Case Report. Use of Mineral Trioxide Aggregate in Permanent Incisors With Horizontal Root Fractures: A Five-Year Follow-Up

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Abstract

Incisors are the most frequently involved teeth to suffer dental trauma, with root fractures occurring in 3% of injuries due to dental trauma. Horizontal root fractures mostly affect upper central incisors, mainly in the middle third of the root. Nevertheless, apical and coronal third fractures are also sometimes reported. This case report presents the five-year follow-up of a 16-year-old male who had sustained trauma to his upper right central incisor (11) with a horizontal root fracture in the middle third of the root, and to the right lateral incisor (12) in its cervical third. The upper central incisor was treated with mineral trioxide aggregate (MTA) at the fracture line and the upper lateral incisor was filled with MTA and gutta-percha to achieve an apical seal. MTA allowed healing and prevented the occurrence of clinical symptoms. In conclusion, MTA appeared to be a valid option for the horizontal root fracture and had the added advantage of speed of completion of therapy.

Key Words: Horizontal Root Fracture, Mineral Trioxide Aggregate (MTA)

Introduction

Dental trauma may happen as a result of sport activities, such as a fall from bicycle, or from other causes and can present in many forms, including root fractures. Root fractures are described according to the direction of the fracture lines as horizontal root fractures or vertical root fractures. Incisors are the most frequently involved teeth with relatively few root fractures, which occur in 3% of injuries due to dental trauma. [1]. Horizontal root fractures, mostly affect maxillary central incisors, mainly in the middle third of the root; nevertheless, apical and coronal third fractures are also sometimes reported [2].

The majority of root fractures have been shown to undergo some form of healing [2,3]. It has been reported that 77% of root-fractured teeth healed, with pulp necrosis occurring in 20% [1]. Usually, four types of healing sequelae are given. These are:

1. Repair with calcified tissue, giving union across the fracture.
2. Healing with connective tissue.
3. Healing with calcified tissue and connective tissue.
4. Healing with granulation tissue.

The last mode of healing, with granulation tissue, is a sign of pulp necrosis and an indication that endodontic treatment of the coronal portion of the tooth is required. According to Andreasen and Hjörting-Hansen (1967), necrosis of the pulp usually occurs only in the coronal fragment, while the pulp of the apical fragment remains vital [4]. This finding provided a basis for testing calcium hydroxide in the treatment of non-vital coronal root canal fragments. Such treatment was intended to achieve peri-radicular healing and the formation of hard tissue that closed the fracture line apically and acted as a barrier [4,5].

Basically, four types of conservative endodontic treatment have been described [3,6,7]. They are cleansing and gutta-percha (GP) filling of the root canal of the coronal fragment only, cleansing and filling of the root canal in both fragments, cleansing and GP filling of the root canal of the coronal fragment and surgical removal of the apical fragment, and treatment of the root canal with calcium hydroxide followed by filling with GP. The beneficial result of root canal treatment with calcium

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hydroxide was probably because of its antibacterial effect and its ability to promote the formation of a hard-tissue barrier at the canal's apical opening in the coronal fragment, thereby facilitating adequate filling with GP [5]. If the pulp is no longer vital, the use of an intra-canal calcium hydroxide dressing may provide a hard tissue barrier at the apical end of the coronal part of the fracture. Nevertheless, this procedure demands time, on average seven to eight months, for apical bridge formation and often there is a need for periodic changes of the material [8-10]. It may also further weaken the teeth by the repetition of endodontic procedures during the replacement of the intra-canal dressing [11,12] and the prognosis may be compromised by the placement of a temporary coronal seal [13]. To eliminate the disadvantages of the calcium hydroxide barrier technique, many alternative approaches have been suggested, with the aim of developing a one-step procedure for the completion of the endodontic treatment. However, the results were usually inadequate because of lack of biocompatibility or availability of the materials [14,15].

One of these alternatives, mineral trioxide aggregate (MTA), which was first introduced in 1993, has been advocated for creation of an apical barrier. Grey MTA (Proroot MTA, Dentsply) has been reported to have superior biocompatibility, sealing ability and is less cytotoxic than other materials currently used in pulpal therapy. Current literature supports its efficacy in promoting the overgrowth of cementum and it may facilitate the regeneration of the periodontal ligament because of its alkaline pH of 12.5 and the presence of several mineral oxides in its composition [16]. It sets to a hard consistency about four hours after mixing and insertion, thus allowing early completion of final obturation of the root canal when acting as artificial barrier.

Biocompatibility of MTA has been found to be equal or superior to that of amalgam, intermediate restorative material (IMR) and zinc oxide eugenol (ZOE) [17-19]. In a histologic study of perforation repair using MTA in the canine model, cementum was shown to grow over the MTA with minimal inflammation present, even when the material was extruded beyond the perforation site [20]. To the best of the authors' knowledge, however, there are few case reports on long-term follow-up of successful use of MTA for obtaining an artificial barrier in humans [21,22].

The purpose of this case report is to assess the clinical and radiographic outcome of MTA alone, and MTA combined with gutta-percha acting as a barrier at horizontal root fractures in the middle third of the root and cervical third after a five-year follow-up.

Case Report

In 2005, a 16-year-old male visited Marmara University Dental School's Department of Paediatric Dentistry 20 days after trauma. A panoramic radiograph revealed a horizontal root fracture in the middle third of maxillary right central incisor (11) and cervical third of right lateral incisor (12) *(Figure 1)*. The space between the fractured segments appeared minimal and a widened but an intact periodontal ligament (PDL) was visible surrounding the fracture.

This case report presents a five-year follow-up of teeth after treatment of the fracture lines with MTA. These fracture lines were in the upper right central incisor (11) with a horizontal root fracture in the middle third of the root, and the upper right lateral incisor (12) in its gingival third.

The patient reported a jogging accident, which had occurred 20 days previously. He suffered moderate trauma to the maxillary anterior region. Soft-

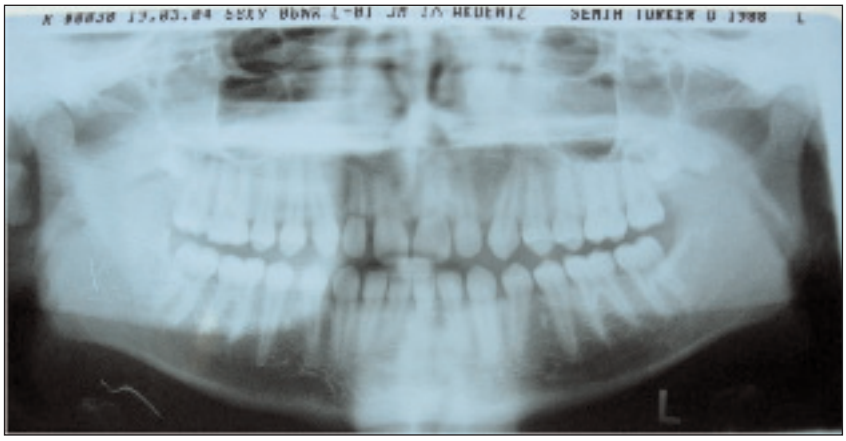

Figure 1. *Panoramic radiograph showing root fractures of the upper right maxillary central and lateral incisors*

Figure 2. *Endodontic treatment of the upper lateral incisor with MTA and GP.*

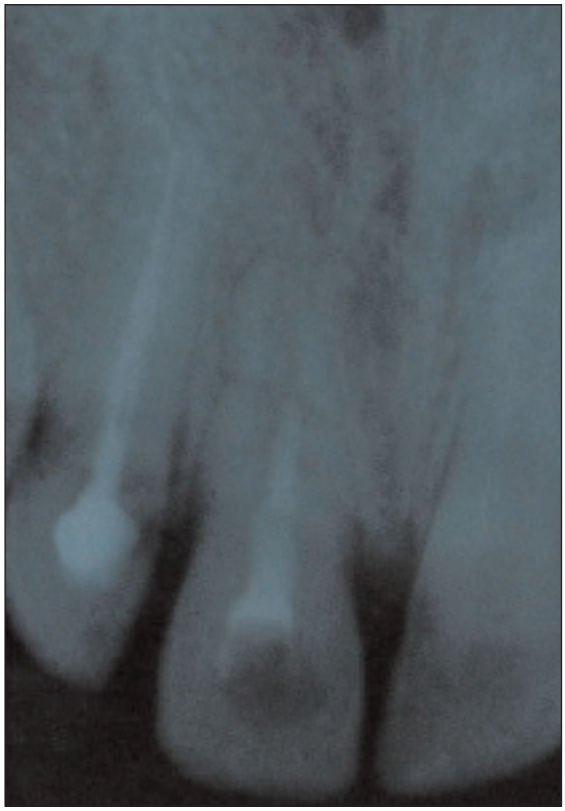

Figure 3. *Endodontic treatment of upper central incisor with MTA.*

tissue examination revealed no signs of scarring or any other evidence indicating previous trauma. Radiographs showed the upper right central incisor (11) with a horizontal root fracture in the middle third of its root, and the upper right lateral incisor (12) with a fracture in its cervical third. There was some sign of pathology visible on the radiograph. The patient complained of some pain or discomfort from the tooth. He had no spontaneous pain and no tenderness but pain on palpation of the soft tissues. The teeth were sensitive to percussion and a vitality test revealed non-vital pulp tissue.

After local anaesthesia, only the coronal fragment of central incisor to the apical mid-fractured site and whole root canal of lateral incisor were cleaned biomechanically and irrigated with a sodium hypochlorite 2.5% (Niclor OGNA) solution. The canals were then dried with paper points. The MTA material (Proroot MTA, Dentsply) was mixed in a 3:1 proportion and was carried with a small amalgam carrier to gingival third of the lateral incisor and whole coronal fragment of the central incisor to the apical fracture site and put in place with fine condensers and adapted gently. To check the correct positioning of the MTA mixture, an intra-oral periapical radiograph 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 DE, USA). After 24 hours, 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 lateral incisor root canal was obturated with gutta-percha and sealed with Endomethasone-N® (Septodont). The final restorations were sealed with composite resin coronally *(Figures 2* and *3*).

The patient attended the all routine follow-up appointments, which were at six-monthly intervals. The symptoms ceased and the results were satisfactory after five years of follow-up.

A radiographic follow-up after five years revealed no periapical pathology, and no internal or external resorption *(Figure 4a)*. The clinical follow-up after five years revealed adequate clinical function and no tenderness of percussion, pain or discomfort since the root canal obturation and no abscess formation *(Figure 4b)*. This case illustrates the potential for repair of horizontal root fracture sealing with MTA.

Discussion

Root fractures heal differently depending on the degree of separation of the fragments, the severity of injury, and the ability of the pulp to heal. If the dental pulp is necrotic, repair does not occur with-

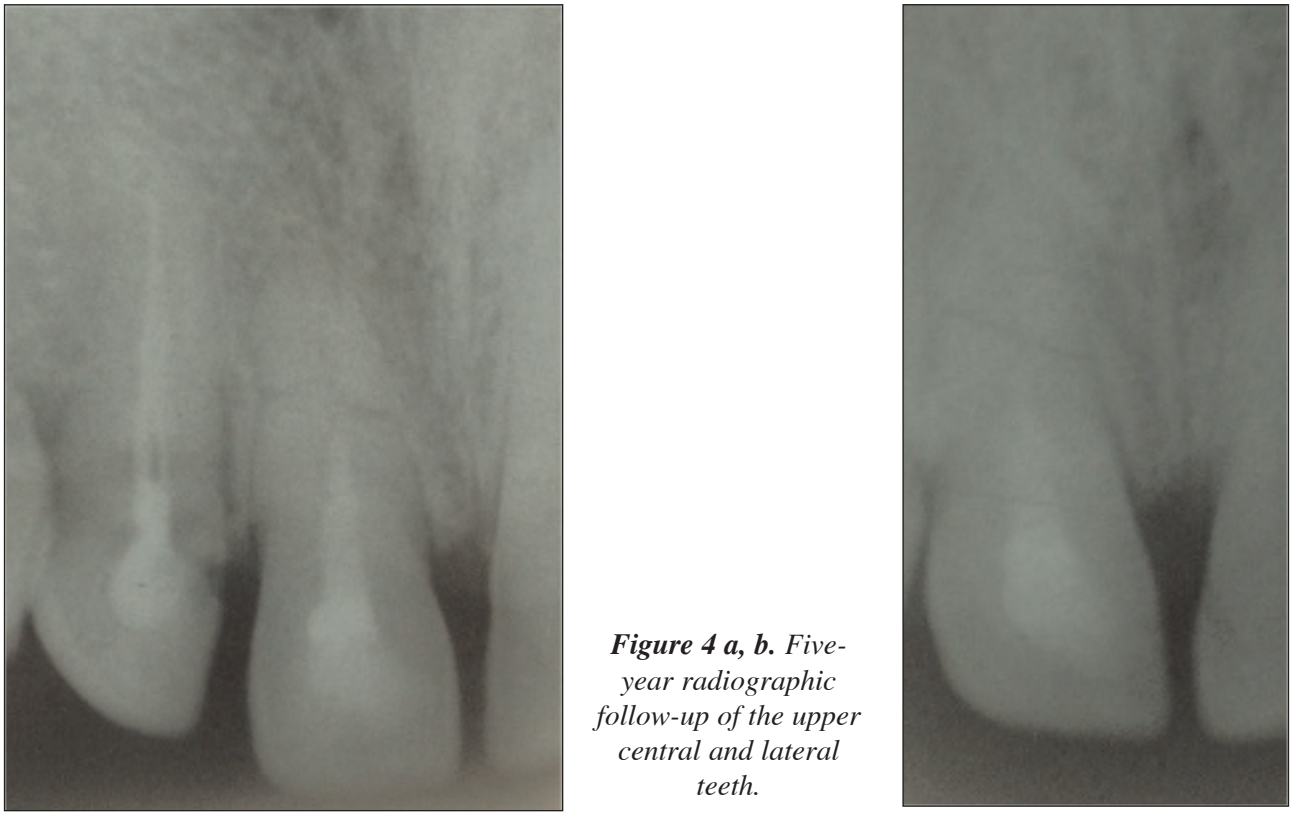

Figure 4 a, b. *Five-year radiographic follow-up of the upper central and lateral teeth.*

out root-canal treatment. A factor with significant influence on the healing process in cases of horizontal fractures is the presence or absence of communication of the fracture line with the oral environment because of contamination from bacteria present in the sulcus [23].

When the pulp-tissue vitality is preserved, the odontoblasts and the cells from the cementum are usually responsible for the healing process [23]. Deposition of calcified tissue occurs, with the possibility of a connection of the root pieces. The ratio of healing by odontoblasts or cementoblasts appears to be dependent on the injuries each tissue has been subjected to and whether or not revascularisation of the pulp takes place. The possibility of spontaneous healing after a root fracture in teeth that maintain pulp vitality is clinically significant [23], and may occur in approximately 70%–80% of intra-alveolar root fracture cases [24]. However, if the pulp injury is severe, healing does not occur and granulation tissue separates the fractured segments, obviously without the hard-tissue healing [23]. In the case reported, pulp vitality tests and the patient's symptoms influenced the decision to perform root canal treatment.

Although formaldehyde-releasing root canal sealers are no longer to be recommended, at the time the current root canal treatment was performed, Endomethasone was used because of its good antibacterial activity [25] without overfilling to avoid its undesirable effects.

Treatment options with root fractures typically include reduction of the fracture and stabilisation by rigid fixation for about 12 weeks as initial treatment [26]. Successful results of such treatments in horizontal fractures have been reported as ranging from 54% to 77% [27,28]. In this case, the patient presented with a horizontal root fracture in the middle third of his upper right central incisor (11) and cervical third of his upper right lateral incisor (12). The pathosis was evident, owing to the development of pulp necrosis. The space between the fractured segments appeared minimal and a widened but intact PDL was visible surrounding the fracture. It was decided not splint the teeth because the fracture was in the apical mid-third with little displacement.

The healing of horizontal root fractures seems to involve hard tissue deposition in and around the fracture site. In recent years, researchers have been investigating materials capable of being applied at the fracture site to create an artificial barrier. Calcium hydroxide (CH) is currently the most widely accepted material for this purpose because it limits bacterial infection and establishes a suitable environment for the induction of calcified tissue

Figure 5 a-b. *Intra-oral view of the patient five years after initial treatment*

[29]. The most important problem with the typical calcified barrier formed with calcium hydroxide is the duration of the therapy, which is from 3-21 months [30]. Also, prolonged exposure of dentine to CH apparently has a weakening effect on the dentine due to the proteolytic capacity of CH, and long duration of the CH artificial barrier technique always requires prolonged patient-motivation, which is another disadvantage [31].

With the MTA technique, a one-step obturation could be performed at the fracture site. The MTA mixture creates an artificial stop to the filling material and prevents the above-mentioned weakening of dentine. This material may be suitable for closing the communication between the root canal and surrounding periodontal tissues. MTA was chosen in order to fill the fragile fractured root with a material with a fast-setting time and excellent biological and physical properties [32,33]. In this case, the MTA mixture was placed in order to prevent the extrusion of the material. It allowed healing and prevented the occurrence of any clinical symptoms. This study's results are similar to those reported in other studies in which MTA appeared to show good sealing ability, a high degree of biocompatibility, and a reasonable setting time [19,34].

MTA appears to be advantageous for repair of perforations and resorptive lesions. Deposition of cementum and establishment of a periodontal ligament is preferable to the formation of fibrous tissue that occurs with other materials. The cementum may form a biological seal that is similar to that of a normal root surface.

Bortoluzzi *et al.* (2007) evaluated the fracture resistance of bovine incisors submitted to different reinforcement treatments with MTA in an experimental model and the results were superior to those obtained with calcium hydroxide due to an increase in the resistance to fracture of weakened bovine teeth in an experimental immature tooth model [35]. Similar findings were found by Hatibovic-Kofman *et al.* (2006) when they compared calcium hydroxide and MTA-filled immature teeth over time and the effects regarding fracture strength [36]. The teeth root-treated with MTA showed the highest fracture resistance at one year, because only MTA induced the expression of TIMP-2 in the dentine matrix and possibly prevented rapid destruction of collagen [36].

Conclusions

Long-term follow-up of patients with injuries is important because pathological changes can occur several years following injury. So far, for the patient described in this case report, MTA appears to have been a valid option for horizontal root fractures, with the added advantage of speed of completion of therapy. However, although promising, further histological investigations are required to confirm favourable outcomes after the use of this technique.

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