is also important that the clinician has the equipment and skill set to make appropriate use of the additional information gained from the scan. There is little point in taking a CBCT to assess for an unfilled MB2 canal if a lack of magnification and skills would still preclude its discovery.

Canal sclerosis is a common challenge to adequately disinfecting the canals. CBCT may, however, be of minimal benefit in assisting with the location of the canal as the resolution is significantly worse than that of a periapical radiograph. Therefore, if the radiograph did not reveal a canal, it would be unlikely be visible with CBCT.

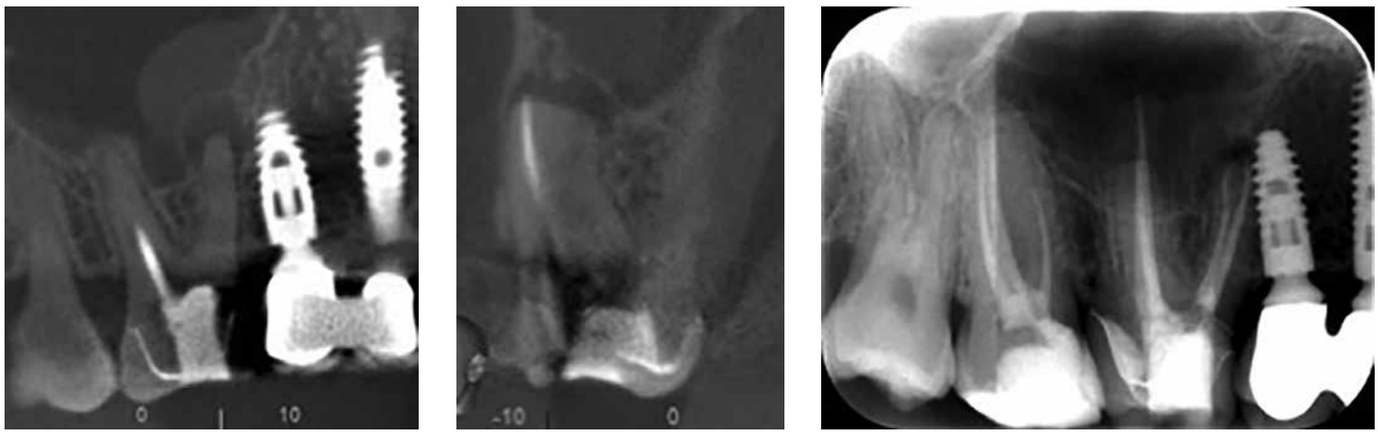
Assessment of treatment complications

CBCT scans are useful to assess complications such as fractured files and perforations. In cases where it is unlikely that a file can be removed, CBCT will provide information about the root canal morphology to determine if the file can be bypassed (Figures 4A-4G). Perforations on a buccal or palatal aspect may also be more clearly assessed with CBCT to determine the most appropriate management technique.

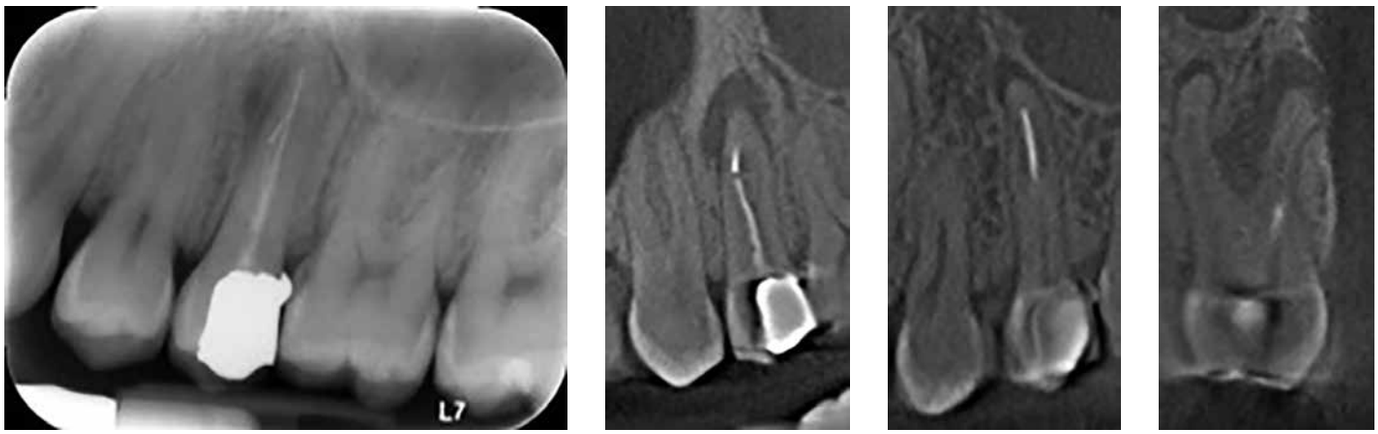
Assessment of root resorption

Conventional radiographic detection and assessment of root resorption may be challenging. This is compounded if the lesion is on the buccal or lingual/palatal aspect of the

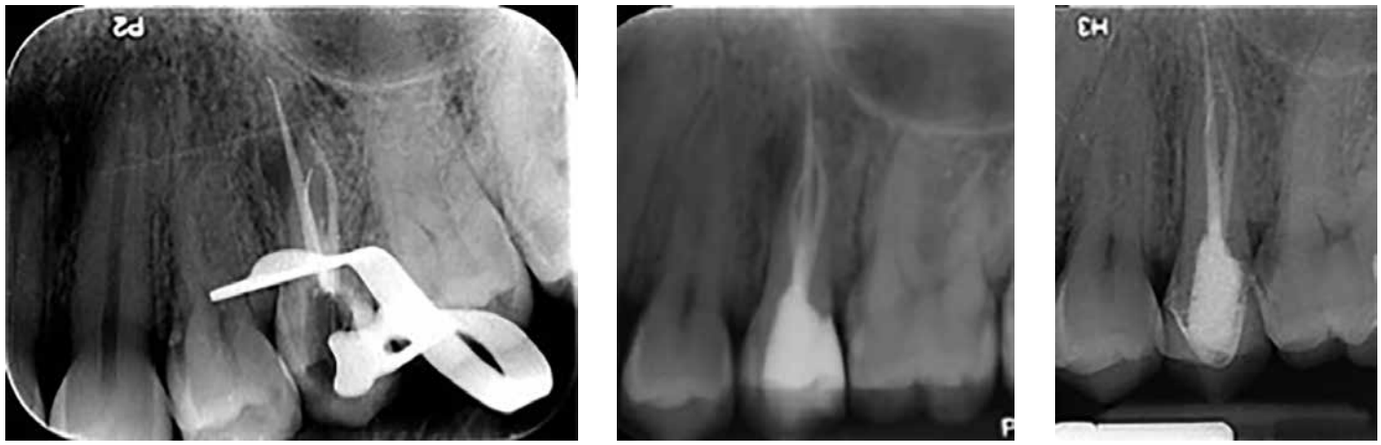
Figures 3A-3C: 3A. Periapical showing a good root filling in the UL6. 3B. Six months later, the patient had mild pain on biting, and the periapical showed an increase in the lesion around the UL6 mesial root. 3C. The axial section of CBCT scan showed an unfilled MB2



Figures 3D-3F: 3D-3E. The patient underwent a CBCT scan, and the sagittal (D) and coronal (E) sections show an unfilled MB2. 3F. Root canal retreatment was performed, and the MB2 was successfully located, disinfected, and obturated



Figures 4A-4D: 4A. Periapical showing a root-filled UL5 with a periapical area and fractured file in one canal. 4B. Sagittal reconstructed CBCT section through the buccal root shows the fractured file to be in buccal root in mesiobuccal canal. There is an additional distobuccal canal that converges with the mesiobuccal canal just beyond the point of instrument fracture. 4C. Sagittal reconstructed CBCT section through the palatal root shows it to also have a periapical area associated with it. 4D. Coronal reconstructed CBCT showing buccal and palatal roots and periapical areas

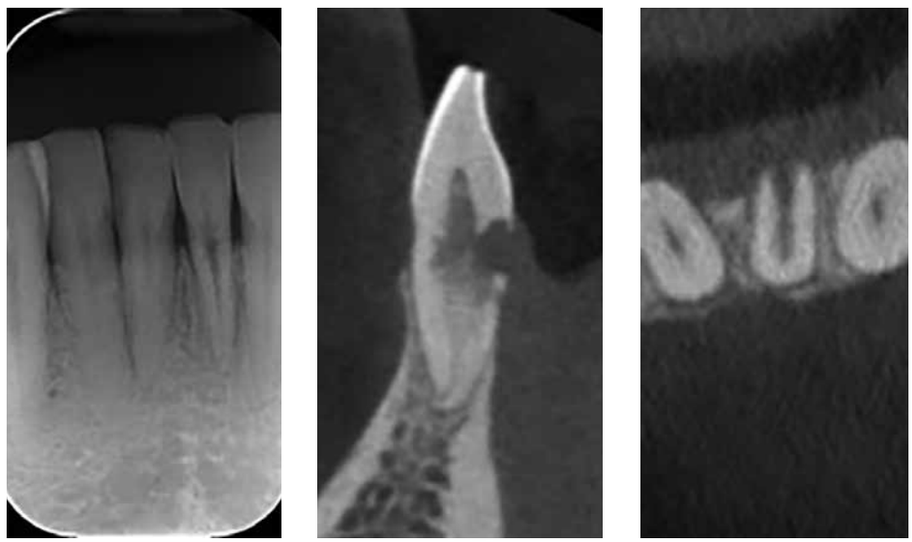


Figures 4E-4G: 4E. Knowledge that the mesiobuccal and distal canals converge enable root canal treatment to be performed, and the file to be bypassed. 4F. Postoperative periapical showing completion of the root canal treatment. 4G. One-year postoperative periapical showing periapical healing of the UL5

tooth where it will be masked by the more radiodense tooth structure. It may also be difficult to distinguish between internal inflammatory and external cervical root resorption from periapicals alone.

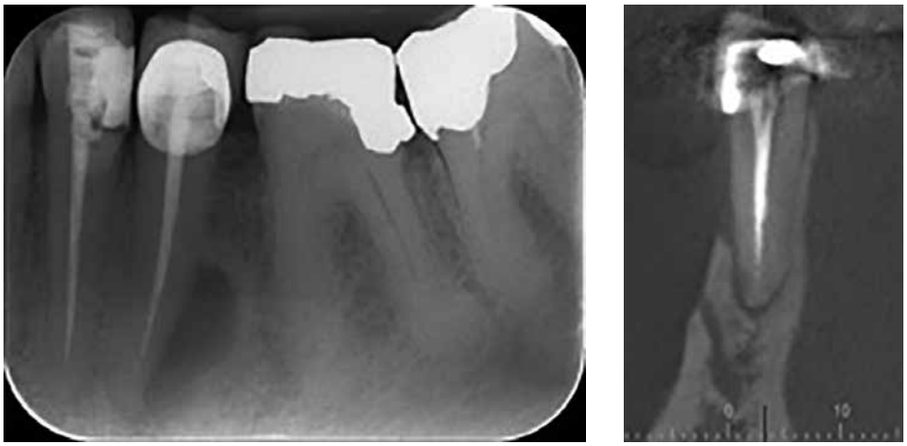
CBCT has been shown to be significantly more sensitive in detecting resorptive lesions (Estrela, et al., 2009) and also in assisting clinicians with choosing the correct treatment options (Patel, et al., 2009). The buccolingual extent of the resorption and assessment of perforations into the root canal or periodontal ligament can be more easily assessed with a CBCT. This will determine whether conventional treatment, surgery, or a combination of both is required.

This advance knowledge will enable treatment to be completed more efficiently and, in some cases, prevent patients undergoing unnecessary investigations on teeth (Figures 5A-5C). Preoperative CBCT scans



Figures 5A-5C: 5A. Periapical showing a possible resorption lesion of the LL1. 5B. Sagittal reconstructed CBCT section shows the full extent of the external cervical root resorption and its perforation into the pulp chamber. 5C. Axial reconstructed CBCT section clearly showing the resorption lesion perforating the pulp. This tooth is unsavable

CBCT is useful in the planning of surgical endodontic procedures, as it will provide accurate information as to the size and location of the periapical lesion and root apex in relation to structures such as the maxillary sinus, inferior dental canal and mental foramen.



Figures 6A-6B: 6A. Periapical radiograph of LL5 showing a root-filled tooth with a fractured file fragment in the apical portion. There is a large periapical area associated with this tooth. 6B. CBCT reconstructed images showing the mental foramen in close proximity to the LL5 apex. There is a high risk that the mental nerve could be damaged if root end surgery was performed on the LL5

should therefore be performed on all teeth with resorptive lesions that are potentially treatable.

Surgical planning

CBCT is useful in the planning of surgical endodontic procedures, as it will provide accurate information as to the size and location of the periapical lesion and root apex in relation to structures such as the maxillary sinus, inferior dental canal, and mental foramen (Figures 6A and 6B). Additional untreated canals (such as an MB2) may also be located. The amount of destruction of the cortical plates may also be assessed to determine whether membranes and grafting procedures are appropriate.

Conclusion

The use of CBCT in endodontics is rapidly increasing. Deciding when a CBCT is clinically necessary is a subject that causes great debate among endodontists. As ionizing radiation is used, it is essential that exposures are kept as low as reasonably achievable. Cases must therefore be assessed on an individual basis to determine whether the additional information from the scan will be beneficial in influencing the management of the case. EP

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