CASE REPORT

Diagnosis demystified: CT as diagnostic tool in endodontics

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SUMMARY

Diagnosis in endodontics is usually based on clinical and radiographical presentations, which are only empirical methods. The role of healing profession is to apply knowledge and skills towards maintaining and restoring the patient's health. Recent advances in imaging technologies have added to correct interpretation and diagnosis. CT is proving to be an effective tool in solving endodontic mysteries through its three-dimensional visualisation. CT imaging offers many diagnostic advantages to produce reconstructed images in selected projection and low-contrast resolution far superior to that of all other X-ray imaging modalities. This case report is an endeavour towards effective treatment planning of cases with root fracture, root resorption using spiral CT as an adjuvant diagnostic tool.

BACKGROUND

Traumatic injuries occur more commonly in young patients and vary in severity from enamel fractures to avulsion. Horizontal root fractures have a relatively low incidence, ranging from 0.2% to 7% when compared with other dental impact injuries. They are frequently seen in the middle third of the root followed by apical and coronal third fractures; the most affected teeth are the maxillary central incisors of male patients.¹ Diagnosis of root fracture is an important procedure to assess the prognosis and determine the appropriate treatment for the individual tooth. The prognosis of the affected tooth is influenced by several factors, such as age of the patient, stage of root formation, degree of dislocation of the coronal fragment, mobility of the coronal fragment and width of diastasis between the fragments.² Intraoral radiography is the most widely used imaging modality to detect root fracture. However, detection accuracy is low and problematic.³⁻⁴ Recently, three-dimensional (3D) images using various CT methods have been adopted to overcome the inherent disadvantages of conventional radiographical methods, that is, magnification, distortion and anatomic superimposition of two-dimensional (2D) images.

We are presenting an unusual case, featuring Ellis class 6 with respect to (wrt) maxillary right central incisor, external root resorption with Ellis class 3 wrt maxillary left central incisor and Ellis class 8 wrt maxillary right lateral incisor all in single patient. In this report, we could achieve effective treatment planning only after obtaining CT images. We aim to present a case regarding the use of CT in the detection of external root resorption, mid-

horizontal root fracture and discuss the potential use of CT in treatment planning.

CASE PRESENTATION

A 25-year-old male patient visited with the complaint of getting his upper front teeth restored. The patient's medical history was not significant, but the dental history revealed history of trauma 2 years back. On clinical examination (figure 1): maxillary right lateral incisor (tooth 12) was missing; maxillary right central incisor (tooth 11) and maxillary left central incisor (tooth 21) showed crown fracture at cervical third. There was no mobility, fistulae or pain to percussion or palpation. A routine periapical radiograph revealed a horizontal mid root fracture in the maxillary right central incisor 11 (figure 2) and although the clinical examination showed maxillary right lateral incisor (tooth 12) was missing, radiographically it revealed fracture of the crown en masse. Tooth 21 showed root resorption. Pulp vitality testing elicited no response from teeth 11 and 21. Treatment was started with access opening of maxillary right central incisor. On exploration, there was an obstruction at the middle third of root. Displacement of fracture fragment was suspected. Radiographs with different angulations were taken but amount and type of displacement were not clear. The decision to proceed with root canal treatment was postponed. The appointment was then concluded with the application of sterile cotton pellets and intermediate restorative material

Figure 1 Preoperative clinical image showing missing tooth 12, cervical third crown fracture of teeth 11 and 21.

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Figure 2 Radiograph showing obstruction of file at middle third of horizontal root fracture wrt 11, also seen are root resorption wrt 21 and subgingival fracture wrt 12.

(IRM) cement (Dentsply DeTrey GmbH, Konstanz, Germany). It was decided to obtain CT imaging for further evaluation.

INVESTIGATIONS

IOPA radiograph

Intraoral peri apical (IOPA) radiograph revealed the presence of a horizontal root fracture in the mid-root of tooth 11 (figure 2). Tooth 12 revealed fracture of the crown en masse diagnosed as Ellis class 8 fracture. Two radiographs with different vertical angulations were taken. Tooth 21 was diagnosed as external root resorption with Ellis class 3 fracture.

CT scans

CT analysis was performed in all 3D, axial, sagittal and cross-sectional images, with a 0.5 mm slice thickness (General Electric, Siemens, 64 slice, 120 kV, 90 mA). The sagittal images revealed horizontal root fracture of tooth 11 accurately showing degree of dislocation of the coronal fragment and width of diastasis between the fragments (figure 3). Transverse views show root resorption confirming the earlier diagnosis of external root resorption (figure 4).

DIFFERENTIAL DIAGNOSIS

- ▶ Ellis class 6 fracture wrt 11
- ▶ Ellis class 8 fracture wrt 12
- ▶ External root resorption with Ellis class 3 fracture wrt 21

TREATMENT

Treatment plan

Tooth 11—horizontal root fracture:

- ▶ Root canal treatment (RCT) and mineral trioxide aggregate (MTA) apexification wrt only coronal fragment
- ▶ Light transmitting post and internal splinting
- ▶ Composite build up

Tooth 12—submerged root fragment:

Figure 3 Sagittal section of CT scan showing dislocation of fracture fragment.

- ▶ Gingivectomy
 - ▶ Crown lengthening procedure
 - ▶ RCT
 - ▶ Post and core
 - ▶ Metal fused ceramic crown
- Tooth 21—Coronal fracture with external root resorption
- ▶ Calcium hydroxide placement
 - ▶ RCT
 - ▶ Composite restoration

Treatment for tooth 11

CT scans revealed accurately the degree of dislocation of the coronal fragment. It was decided to treat only coronal fragment.

Figure 4 Transverse section of CT scan showing horizontal fracture and external root resorption showing no connection with the pulp space.

Figure 5 Radiograph showing MTA apical plug at only coronal fragment wrt 11.

Hence only the coronal fragment of central incisor to the apical mid-fractured site were cleaned biomechanically and irrigated with a sodium hypochlorite 2.5% solution. The canals were then dried with paper points. The MTA material (Pro root MTA, Dentsply) was mixed in a 3:1 proportion and was carried with a small amalgam carrier to coronal fragment of the central incisor to the apical fracture site (figure 5) and put in place with fine condensers and adapted gently. To check the correct positioning of the MTA mixture, an IOPA was taken. A wet cotton pellet with sterile water was then placed in the pulp chamber and the access cavity was closed with temporary filling material IRM (Caulk/Dentsply, Milford Delaware, USA). After 24 h, the IRM and the cotton pellet were removed and the set of the MTA was gently tested with gutta-percha and the rest of the root canal was obturated with thermoplasticised technique. Fractured crown was reinforced intraradicularly with flowable composite and a light transmitting fibre post (figure 6) and restored with composite resin.

Treatment for 12

Under local anaesthesia gingivectomy (figure 7) was performed to re-establish the gingival margin and convert the subgingival fracture site to a supra gingival one. A standard root canal procedure was carried out and root canal was obturated with gutta-percha and zinc oxide-eugenol sealer, using the lateral condensation method (figure 8). A postoperative radiograph was obtained, subsequent to which a custom cast post and core and

Figure 6 Light transmitting post was placed wrt 11.

porcelain fused to metal crown was placed. Appearance of the prosthesis was enhanced with the use of pink porcelain to simulate gingival tissue, all leading to a result which was profoundly satisfying for the patient as well the clinician.

Treatment for 21

The endodontic treatment was initiated immediately after isolation with a rubber dam. The root canals were instrumented manually under strict asepsis with copious irrigation, aspiration and flushing with 2.5% sodium hypochlorite. Besides the fact that there was a large external resorption, there was no connection to the pulp space (figure 4) and no bleeding on instrumentation. The root canals were dried and filled with EDTA (17%) that was stirred for 3 min with a K-file to remove smear layer. The canals were then filled with a calcium hydroxide-based intracanal dressing, which was changed every week during a 1 month period. A standard root canal procedure was carried out and root canal was obturated with gutta-percha and with a calcium hydroxide-based sealer (Sealapex, Sybron Endo, and Orange, California, USA), using the lateral condensation method (figure 8). Fractured crown was reinforced

Figure 7 Photograph showing gingivectomy wrt 12.

Figure 8 Conventional root canal treatment wrt 12 and 21.

intraradicularly with flowable composite and a light transmitting fibre post (figure 9) and restored with composite resin (figure 10).

OUTCOME AND FOLLOW-UP

Endodontic treatment was successful and patient is under follow-up.

DISCUSSION

Traumatic dental injuries are commonly seen in children and adolescents. Maxillary central incisors are most vulnerable to injury, sustaining approximately 80% of all dental injuries,

Figure 9 Light transmitting post was placed wrt 21.

followed by the maxillary lateral and the mandibular incisors.⁵ The literature indicates that many factors influence the type of healing that occurs for root fractures and early definite diagnosis is essential to avoid inappropriate treatment. However, it is often difficult to reach an accurate diagnosis on the basis of the presenting signs and symptoms because those symptoms are variable or non-specific.⁶⁻⁸ Conventional radiographs can be helpful for diagnosis when the X-ray beam is parallel to the plane of fracture, but this is scarcely possible. Superimposition of neighbouring structures further limits the ability to detect root fractures by using conventional radiographs.^{9 10}

CT provides abundant image information not attainable by either periapical radiograph or panoramic radiograph. Its application for clinical use is very effective for examining and diagnosing areas of interest for endodontic therapy. CT is an X-ray imaging technique that produces 3D images of an object by using a series of 2D set of image data to mathematically reconstruct a cross-section of it. This system measures the attenuation of X-rays entering the body from many different angles. The computer then reconstructs the part under observation in a series of cross-sections or planes. Spiral CT scanners use continuous scanning to generate cross-sectional slices and make a set of 3D images. In this way, the time it takes to produce tomographic pictures is reduced.¹¹ Compared with the conventional radiographs, the axial CT images were quite helpful in determining the spatial relationship between the apex and the surrounding bone.¹² The technique of dental CT also known as dentascanner was developed by Schwartz *et al*,¹³ The dental CT can be performed with a conventional CT, a spiral CT or a multislice CT scanner. There are several techniques related to CT in the dental field: tuned aperture CT (TACT), and micro-CT, cone beam CT. Tachibana and Matsumoto¹⁴ published one of the first reports on the application of CT technology in endodontics. Recent studies have shown that CT scans are more accurate than periapical radiographs and effective in a safe way to detect both horizontal and vertical root fractures (table 1).¹⁵⁻¹⁸

Advantages with spiral CT is that the scanned volume also includes the opposite side of the jawbone, a fact that in some cases made it easier to distinguish between a normal bone pattern with irregular and large trabecular spaces and a lesion. CT has several other advantages over conventional radiography in addition to 3D images. These include the elimination of anatomical noise and high contrast resolution, allowing differentiation of tissues with less than 1% physical density difference to be distinguished compared with a 10% difference in physical difference which is required with conventional radiography.¹⁹

However, the uptake of CT in endodontics has been slow for several reasons, including the high effective dose²⁰ and relatively low resolution of this imaging technique. Other disadvantages of CT are the high costs of the scans, scatter because of metallic objects, poor resolution compared with conventional radiographs and the fact that these machines are only found in dedicated radiography units (eg, hospitals). Access may thus be problematic for dentists in practice. CT technology has now become superseded by cone beam CT technology in the management of endodontic problems.

DIAGNOSIS

Horizontal root fracture

The literature indicates that many factors influence the type of healing that occurs for root fractures and early definite diagnosis is essential to avoid inappropriate treatment. Unfortunately, both conventional films and digital imaging systems provide poor

Figure 10 Preoperative and postoperative photograph.

sensitivity in the detection of root fractures. This limitation is the result of a combination of factors: superimposition of overlying and adjacent anatomical structures, processing errors from manual film processing or from automatic film processing machines, a beam direction that may not be parallel to the fracture line and the display of a 2D image of a 3D object.^{21 22} These limiting factors indicated the need for the development of alternative diagnostic imaging systems that carry the potential for improving detection. In recent years, CT has been introduced as an alternative to film-based radiography and conventional digital radiographical systems. SCT acquires raw projection data with a spiral-sampling locus in a relatively short period. Without any additional scanning time, these data can be viewed as conventional transaxial images, such as multiplanar reconstructions, or as 3D reconstructions. With SCT, it is possible to reconstruct overlapping structures at arbitrary intervals and thus the ability to resolve small objects is increased and also produces 3D imaging of the hard tissues of the jaws with reduced radiation dose. Recent studies have shown that CT scans are more accurate than periapical radiographs and effective in a safe way to detect both horizontal and vertical root fractures.^{23–26}

External root resorption

Diagnosis should be based on a combination of radiographical and clinical examination. Intraoral radiographs of the lesion usually show an uneven root surface outline, and radiographs

obtained at different angles may be useful to determine which surface are affected.²⁷ Vitality testing may also be helpful in detecting the type of ERR.^{28 29} At present, conventional intraoral film radiography (F), photostimulable phosphor plate and charge-coupled device chips are the most commonly used radiological methods for the diagnosis of ERR. Andreassen *et al*¹⁷ reported that those lesions less than 0.3 mm in depth and 0.6 mm in diameter are not detected by conventional periapical radiography. Recent studies have indicated that CT, and with its higher sensitivity and specificity is a useful diagnostic tool particularly in detecting small and less accessible root resorption.³⁰

Clinical approach:

In horizontal root fractures, when the coronal segment pulp becomes necrotic and there is no radiographical or clinical evidence that the apical segment is irreversibly inflamed or necrotic, the treatment of the coronal segment only is indicated after the root fracture. The apical segment will probably remain vital. Therefore, in most cases of unhealing root fractures only the coronal segment is treated. Studies have observed higher fracture resistance, higher clinical and radiographical success at inducing apical closure and absence of signs of clinical and radiographical failure, greater amount of hard tissue formation and a lower level of inflammation when MTA-filled root canals are compared with root canals filled with calcium hydroxide.^{31–34} Hence, in the present MTA was selected in the root canal treatment of the horizontal root fracture, because its use improves the outcome of the treatment.¹⁸ Fractures at the cervical region occasionally result in loss of coronal part of the tooth, which creates aesthetic problems for the patient. However, the presence of fracture line below the gingival attachment or alveolar bone crest presents restorative difficulties for the clinician. In the present case gingivectomy preceded endodontic treatment and restored with a postcore and porcelain fused to metal crown along with gingival porcelain.

In root resorption cases, either invasive cervical or inflammatory, the sooner the treatment is started, the less severe are the short-term consequences.^{35 36} Therefore, the early diagnosis of root resorption is a key aspect to treatment success. CT is a safe method to investigate external root resorption, with excellent specificity and sensitivity. The 0.3 mm voxel resolution is the best configuration because it associates great diagnostic performance with lower patient exposure to X-rays.³⁷ Treatment of inflammatory resorption is based on removal or reduction of the source of infection.³⁸ Non-surgical root canal therapy with the use of calcium hydroxide as an intracanal medicament is recommended and hence the same was followed in the present case.³⁹ In the present case despite the serious damage to the root by external root resorption, non-surgical root canal therapy can arrest the external root resorption and achieve good result.

Table 1 Example of standard investigation protocols for imaging of the anatomic situation (anatomy) or pathological conditions (pathology) of the jaw with dental CT

	Anatomy	Pathology
Scan type	Spiral	Incremental
Slice thickness (mm)	1.0	1.5
Table feed	1.0	1.0
Field of view (mm)	120(mandible) 100 (maxilla)	120 (mandible) 100 (maxilla)
Scan time (s)	1	2
Matrix	512	512
Tube current (mA)	25–100	25–100
Tube voltage (kV)	120	120
Filter	High-resolution edge-enhanced filter	High-resolution edge-enhanced filter
Window setting	2000 HU with, 400 HU centre (bone window)	2000 HU with, 400 HU centre (bone window)
Scan plane	Hard palate (maxilla) Mandible base (mandible)	Hard palate (maxilla)
Mandible base (mandible)		

The SCT as a diagnostic tool provide 3D imaging of the required region and help in understanding the complex root canal anatomy and, thus helping a great deal in rendering successful endodontic therapy. This case report highlights the role of SCT as an important diagnostic tool in endodontics, thereby enhancing overall success of endodontic therapy.

Learning points

- The decision to select an imaging modality for diagnostic purposes, as in this case, should be based on the diagnostic yield expected and in accordance with the as low as reasonably achievable principle.
- Limited accessibility of CT imaging and large radiation dose are major disadvantages for routine use.
- With the advantage of three-dimensional visualisation, CT is a valuable diagnostic tool for better treatment planning and better prognosis.

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Competing interests None.

Patient consent Obtained.

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