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Root Fracture: An Unexpected Encounter

Abstract: This report describes a case where a root fracture in a traumatized upper central incisor was not discovered until after orthodontic treatment had commenced, despite rigorous clinical and radiographic assessment.
Clinical Relevance: An increased overjet is associated with a greater incidence of trauma to the upper incisors; it is important that both orthodontists and general dental practitioners are aware of the orthodontic implications of these susceptible patients.
Ortho Update 2010; 3: 20–25

Traumatic injuries to the teeth and their supporting structures are common in young patients.[1] However, root fractures account for only 7% of traumatic injuries to the permanent dentition.[2] Root fractures may be classified into coronal, middle or apical third, according to their position. Fractures in the coronal third have the poorest prognosis not only because they frequently become contaminated with bacteria from the gingival sulcus through a communication with the oral environment, but also because the coronal fragments are more likely to be mobile.[3]

The presentation of a root fracture may vary from a clinically normal tooth to a displaced or mobile tooth. Root fractures are usually identified clinically and radiographically shortly after a traumatic injury, although sometimes they may not be identified until many years later.[4]

Although in some cases root fractures heal without any intervention,[4] they are usually treated by reduction, stabilization and relief of the occlusion.[3] All root fractures can be managed in the same way provided that they are located below the level of the alveolar crest and do not communicate with the oral cavity.[3,5] If this initial treatment is not successful, endodontic, periodontal or orthodontic therapy may also be required.[3] Where there is communication between the fracture and the oral cavity, the coronal fragment is extracted and the remaining root may either be extruded and restored[3,6] or extracted.

Healing of root fractures occurs by three different mechanisms:

- Hard tissue union;
- Interposition of connective tissue; o
- Interposition of bone and connective tissue.[7]

All three types of healing usually result in asymptomatic non-mobile teeth.[3]

An increased overjet is associated with a greater incidence of trauma to the upper incisors,[8] so it is not surprising that many patients who seek orthodontic treatment have suffered trauma to their upper incisors. Although orthodontic treatment may be undertaken without complication in patients who have sustained injuries to their teeth,[8,9] there are certain risks involved. These risks include loss of vitality, pulpal calcification and induction of significant root resorption.[10] Complications of moving root fractured teeth include separation of the tooth fragments and ankylosis.[7]

When planning treatment for patients who have suffered dental trauma it is important to adapt the ideal treatment plan to accommodate any traumatized teeth.[11] The type and timing of the trauma and the prognosis of the affected teeth must be considered in combination with the patient's orthodontic status.[12] In some cases, it may be preferable to treat patients on a non-extraction basis.[9] It has been suggested that there should be an observational period of two years following a root fracture before orthodontic tooth movement is commenced,[9,13] although there is little evidence to support this practice. Teeth with root fractures that have healed by interposition of connective tissue or interposition of bone and connective tissue need to be treated as teeth with short roots. Root morphology should also be reviewed before treatment is started. Teeth with pipette-shaped or blunt roots, whether having been traumatized or not, are more likely to undergo significant root resorption.[14]

Previously traumatized teeth need to be monitored throughout orthodontic treatment to check for loss of vitality and root resorption. Pulpal health can be assessed by vitality testing, percussion and checking for mobility and colour changes at 3-monthly intervals. Root resorption can only be assessed radiographically.[10] Pre-treatment radiographs should be taken, with repeat views being taken at 6–9 months into treatment. If any resorption is noted, treatment may be paused for 3 months

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Figure 1. Pre-treatment facial view of the patient.

Figure 2. Pre-treatment profile view of the patient.

Skeletal		
	Actual	**Mean**
SNA	86.5°	81.5°
SNB	78.0°	78.0°
ANB	8.5°	3.0°
SN/MxP	13.0°	7.5°
MxP/MnP	24.0°	27.0°
LAFH/TAFH%	53.0°	56.0°
Teeth		
	Actual	**Mean**
Overjet	4.0 mm	3.5 mm
Overbite	-1.0 mm	4.0 mm
UI/MxP	122.0°	109.0°
LI/MnP	103.5°	92.0°
LI-APo	4.0 mm	1.0 mm

Table 1. Eastman analysis of pre-treatment lateral cephalogram.

Figure 3. Pre-treatment right buccal view of the occlusion.

Figure 4. Pre-treatment frontal view of the occlusion.

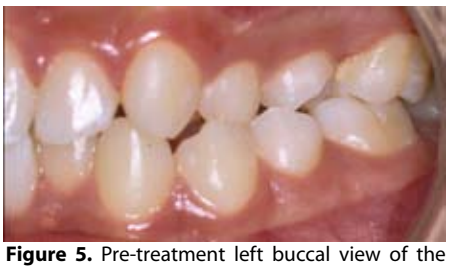

Figure 5. Pre-treatment left buccal view of the occlusion.

Figure 6. Pre-treatment occlusal view of the mandibular arch.

Figure 7. Pre-treatment occlusal view of the maxillary arch.

to try to reduce any further resorption. If treatment is continued, radiographs should be taken at 2-monthly intervals.[13]

If a tooth loses vitality during orthodontic treatment, tooth movement should stop while endodontic treatment is carried out.[7] Some authors recommend that the final gutta percha root filling should not be placed until orthodontic treatment is complete; the root canal being filled with a non-setting calcium hydroxide paste in the interim.[13] If a tooth with an immature root devitalizes during treatment, successful apexification may be carried out during tooth movement.[15] There is no contra-indication to moving teeth that have been root-filled, provided that there is no associated pathology.[16]

While there are many reports of orthodontic treatment having been carried out for patients with traumatized incisors, some of which had sustained root fractures, to our knowledge, there has been no report of a root fracture being discovered in a traumatized tooth after commencing orthodontic treatment.

This report describes a case where a root fracture in a traumatized upper central incisor was not discovered until after orthodontic treatment commenced, despite rigorous clinical and radiographic assessment.

Case history

An 11-year-old male was referred to the orthodontic department at a teaching hospital for treatment of a Class II division I malocclusion. The history and clinical examination revealed that the patient had suffered trauma to

Figure 8. Pre-treatment lateral cephalogram.

Figure 9. Pre-treatment DPT.

his upper right central incisor at the age of 8 years. This tooth had been treated by encouraging apexification prior to placement of a gutta percha root filling by the paediatric dental department. The patient was still attending the paediatric dental department for review of the upper right central incisor, which had been asymptomatic since placement of the root filling.

Extra-oral assessment (Figures 1 and 2)

- Skeletal Class II pattern;
- Average lower face height;
- Average FMPA;
- At rest, lips were competent;
- Acceptable facial profile; obtuse nasolabial angle.

Intra-oral assessment (Figures 3, 4, 5, 6 and 7)

- Bimaxillary proclination;
- Mild mandibular arch crowding (approximately 3 mm);
- Mild maxillary arch crowding (approximately 4 mm);
- Molar relationship Class I bilaterally;
- Crossbite affecting the premolars on the left;
- Overjet 6 mm.

Radiographic assessment

Lateral cephalogram and Eastman analysis confirmed Class II skeletal relationship and the presence of bimaxillary proclination (Figure 8, Table 1);

Dental panoramic tomograph (DPT) showed normal development for the patient's age; lower left third molar absent; large root filling in the upper right central incisor; occlusal caries in the lower second molars (Figure 9);

Upper standard occlusal revealed no supernumerary teeth in the anterior maxilla (Figure 10);

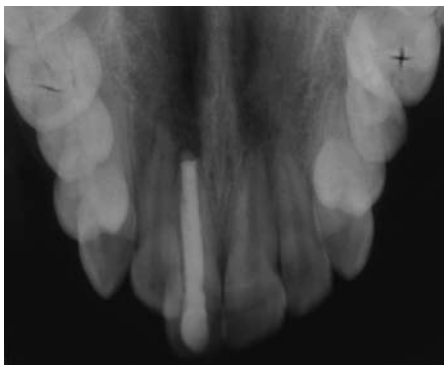

Figure 10. Pre-treatment anterior standard occlusal view.

A periapical film of the upper incisors showed the upper right central incisor to have a large satisfactory root filling in place; no periapical radiolucency or root fracture evident (Figure 11).

None of the radiographs, when analysed collectively or alone, showed any evidence of a root fracture affecting the upper right central incisor. The patient had restorations placed in his lower second molar teeth by his general dental practitioner (GDP) prior to commencing orthodontic treatment.

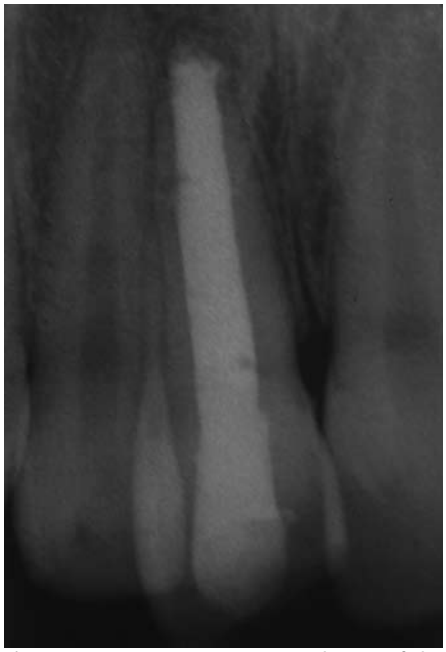

Figure 11. Pre-treatment periapical view of the upper right central incisor.

Aims of treatment

- Preserve facial profile;
- Relieve crowding in both arches;
- Correct bimaxillary proclination;
- Correct crossbite in left premolar region;
- Correct centerlines;
- Level and align arches;
- Achieve Class I incisor relationship.

Treatment plan and rationale

Clinically and radiographically the patient had bimaxillary proclination and crowding. In order to avoid extractions, headgear could have been used to distalize the buccal segments. However, the patient refused to wear headgear. Interproximal enamel reduction was also considered, but this technique may not have provided sufficient space to allow relief of crowding. In addition, the patient and his parents were concerned about the possibility of sensitivity if enamel reduction was utilized. The following treatment plan was therefore formulated to meet the patient's needs:

- Extraction of maxillary first premolars and lower second premolars;
- Upper and lower fixed appliances with or without Class II intermaxillary elastic traction.

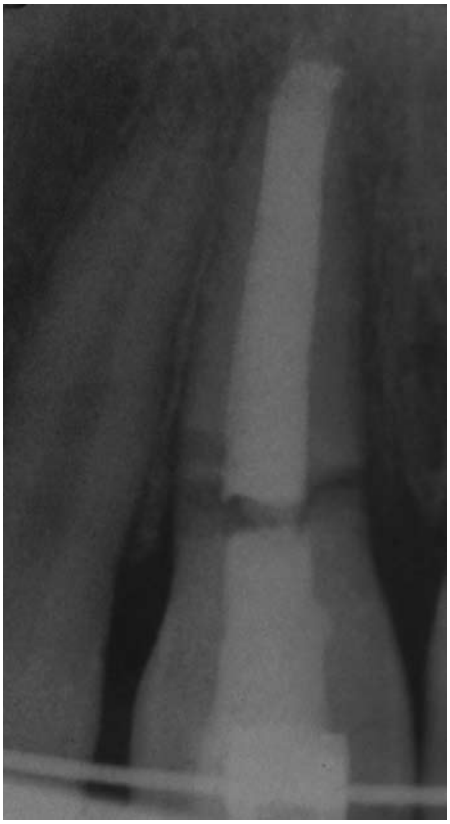

Figure 12. Periapical view of the upper right central incisor 3 months after placement of orthodontic appliances.

Figure 13. Mid-treatment lateral cephalogram.

Skeletal		
	Actual	**Mean**
SNA	88.5°	81.5°
SNB	79.5°	78.0°
ANB	8.0°	3.0°
SN/MxP	11.0°	7.5°
MxP/MnP	24.5°	27.0°
LAFH/TAFH%	54.5°	56.0°
Teeth		
	Actual	**Mean**
Overjet	2.5 mm	3.5 mm
Overbite	0.5 mm	4.0 mm
UI/MxP	115.0°	109.0°
LI/MnP	102.0°	92.0°
LI-APo	3.5 mm	1.0 mm

Table 2. Eastman analysis of mid-treatment lateral cephalogram.

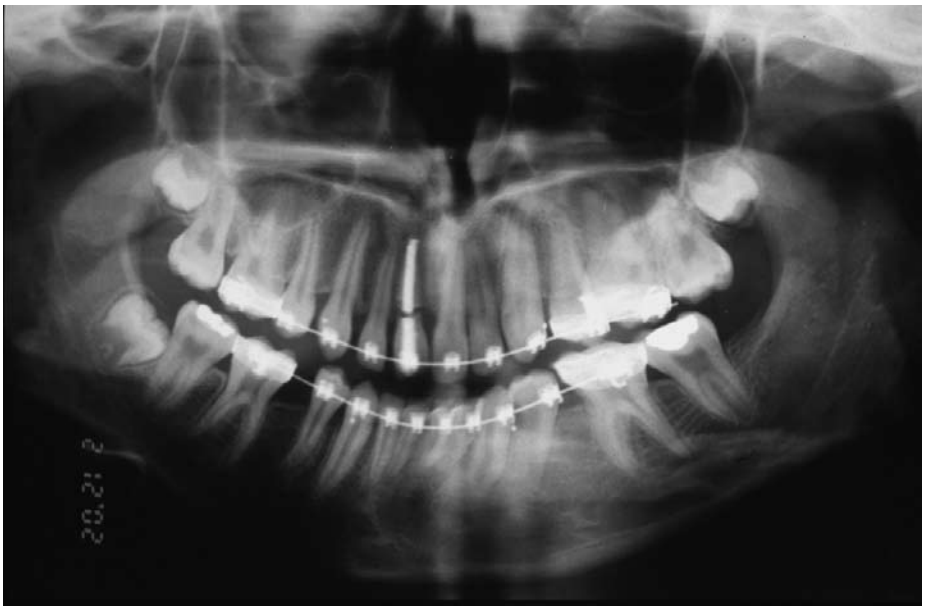

Figure 14. Mid-treatment DPT.

Treatment progress

Prior to starting treatment, the patient and his parents were warned about the risks, such as root resorption and ankylosis, of moving a traumatized tooth with orthodontic forces. The patient was treated with pre-adjusted edgewise appliances with Class II intermaxillary elastics. His treatment took 21 months until debond.

Three months after the start of treatment, Grade 2 mobility was noted in the upper right central incisor. A periapical radiograph was taken to check for root resorption and investigate the mobility of this tooth. The radiograph revealed a fracture in the coronal third of the root of the upper right central incisor, with separation of the two fragments (Figure 12). The patient and parents were immediately informed and the following treatment options were discussed:

- Extract the crown and root of the upper right central incisor and maintain the space for future restoration;
- Extract the crown and root of the upper right central incisor and close the space using the upper right lateral incisor (with restorative modification) as the new central incisor;
- Extract the crown of the upper right central incisor but leave the root *in situ* to maintain alveolar bone levels for an implant to be placed in the future;
- Preserve the upper right central incisor and accept a slightly compromised final orthodontic result.

It was decided to preserve the upper right central incisor, as extraction and space closure using the lateral incisor as the new central incisor would have produced a poor aesthetic result, particularly in view of the emergence profile. The preservation of this tooth would maintain bone such that an implant could be placed in the future if

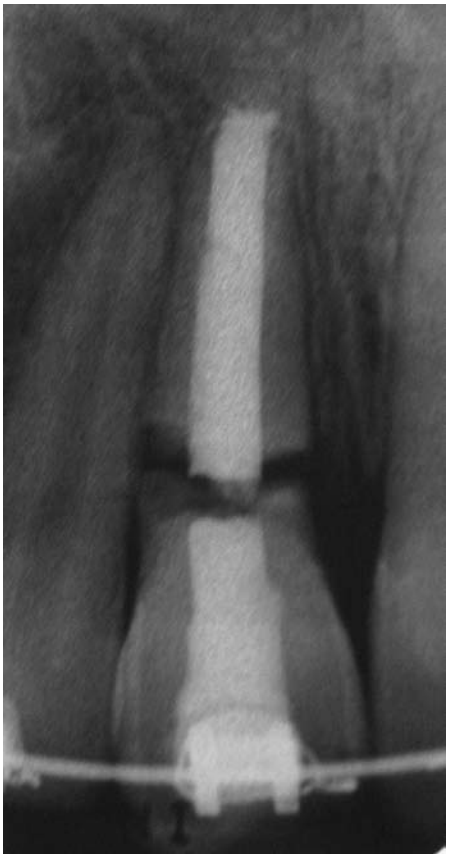

Figure 15. Periapical view of the upper right central incisor prior to space closure.

Figure 16. Facial view post debond.

Figure 17. Profile view post debond.

Figure 18. Right buccal view of the occlusion post debond.

Figure 19. Frontal view of the occlusion post debond.

Figure 20. Left buccal view of the occlusion post debond.

the need arose.

It was explained to both the patient and parents that the upper right central incisor had a guarded prognosis and would require periodic clinical and radiographic monitoring.

Prior to complete space closure, a lateral cephalogram was taken to assess the labial inclinations of the anterior teeth (Figure 13); a DPT was taken to check for root resorption and to assess root paralleling (Figure 14), and a periapical view of the upper right central incisor was taken to assess the amount of separation of the tooth fragments (Figure 15). These radiographs showed no major signs of root resorption, but confirmed further separation of the fragments of the upper right central incisor. Eastman analysis of the mid-treatment lateral cephalogram confirmed a reduction in the overjet and incisor angulation due to retraction mechanics during partial space closure (Table 2).

Towards the end of treatment a residual space of 0.5 mm was present distal to the upper right central incisor. Class II intermaxillary traction was utilized but, in spite of the patient's compliance with treatment, the spacing remained. This was most likely due to the fact that the root fracture made it impossible to torque the root of the upper right central incisor labially.

Treatment results (Figures 16, 17, 18, 19 and 20)

- Facial profile preserved;
- Crowding relieved with premolar extractions;
- Bimaxillary proclination corrected;
- Crossbite corrected;
- Centrelines almost corrected (to within 1 mm);
- Arches levelled and aligned;
- Class I incisor relationship achieved (canines still remained ¼ to ½ unit Class II);
- The upper right central incisor was Grade 2 mobile at debond.

Discussion

It seems unlikely that the root fracture in the upper right central incisor was present at the time root canal treatment was carried out, otherwise it would have been discovered by the paediatric dental team. The fact that the fracture was not visible on any of the radiographs taken as part of the orthodontic assessment also suggests that the fracture was not present at this stage. Orthodontic treatment did not commence until about 12 months later, so it is possible that the fracture occurred after these radiographs were taken. Mobility was not noted in the tooth until after the orthodontic appliance was fitted, so the fracture may even have happened after treatment started. The patient reported no incidence of dental trauma between the time of the pre-treatment radiographs being taken and the root fracture being discovered.

A recent study of dental trauma cases found that 32% of teeth that had undergone apexification developed a root

fracture during the period of follow-up. Although 85% of these fractures were associated with subsequent incidences of dental trauma, 15% were said to have occurred spontaneously.[17] Teeth in which the pulp has become necrotic before the completion of root formation are severely weakened[18] owing to the reduced thickness of their dentine. There is also evidence from animal studies that long term use of calcium hydroxide as a root canal dressing may increase the risk of root fracture.[19] In our case, it is possible that occlusal forces alone could have caused the fracture in the upper right central incisor if the root had sufficiently thin dentinal walls or had become brittle through the long term use of calcium hydroxide during the apexification process.

Alternatively, the forces generated during lateral condensation of the root filling could have contributed to the root fracture. However, it seems more likely that these forces would have led to a vertical root fracture rather than a horizontal one. Although there have been studies to investigate the relationship between vertical root fracture and lateral condensation,[20,21] there do not appear to be any reports that link this technique to horizontal root fractures.

The position and severity of a fracture, the degree of displacement of the fragments and the position of the x-ray tubehead and film in relation to the fracture line all influence radiographic appearances.[22] These factors could have made the root fracture in the upper right central incisor difficult to identify radiographically. Cone beam computed tomography (CBCT), which has a low effective dose in the same order of magnitude as conventional dental radiographs,[23] may have proved useful in our case; one scan can provide more diagnostic information than several periapical radiographs of the same region.[23] This imaging modality has been used in the detection of a horizontal root fracture,[24] but was unfortunately not available in the teaching hospital at the time the patient presented.

Summary

When carrying out orthodontic treatment for patients who have traumatized incisors, various complications may occur including loss of vitality, root resorption, ankylosis and separation of the fragments of a fractured tooth. Rarely, as in this case, a root fracture may be discovered after treatment has started. Informed consent is therefore of paramount importance when carrying out orthodontic treatment for these patients. Good communication between the patient, orthodontist and GDP is also imperative.[7,10]

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