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An oblique crown-root fracture of the mesial root of molar with vital pulp – a case study

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ABSTRACT

An oblique crown-root fracture was detected incidentally in the cervical middle third of the mesial root of a non-endodontically treated second lower right molar. Because the tooth was asymptomatic, the pulp responded positively to testing and no periapical pathosis was detected, an endodontic treatment was not indicated. Considering the unusual condition of tooth 47, substantial efforts were made to save tooth 46, which had been extensively destroyed by caries. A control cone beam computed tomography (CBCT) acquired 12 months after completion of the endodontic treatment of tooth 46 revealed almost complete resolution of the periapical pathosis in the first right molar, no changes in the fracture line and no periradicular radiolucency in the second right molar. The loss of this tooth could have resulted in post-extraction atrophy of the alveolar bone and loss of support for the fractured root of the adjacent tooth.

Keywords: crown-root fracture; oblique root fracture; cone beam computed tomography; CBCT.

INTRODUCTION

Root fractures of permanent teeth, either horizontal or vertical, occur in 0.5–7% of all trauma cases [1, 2, 3]. Most horizontal root fractures (HRF) occur 11–20 and appear with greater frequency in males; they are most prevalent in maxillary anterior teeth with complete root formation [4, 5]. Usually, HRF are caused by severe traumas incurred during street fights, contact sports or accidental injury [6]. In the posterior teeth, horizontal or oblique root fractures are uncommon [7]. In this group of teeth, especially those treated endodontically, vertical root fractures (VRF) are more likely to occur. Iatrogenic dental procedures, such as the use of extensive force during lateral condensation and restorative procedures after root canal therapy (improper post placement), are the main factors responsible for HRF [7, 8]. In contrast to VRF, HRF are more likely to occur in the posterior teeth of patients between 40–60 years old [9].

The classification of HRF based on the location of the fracture line (cervical third, middle third, or apical third) and the position of the coronal fragment (dislocation or not dislocated). The majority of root fractures occur in the middle-third of the root, and teeth with such fractures do not show signs of displacement or mobility. Fractures in the apical and cervical thirds occur with equal frequency. However, fractures in the cervical area have the poorest prognosis due to the proximity of the fracture to the gingival sulcus and the possibility of microbial contamination [10, 11].

Transverse or VRF require radiographic confirmation [12]. To obtain a clear image of the fracture line, multiple radiographic views from several angles are required. Generally, parallel periapical radiograph, occlusal radiograph and tube shift radiograph are recommended [13]. For the proper diagnosis of a root fracture, cone beam computed tomography (CBCT) scans may be considered [14, 15].

The healing type of root fractures depends on the stage of root development, coronal fragment mobility, dislocation and separation between fragments, time elapsed between trauma and treatment, occlusion, and the general health and age of the patient [4, 14]. Andreasen and Hjorting-Hansen divided the healing of the root fracture into 4 types: healing with calcified tissue, interposition of connective tissue, interposition of bone and connective tissue and interposition of granulation tissue [16, 17, 18].

This case report describes a horizontal/oblique fracture of the mesial root on the vital mandibular left second molar, which was only found by chance on a radiograph that had been taken during the endodontic treatment of an adjacent tooth.

CASE REPORT

A 25-year-old man was referred to the dental clinic for management of asymptomatic tooth 46. The patient's chief complaint was the presence of sharp edges on the tooth. The patient's medical history was noncontributory. The patient's oral hygiene was fair. Intraoral examination revealed extensive carious destruction of the crown on 46. Tooth 46 was not tender to percussion or biting, and there was no evidence of swelling or sinus tract formation in this region. A preclinical radiograph revealed a diffuse radiolucent lesion surrounding the apical portions of the roots of 46 (Fig. 1A). Coincidentally, an oblique radiolucent line involving both the crown and the mesial root of

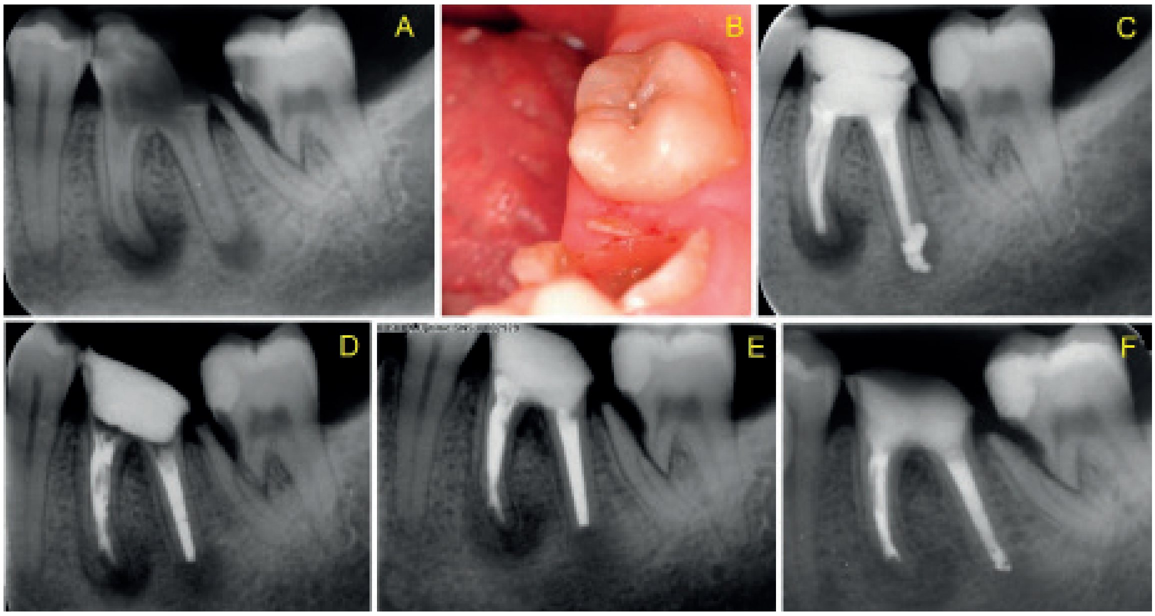

FIGURE 1. (A) A preoperative radiograph revealed a periradicular pathosis in the first right molar, oblique crown-root fracture of the mesial root of the second right molar and a carious lesion on the mesial aspect of 47; (B) Intraoral picture taken just after caries removal and placing composite filling in tooth 47. The crown of 46 extensively destroyed by caries. An apical fractured fragment extruded above the gingiva placed mesially and lingually to the crown of 47; (C) A radiograph taken after the 2nd placement of calcium hydroxide paste. The distal canal overfilled; (D) A 3-month follow-up radiograph shows total resorption of calcium hydroxide paste from periapical tissues. An apical fractured fragment after shortening; (E) A radiograph taken after the completion of root canal treatment; (F) A 12-month follow-up radiograph shows no periradicular radiolucency in the apical region of 46 and mesial root of 47

47 was discovered. It corresponded to an oblique root fracture in the cervical and middle thirds of the mesial root of the non-endodontically treated second lower right molar. The patient was not aware of this fracture and reported no symptoms. The clinical examination revealed that the apically fractured fragment was extruded above the gingiva mesially and lingually to the crown of 47 (Fig. 1B). Moreover, a carious lesion on the proximal surface of 47 was observed. Otherwise, the crown of 47 did not present any discoloration or mobility. The patient did not experience any tenderness to percussion, palpation or biting on the fractured tooth. Clinically, 47 was in contact with a distal part of tooth 16 and a mesial part of tooth 17.

Because of an unusual root fracture, extended pulp vitality testing was performed: thermal, electric and laser Doppler flowmetry (LDF) testing. The pulp sensibility of teeth: 46, 47 and 36, 37 (as control) was tested. Electric sensibility testing was performed by Analytic Technology Pulp Tester (Sybron Endo, Orange, CA). A cold sensitive test was performed in a generally accepted way by cool spray Unigloves R Polar Mint (Arzt-und Klinikbedarf Handelsges mbH, Troisdorf, Germany). The examination determining blood flow in the dental pulp was made using a LDF PeriFlux System 5000 (Perimed, Järfälla--Stockholm, Sweden) and a probe 407. The device emits monochrome light with a wavelength of 780 nm produced by a 1 mW diode laser. The examination was carried out in the patient after an earlier occlusal splint of polyvinylsiloxane mass. Holes were cut out to stabilize the measuring probe in the appropriate place of the examined teeth. The measurements were performed by 1 person in a room at a constant temperature, after the patient had a 20 min rest period in a comfortable, seated position with the maximum isolation possible from external stimuli (elimination of telephones ringing, doors opening, and personnel talks). The recorded flow measurement during each test lasted 2 min. The calmest flow lasting 30 s was selected for analysis. The volume of flow (perfusion) was expressed as the product of the concentration of blood cells and their speed, using the perfusion unit. Results are presented in Table 1.

TABLE 1. **Threshold values of electric excitability of the pulp (E) and pulp response to cold thermal stimulus (T) and laser Doppler flowmetry (LDF) results obtained in subsequent clinical trials**

Tooth No.		47	46	36	37
First visit examination	E	56	–	64	59
	T	(+)	(–)	(+)	(+)
	LDF PU ±SD	8.4 ±1.3	–	4.9 ±2.5	9.3 ±1.7
Examination after 3 months	E	47	–	58	52
	T	(+)	(–)	(+)	(+)
	LDF PU ±SD	7.1 ±1.8	–	5.4 ±1.8	7.5 ±1.6
Examination after 12 months	E	51	–	60	56
	T	(+)	(–)	(+)	(+)
	LDF PU ±SD	8.0 ±1.6	–	4.8 ±1.9	8.9 ±1.9

PU – perfusion unit; SD – standard deviation; – no response at maximum current voltage; (–) – no pulp reaction to cold test, (+) – appropriate response to cold test

Because of the unusual condition of tooth 47, extensive efforts were made to save tooth 46. The loss of this tooth could have resulted in post-extraction atrophy of the alveolar bone and loss of support for the fractured root in the adjacent tooth. The patient was advised of the poor prognosis but decided to proceed with treatment because he desired to retain 47 for as long as possible. The patient was informed of the potential risks of the endodontic treatment of 46 and the uncertainty of saving tooth 47.

Because tooth 47 was asymptomatic, the pulp gave a positive response in testing, and no periapical pathosis was detected, an endodontic treatment was not indicated. On the 1st visit, the caries was completely removed from crown 47 without using local anesthesia. The caries removal was painful for the patient, which confirmed pulp vitality. Filtek Ultimate (3M ESPE) was used for the restoration (Fig. 1B). After root canal cleansing and shaping with the use of Kerr hand files (K-files, VDV, München, Germany) and 2% sodium hypochlorite (Chloraxid, Cerkamed, Poland), 3 canals of tooth 46 were temporarily filled with calcium hydroxide paste (UltraCal XS, Ultradent Products Inc, South Jordan, UT). The access cavity was temporarily sealed with Fuji IX (GC, Tokyo, Japan). To refine the radiological findings, CBCT (Cranex 3D; Soredex, Tulusa, Finland) imaging was performed. The axial, sagittal and coronal images revealed an oblique, wide radiolucent fracture line that was oriented in the sagittal plane and started in the cervical region, with wide separation and displacement of the root fragments and disruption of the root outline (Fig. 2A–P). The fracture had a mesial margin in the gingival third of the crown and coursed obliquely to the exit in the middle of the distal aspect of the mesial root of 47 (Fig. 2O–P). Interestingly, there was no increase in the width of the periodontal ligament space adjacent to the fracture line or apically in either root of 47. Bone loss and bone rarefaction was detected in the area of the fracture line. The level of alveolar bone between the first and second molars was intact. Root resorption and apical pathosis were not detected.

After 7 days, the roots were re-entered for another application of calcium hydroxide paste. The acquired control radiograph revealed overfilling of the distal canal with the calcium hydroxide paste (Fig. 1C). In addition, the extruded root fragment was cut down below the level of the gingiva with the use of a diamond flame bur on an air turbine handpiece. The patient was reviewed at 3 months. At that time, both 46 and 47 were symptom free. On clinical examination, there was no mobility or pain in response to percussion, palpation or biting. The electric and thermal pulp sensibility tests were both positive in tooth 47 and coronal pulp blood flow was maintained (Tab. 1). At that time, the periodontal ligament space was isolated from the oral environment by a healthy mucous membrane. The subsequent control radiograph showed that the extruded calcium hydroxide paste had completely resorbed (Fig. 1D). Moreover, the periradicular pathosis next to the mesial root of 46 had reduced in size. Thus, the decision was made to fill the canals of 46 with a lateral compaction of cold gutta-percha combined with AH plus sealer (Dentsply, DeTrey, Konstanz, Germany). The access cavity was again temporarily sealed with Fuji IX and Filtek Ultimate, and a control radiograph was acquired (Fig. 1E). The patient was reviewed at 12 months after the completion of the endodontic therapy. At that time, both 46 and 47 showed no clinical symptoms. On clinical examination, there was no mobility or pain in response to percussion or biting in either tooth. Tooth 47 showed adequate clinical function. A 12-month follow-up radiograph showed no periradicular radiolucency in either 46 or 47 (Fig. 1F). Furthermore, the vitality of the fractured molar pulp was confirmed by thermal, electric and LDF tests (Tab. 1). The control CBCT showed no changes in the fracture line and no periradicular radiolucency next to the roots of the second right molar (Fig. 3A–P). Moreover, scans showed the almost complete resolution of the periapical pathosis in the apical region of the first right molar. The patient was referred to a prosthodontic specialist to make a crown for tooth 46.

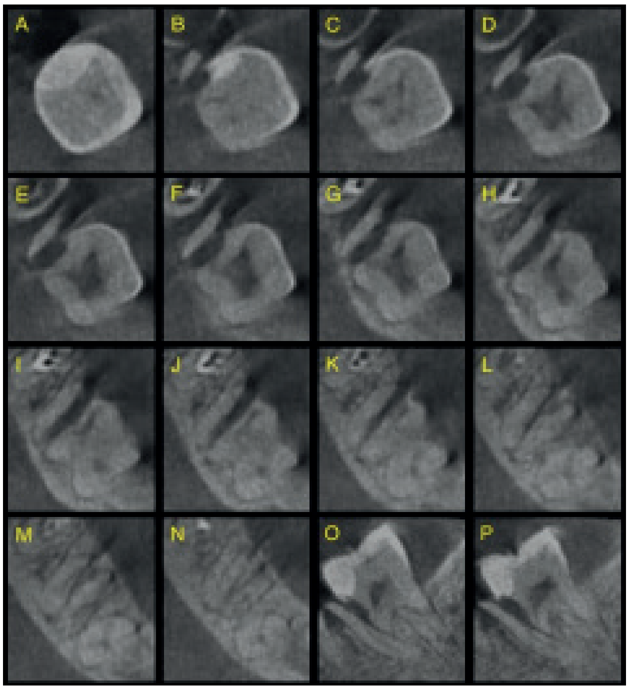

FIGURE 2. A cone beam computed tomography scans of tooth 47 performed 2 days after the 1st visit: (A–N) consecutive axial cone beam computed tomography images; (O–P) selected sagittal cone beam computed tomography images

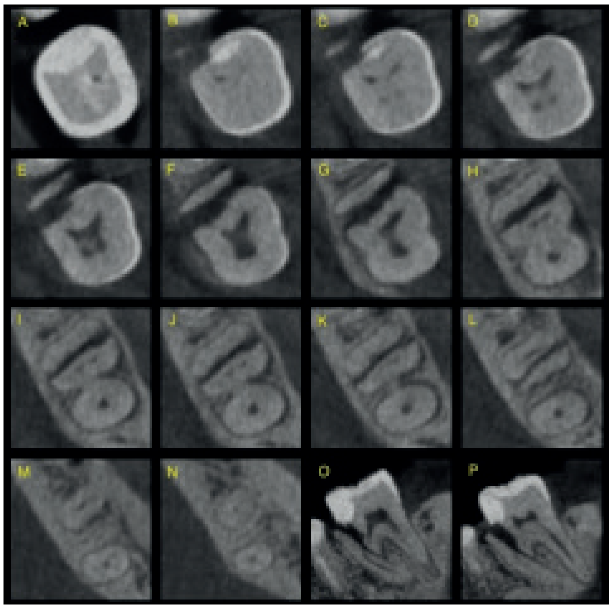

FIGURE 3. A 12-month follow up cone beam computed tomography scans of tooth: (A–N) consecutive axial cone beam computed tomography images; (O–P) selected sagittal cone beam computed tomography images. Apical fractured fragment visibly shorter than on previous cone beam computed tomography sagittal scans

DISCUSSION

Horizontal root fractures in vital, non-endodontically treated posterior teeth are very rare [19, 20]. Jerome detected a horizontal fracture in the mesiobuccal root of a maxillary molar caused by traumatic injury during surgery to the maxillary sinus [21]. Legan et al. reported a case of HRF in an upper second premolar, possibly caused by excessive traumatic force exerted during the cementation of an overcontoured crown on the adjacent first molar [22]. Clarkson et al. reported a case of horizontal fracture of the palatal root of an upper premolar that was likely caused by trauma or by the patient's bruxing habit [20]. All these reports describe horizontal fractures of the roots of the upper teeth [20, 21, 22]. Interestingly, HRF in the lower posterior teeth are unusual. Wang et al. describes HRF in lower premolars: 1 in a first premolar and 4 in second premolars [19]. So far, a HRF of a non-endodontically treated mandibular molar has not been described. However, in some cases, VRF in non-endodontically treated teeth were described. Fractures occurred almost exclusively in posterior teeth (mostly first molars) with no or minimal restorations in Chinese males [23, 24]. The true reason for vertical or HRF in non-endodontically treated posterior teeth is still unknown [19, 23, 24]. Some authors have suggested that clenching habits and the habit of chewing hard foods for a long time (betel nuts, bony meat, smokeless tobacco) are the most reasonable causes of the fractures [23, 25]. The presence of excessive attrition of the occlusal surfaces of the posterior teeth is also significant, which indicates that these teeth have sustained heavy, repeated and prolonged stress [19, 25]. In addition, root fractures may be caused by traumatic occlusion, tooth morphology, root curvature, changes in dentine elasticity, hereditary predilections, and physical trauma [7, 10, 23, 25]. In this case report, occlusal trauma was postulated as the cause of the root fracture.

The 1st step in the treatment of a HRF is a proper diagnosis. The diagnosis of a HRF is typically based on the radiographic demonstration of a fracture line, mobility of the coronal segment of the tooth and vitality testing [10, 26, 27]. The most common method used to detect such a fracture is radiography. This method is popular because of its low cost, convenience and high resolution [26, 27]. Typically, the fracture line is oriented obliquely in the apical- and middle-third of the root and is more horizontally oriented in the cervical third [10, 27]. In this case report, the fracture line was oriented obliquely and ran through the cervical-third and middle-third of the mesial root of the second right lower molar. A fracture line can go unnoticed if the X-ray beam does not pass along the fracture line; thus, it is recommended that 2 additional periapical radiographs (1 with a positive and 1 with a negative 15° angle to the fracture line) be taken [10, 27]. In this study, 1 radiograph was sufficient to visualize the fracture line because adjacent fractured segments were separated by healing tissues. In addition, CBCT was performed to confirm the oblique root fracture.

Clinical examination of root fractures should evaluate sensitivity to percussion, mobility, tooth color and electrical stimulation [28]. In this case, a negative response to both vertical and horizontal percussion was shown. The crown of 47 did not present mobility and did not show any discoloration; additionally, the tooth responded positively to electric and thermal pulp sensibility testing. Furthermore, the vitality of the pulp was confirmed by LDF. This method was developed to measure the pulpal blood flow in intact teeth. Laser Doppler flowmetry is a noninvasive, objective, painless, and easily repeated method that is suitable for clinical use. Only its high cost and time-consuming examination might discourage its routine clinical use in an average dental practice. It should be noted that the use of this method has limitations because LDF probes only detect coronal pulpal blood flow [29]. Based on clinical examinations that confirmed pulp vitality and CBCT scans that excluded any periapical disease, endodontic treatment was not indicated.

Andreasen and Hjorting-Hansen divided the healing of root fracture into 4 types: healing with calcified tissue (30%), healing with interproximal connective tissue (43%), healing with interproximal bone and connective tissue (5%) and interproximal inflammatory tissue without healing (22%) [16]. Any type of healing tissue formed between the fractures, with the exception of interproximal inflammatory tissue, is considered to indicate a successful treatment. Usually, teeth with the first 3 types of healing are asymptomatic and probably respond to electric vitality tests [10, 18]. In this case report, the fragments on the radiograph appeared to be separated by a radiolucent line, and the fracture edges appeared rounded. This indicated that connective tissue was present between segments.

It is common opinion that a tooth with a fracture in the middle or coronal third of the root has a poor prognosis. Zachrisson and Jacobsen showed that the location of the fracture is immaterial if a tooth can be stabilized long enough for repair to occur [30]. The only exceptions are fractures that occur so close to the crest of the alveolar bone that support of the tooth is compromised. In this case report, extensive efforts were made to save tooth 46. The loss of this tooth could have resulted in post-extraction atrophy of the alveolar bone and loss of support for the fractured root in the adjacent tooth.

Long-term follow-up with radiographs and clinical tests is indicated in root fracture cases. An asymptomatic status, positive response to pulp testing, signs of repair between fractured segments and absence of apical periodontitis are the indicators demonstrating a positive prognosis [10]. In this case, all of these features were present on the 1st visit and 12 months after the completion of the endodontic therapy.

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