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Endodontic Treatment of a Tooth with Traumatic Fracture of Root Middle Third

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ABSTRACT

Root fracture occurs in 0.5 to 7% of all dental injuries. Subsequent to this injury, the coronal segment is displaced, while the apical segment is rarely displaced. Emergency treatment involves repositioning of the coronal segment close to the radicular segment as much as possible to enhance the chance of pulp revascularization. If pulp necrosis occurs, the infective products cause an inflammatory response and radiolucency is seen at the fracture line. In the present case, the patient had two maxillary central incisors with horizontal middle third root fractures due to a traumatic accident four years earlier. The right central incisor showed an endodontic abscess due to pulp infection in the coronal segment. The coronal fragment was treated. In this case study all signs and symptoms resolved after treatment and three year follow-up showed a successful treatment outcome. The left central incisor had a vital pulp according to vitality tests, so "observation only" strategy was considered for this tooth.

Keywords: Dental Pulp; Endodontic; Mineral Trioxide Aggregate; Tooth Fracture; Trauma

Introduction

Horizontal root fracture, defined as fracture involving dentin, pulp and cementum, is relatively uncommon among dental injuries. It comprises 0.5 to 7% of all dental injuries [1]. Permanent maxillary incisors are more prone to root fracture, with more common involvement of central incisors (68%) [2]. In teeth with incomplete root development, root fracture is unusual because of alveolar socket elasticity. Thus in younger individuals, the teeth is more susceptible to luxation injuries in comparison to fracture injuries [1].

Pulp necrosis, root canal obliteration, internal and external root resorption, inflammation around the fracture line and periapical inflammation are pathological complications that may occur in horizontally fractured teeth [3].

Injuries like concussion, subluxation, extrusive or lateral luxation may occur in the coronal fragment [4]. The coronal segment is usually displaced to some extent while the apical segment is rarely displaced [3]. Some degree of tooth crown mobility may be seen depending upon the location of root fracture [1]. Horizontal root fractures are mainly divided into three groups based on the site of the fracture namely apical, middle or cervical third fractures. Moreover, the horizontal root fracture can be oblique or transverse, single or multiple and complete or incomplete [5].

Horizontal root fracture diagnosis is based on radiographic and clinical assessments. Clinical evaluations reveal coronal segment displacement or mobility and presence/absence of pain to percussion of the teeth or palpation of the soft tissues. A conventional periapical radiograph along with two additional periapical radiographs with different vertical angulations (one with a positive angulation of 15° and one with a negative angulation of 15° relative to the fracture line) are required to disclose the position of the fracture line accurately [3], also the role of cone-beam computed tomography (CBCT) has been highlighted in recent studies [6, 7]. Achieving a precise diagnosis of the pulp status of traumatized teeth is difficult. Laser doppler flow cytometry in combination with tissue oxygen monitor has great value in the timely and precise reflection of changes in pulp status after dental trauma [8].

Figure 1. Tracing was done by using the periapical radiograph in the first appointment, radiolucency at the fracture line and resorption of the apical part of the coronal segment of tooth #8 can also be seen in this radiograph

Figure 2. Post-surgical radiograph showing the canal was sealed using mineral trioxide aggregate (MTA) and a thin layer of light-cure glass ionomer was placed on the MTA and the access cavity was restored using composite resin

Treatment approaches should be selected with regard to the prognostic considerations *i.e.* degree of displacement of the fragments, patient age, stage of root development, mobility of coronal fragment and diastasis of the fragments [1].

Treatment at the time of the emergency visit consists of repositioning and stabilizing the displaced coronal segment of the tooth to allow the healing of the periodontal ligaments supporting the coronal segment. A two- to four-week semi-rigid splint has been advocated for the root-fractured tooth [9]. Emergency endodontic treatment is not recommended in the absence of clinical and/or pathological signs for the root-fractured tooth; the tooth should first be followed up clinically and radiographically [3].

Pulpal necrosis takes place in about 25% of root-fractured teeth [10]. On the other hand, reversal of the pulp vitality may occur after a few months to two years [11].

Understanding the different healing patterns is essential for a successful treatment plan [10]. Four types of responses to root fracture have been proposed [12]: Healing with calcified tissue formation; two fragments appear in close contact radiographically, healing with interproximal connective tissue formation where the fragments appear separated by a narrow radiolucent line and the fracture edges appear rounded radiographically, healing with interproximal bone and connective tissue formation and the fragments appear separated by a distinct bony ridge radiographically and finally inter proximal inflammatory tissue without healing and the radiographic appearance shows widening of the fracture line or a developed radiolucency corresponding to the fracture line. The fourth type response is considered a failure and takes place when the coronal segment loses pulp vitality and the infected pulp byproducts cause an inflammatory response and radiolucency around the fracture line. Endodontic intervention is required in this situation [10, 12].

Endodontic treatment may include treatment of the apical and coronal segments if both segments show pulp tissue necrosis and the fragments are in close contact; the infected byproducts may leak from the fracture line and lead to treatment failure [13, 14]. In some situations, endodontic treatment of the coronal segment and surgical removal of the necrotic apical fragment is recommended [3].

When pulp vitality of the apical segment is preserved and the coronal pulp is necrotic and infected but this segment has no mobility, the treatment plan may include endodontic treatment of the coronal segment without any manipulation of the apical segment [14, 15].

An intra-radicular splint of the coronal fragment has been recommended in cases of compromised crown/root ratio to improve the tooth stability [13, 16]. When the fracture line is at or near the alveolar crest, extraction of the coronal segment and extrusion of the root segment may be considered [14]. Use of an intra-canal implant in case of coronal segment mobility with or without apical surgery is another recommendation [5]. Extraction of the tooth and subsequent replacement by implant or prosthesis may be the last treatment approach in hopeless cases showing severe mobility [14].

Long-term prognosis of a root-fractured tooth depends on factors such as the amount of fragments' dislocation, stage of root development, the extent of fracture line, the occlusion, the pulp tissue status, the general health of the patient and the probable treatment rendered [1, 14, 17].

Survival rate of the teeth with horizontal root fracture is relatively high (88%) [18] and these teeth have good prognoses if they are treated adequately[19].

Case Report

A 12-year-old girl was referred to an endodontist by a pediatric dentist with a sinus tract in the buccal mucosa adjacent to the right maxillary central incisor. There was a history of trauma to the anterior maxillary region leading to horizontal root fracture of the right and left central incisors four years ago.

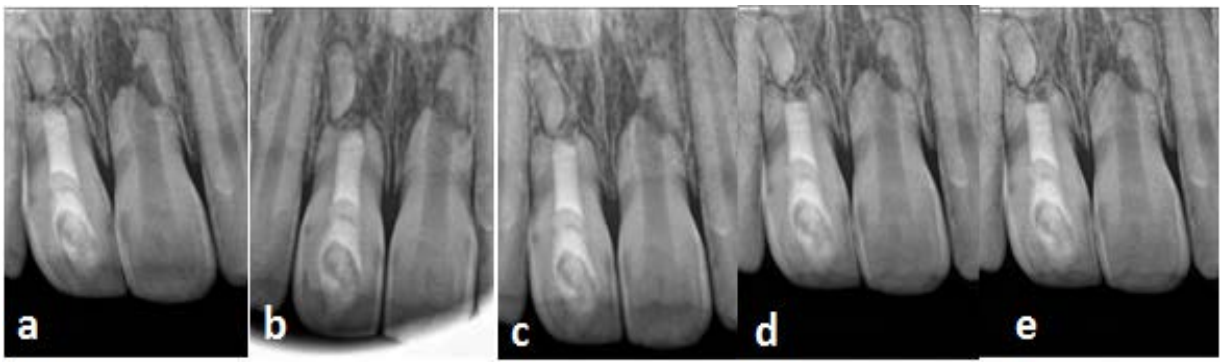

Figure 3. Follow-up radiographs are shown in figures *A* to *E* for 6, 12, 18, 24 and 36 months, respectively, on which we can see complete bone healing, ceasing of the resorbing of the apical part of the coronal segment of tooth #8, and lack of degenerative changes in periapical bone and the structure of tooth #9

Splinting of the anterior tooth had been done two weeks after trauma using #14 stainless steel wire and composite resin for four weeks and the patient had been under follow-up for four years. Clinical and radiographic follow-up assessment done by her pediatric dentist during the four years post trauma revealed that the teeth were vital and there was no radiographic lesion at the fracture line.

The patient's medical history was non-contributory. Clinical examination of the teeth revealed that the tooth #8 had moderate pain on palpation and percussion while tooth #9 had no pain. The gingival sulcus was probed using a periodontal probe. There was no periodontal pocket or gingival recession. But there was mild inflammation of the interdental papilla. Vitality tests showed that tooth #8 did not respond to cold test and electrical pulp tests while the cold test was positive for tooth #9 and it responded to electrical pulp testing.

In radiographic assessment horizontal root fracture was visible in the middle-third of the root of both teeth. Radiolucency at the fracture line and resorption of the apical part of the coronal segment of tooth #8 was also seen. The sinus tract was traced using a #30 gutta-percha. The tracing radiograph showed the tip of the gutta-percha cone extending up to the fracture line (Figure 1). The pulp of the apical fragment of both teeth (#8 and #9) was seen to be completely calcified on the radiograph. Tooth #8 had a mild degree of grey discoloration and class II mobility (within a two-millimeter range). Tooth #9 had no mobility or discoloration.

According to evaluations tooth #8 was necrotic and infected; thus an access cavity was prepared and the estimated working length of coronal fragment was determined using the periapical radiograph (Figure 1). The coronal fragment was debrided and irrigated with 2.5% sodium hypochlorite (Hedinger, Stuttgart, Germany). Calcium hydroxide powder (Sultan, Englewood, NJ, USA) was mixed with distilled water to a creamy consistency and placed into the canal. At the next appointment two weeks later, clinical evaluation revealed that the sinus tract was closed. There was no pus discharge from the sinus tract or any exudation from the canal. The calcium hydroxide was flushed out using 2.5% sodium hypochlorite and the canal was sealed using mineral trioxide aggregate (MTA) (Angelus, Brazil). A thin layer of light-cure glass ionomer (Fuji, GC Corp., Tokyo, Japan) was placed on the MTA and the access cavity was restored using composite resin (Stellite, Japan) (Figure 2).

After one month, the patient revealed no pain on percussion or palpation of the underlying mucosa of tooth #8. Both teeth #8 and #9 were followed up clinically and radiographically for 6, 12, 18, 24 and 36 months. complete bone healing, stop resorbing of the apical part of the coronal segment of tooth #8 and the lack of degenerative changes in periapical bone and the structure of tooth #9 root were seen in the follow up radiographs (Figure 3). Pulp vitality tests were applied on tooth #9 at follow-up appointments and the tooth showed pulp vitality and no pain on percussion or palpation. The patient and her parents were informed about the necessity of accurate annual evaluations to assess the vitality of tooth #9 and the possibility of future endodontic intervention.

Discussion

Horizontal root fracture has the highest chance of pulp vitality preservation when compared to other injures [20]. The risk of pulp necrosis is higher in mature teeth and significant coronal fragment dislocation [21].

In cases of traumatic horizontal root fracture, some authors recommend endodontic intervention when the pulp vitality tests reveal a non-vital pulp after three months [3]; although in evaluation of the healing process of 400 root fractures, Andreasen *et al.* [19] demonstrated that return of vitality of a root-fractured tooth may occur in a period of a few months to two years.

Endodontic intervention is mandatory when discomfort or pain is present or the tooth shows radiolucency next to the fracture line [3, 22-24]. Coronal discoloration is another sign of pulp necrosis [11]. Pulp condition should be determined using pulp sensitivity tests (electrical pulp test or cold test). Negative responses to pulp vitality tests are seen in the first days following trauma and it does not necessarily confirm pulpal necrosis, but may indicate a transient lack of pulp response. Reversal of the vitality of a root-fractured tooth may occur within a few months to two years [9].

In the present case, the patient had trauma to her face when she was eight years old. The left and right central incisors had horizontal root fractures when the roots were not yet matured but the crowns of both teeth were displaced palatally to some extent. The teeth were repositioned and splinted using orthodontic wire and composite resin for two weeks. The pulp vitality tests (cold test and electrical pulp test) had been positive during the three-year follow-up appointments. The patient presented with a sinus tract and abscess due to pulp infection of tooth #8 four years after traumatic accident.

Flores in guidelines for the management of dental injuries mentioned that accurate follow-up appointments are needed to monitor healing and pulpal status for at least one year [15]. But in our case, pulpal necrosis had not occurred during the first three years after the traumatic incident but occurred in the fourth year after trauma.

Well-scheduled follow-ups are critical for traumatized teeth. After the splinting period, periodic evaluation should be done at three months, six months, 12 months and then yearly for five to 10 years [4, 25].

The patient and her parents were informed regarding the necessity of accurate recall appointments for years to assess the vitality of tooth #9 and probable endodontic intervention if needed. Early diagnosis of pulp necrosis is important because root resorption due to pulp infection may jeopardize tooth survival.

Obliteration or calcification of the root canal is a common finding if the pulp of the segments (apical or coronal) remains vital [26, 27]. In the present case, the apical fragments of both teeth #8 and #9 had calcified so we may conclude that the pulp of the apical fragments remained vital after trauma. Surgical removal of the apical fragment is carried out if the apical pulp has become necrotized [3]; as we mentioned earlier, the pulp of both apical fragments remained vital in our case so there was no need to surgically remove these fragments.

Diastasis between fragments has a significant effect on pulpal necrosis [28, 29]. In the present case, diagnostic radiography revealed a gap of about two millimeters between the apical and coronal fragments of the tooth #8. It seems that this finding is to some extent due to the root resorption of the coronal segment. The palatal position of the periapical segment compared to the coronal segment may be another reason for the enhanced diastasis seen between the fragments [30, 31]; we exposed the tracing radiographs at a more vertical angle than the radiographs obtained by the pediatric dentist. Thus, the image of the periapical segment moved in the direction of the movement of the radiographic cone (more apically). Moreover, when we moved the radiographic cone in a less vertical angle at the follow-up appointments, the diastasis between the fragments decreased.

Mineral trioxide aggregate (MTA) is an endodontic material that has shown great properties like high biocompatibility, providing a hydraulic seal by precise adherence to the dentinal walls and cementum formation conductivity [4, 32]. In some situations like root perforations due to over-instrumentation or a tooth with open apices (where there may be extrusion of the filling materials, gutta-percha, root canal sealer or both) fabrication of an apical plug with MTA has been suggested [33]. In most teeth with horizontal root fractures, the pulpal lumen is wide at the apical extent of the coronal segment; thus, MTA can provide a better seal than gutta-percha/sealer [34]. Some clinicians used MTA as a root canal filling material in cases of horizontal root fractures [4, 35, 36]. In our case, MTA was used as an obturating material because there was only three millimeters distance from the radicular pulp space beyond the cemento-enamel junction to the fracture line in addition to a wide lumen diameter at the apical area of the coronal fragment. Acquisition of a perfect seal might be disturbed if we use gutta-percha and sealer for canal obturation [37].

Conclusion

A case of horizontal root fracture was presented. All signs and symptoms resolved after treatment and three-year follow-up showed a successful treatment outcome. Well-ordered follow-ups and in time treatment of pulp necrosis are critical for traumatized teeth such as horizontal root fracture.

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Conflict of Interest: 'None declared'.

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