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Review Article

Horizontal Root Fractures: A Brief Overview

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Abstract

The aim of this briefing article is to provide an evidential overview of the field of dental horizontal root fractures; how to diagnose horizontal root fractures and manage them appropriately; and to clarify of the prognostic factors that affect the outcome. From an educational perspective, the knowledge and confidence gained from learning the essentials of dental anatomy and trauma are important for any clinician who assesses and manages traumatic dental injuries in emergency situations. This article concludes by highlighting the importance of knowing the prognostic factors and understanding the importance of immediate repositioning and stabilization of the horizontal root fractured teeth to improve the long-term outcome.

Keywords: Dental trauma, Endodontic treatment, Horizontal root fractures, Traumatic dental injury

INTRODUCTION

Dental trauma root fractures involve the dentine, cementum, and pulp, and can also be further classified according to displacement of the coronal fragment [1]. The prevalence of root fractures in permanent teeth is rare, accounting for 7.7 % of injuries [2]. Horizontal root fractures occur mainly in the anterior region of the maxilla [3-5] and more frequently in teeth with complete root formation [6]. The teeth most frequently involved are the maxillary incisors in permanent dentition [2] and injuries occur predominantly in males [3]. Root fractures often result from a horizontal blow [7], usually due to a frontal impact [2]. Although most root fractures involve a single tooth [3], adjacent teeth may also be involved [2]. The fracture location can occur in the cervical, middle, or apical root area [4]. Studies report that most root fractures occur in the middle third [5,9-11], but often they can occur in the apical root area as well [4]. The aim of this briefing paper is to bring together information about how to diagnose a horizontal root fracture case, approaches for managing this type of dental injury, and identifying important prognostic factors that will affect the overall treatment outcome. It is not intended to be a comprehensive review of individual research studies and their findings.

DIAGNOSIS

Following injury, the coronal fragment is usually mobile and sometimes displaced [12]. As most root fractures exhibit coronal fragment displacement, pain may occur during occlusion or mastication [13]. In some cases, root fractures may not be initially clear and can be misdiagnosed as a subluxation or luxation injury [10]. It should be noted that in cases where there is minimal luxation (i.e., concussion, subluxation) of the coronal fragment, the root fracture might not be evident until a later radiographic examination is conducted [12]. To check for horizontal root fracture, it may be necessary to alter the vertical angulation of periapical radiographs or to take an occlusal film [14].

Generally, testing is required to assess the health of the pulp; teeth that give a positive pulpal response have been reported to remain positive throughout the observation perio [8]. This finding suggests that a positive pulpal response at the initial examination is a good prognostic factor [10]. However, a negative response to pulp testing is a common finding immediately after traumatic injuries and is not a reliable indication of necrosis because sensitivity frequently returns [15] although this can vary between one month and a year [2]. Most cases of pulpal necrosis (PN) are diagnosed within a few months of a root fracture, and a persistent negative response to pulp testing is usually confirmed on radiographs by radiolucencies adjacent to the fracture line [16].

When a root fractures horizontally, the coronal segment is displaced to a varying degree [17], and the injury can be considered a luxation injury, with resultant trauma to the periodontal ligament (PDL) and neurovascular supply [4]. The apical fragment rarely becomes necrotic because of the minimal disruption to the apical pulpal circulation [10]. If PN of the coronal fragment occurs, there will be radiographic signs of bone loss at the level of the fracture [14]. Andreasen and Hjørting-Hansen [5] have defined four categories of root fracture healing: 1. Healing by hard tissue union (HT), 2. Healing by interposition of connective tissue (CT), 3. Healing by interposition of bone and connective tissue, and 4. Non-Healing. The following clinical and radiographic signs can be recorded, which

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indicate the type of healing [1]:

- HT: (normal tooth mobility, normal pulpal sensibility, slight discernible fracture line, and intact coronal pulp canal radiographically;
- CT: (increased mobility of the involved tooth, normal pulpal sensibility, markedly discernible fracture line, and obliteration of the coronal pulp canal radiographically;
- GT (granulation tissue): (increased excessive mobility of the involved tooth, sometimes extrusion, negative pulp sensibility, increasing radiographic distance between fragments, and bone resorption at the level of the fracture.

Prognostic factors are variables associated with a subsequent outcome and in horizontal root fracture cases; the following should be considered [10]: 1. Root development (there is a higher frequency of no healing with completed root formation compared to incomplete root formation); 2. Age (increasing age seems to influence the chance of optimal healing negatively); 3. Fracture location (cervical root fractures have a fair chance of healing); 4. Crown fracture (is not related to healing complications); 5. Dislocation (HT healing was significantly more prominent in the non-displaced teeth); 6. Mobility (severe mobility of the coronal fragment appears to have a negative influence on healing); 7. Pulp testing (positive pulpal response at the time of injury was found to be related to both pulp healing and hard tissue repair of the fracture); and 8. Diastasis (healing was progressively worsened with increased diastasis between the fragments).

MANAGEMENT

It is commonly accepted that all injuries should be treated as an emergency for the comfort of the patient and to reduce wound-healing complications [2,8,12]. The primary purpose of treating horizontal root fractures is to maintain the vitality of the teeth [18]. From a multivariate analysis of a clinical study of 400 root fractured teeth [10,18,19], there appears to be no definitive proof of a treatment time relationship to prognosis. Thus, based on the limited knowledge of the effect of treatment delay upon wound healing, the recommended treatment guideline is to manage root fractures within the first 24 hours following trauma [12]. However, treatment delays greater than 24 hours post trauma have been reported not to influence the root fracture healing pattern [10].

If displacement has occurred, the coronal fragment should be repositioned as soon as possible by gentle digital manipulation and the position checked radiographically [16]. To facilitate pulpal and periodontal healing, it is essential that the displaced coronal portion be optimally repositioned, and that splinting be maintained for approximately three to four weeks [8,9-12]. The type of splints does not have a significant influence on the eventual healing, but flexible splinting seems to favor hard tissue healing [20]. The ideal properties of a splint used to stabilize dental injuries should incorporate the following three key areas [21]: physiological healing, clinicians' requirements, and the needs of the patient.

Physiological healing involves stabilizing the traumatized teeth in the correct anatomical position while allowing some physiological mobility of the teeth to promote healing and discourage ankylosis; providing adequate fixation of the teeth throughout the fixation period; and causing no damage to the teeth, gingivae, and soft tissues [21].

Clinicians' requirements include being able to apply a splint directly to the teeth using readily available dental materials and without need for laboratory procedures, the splint should be simple to place and easy to remove; the position of the splint should allow pulp testing of the teeth and access must be available for endodontic treatment, if required; and the splint should be relatively inexpensive [21].

The needs of the patient include ensuring that the splint is comfortable in the mouth and does not damage soft tissues; the occlusion is not interfered with; the appearance is aesthetically acceptable; and that the splint is easy to keep clean [21].

The splinting period may be slightly longer, e.g., two to three months, for cervical root fracture cases presenting with severe mobility [16] compared to root fractures in the middle or apical root region. Following initial management, root fractured teeth should be reviewed at six to eight weeks, six months, one year and yearly for five years following dental trauma [16] but this will depend on the location of the fracture. Comparison between splinting and non-splinting for non-displaced teeth was found to reveal no benefit from splinting [19]. A list of factors that may impact the survival rate when managing horizontal root fracture cases is as follows [19]: 1. Treatment delay (there is no significant relation between the time of treatment after injury and the type of healing); 2. Repositioning (optimal repositioning favored pulp healing of root fractures with dislocation of the coronal fragment of up to 1mm); 3. Length of splinting (no significant relationship to the length of the splinting period was found for healing of teeth splinted for two months or less, and for longer splinting periods); 4. Antibiotics (a slight negative effect on the frequency of 'no healing' and a positive effect on 'HT healing' were evident, but these findings were not significant); and 5. Splinting (for non-displaced teeth, splinting did not appear to have any positive effect on HT healing or PN).

FOLLOW-UP APPOINTMENTS

Radiographic examination and sensitivity testing should be carried out at three weeks, six weeks, and six months after the injury [8]. The American Association of Endodontists recommends regular review to observe radiographic evidence of continued/complete root formation in immature teeth and root fracture repair

(calcific, fibrous/fibrotic or bony) [12]. Radiographic findings may be divided into the following categories [4]: 1. Normal healing (union with HT or CT), 2. Resorption within the root canal, 3. Resorption within the bone, and 4. Pulp canal obliteration (PCO). PCO is a common sequel of horizontal root fracture [16] and Caliskan et al.[7] observed approximately 75% of root fractured teeth had PCO in pulp spaces. Two distinct patterns of PCO have been observed [7]: 1. Partial obliteration in the apical fragments and the fracture area and 2. Progressive obliteration of the entire pulp cavity ending with almost total obliteration. In none of the healed cases was calcification associated with pain [7] and pulp necrosis did not develop as a sequel to progressive obliteration [4]. The apical fragment of root fractured teeth almost always contains vital pulp tissue [15], as confirmed by the radiographic findings of PCO of the pulp canal in almost all cases [4]. However, in the event of a negative vital response, pulpal necrosis is recognized from radiographic changes in the fracture area and/or from coronal discoloration, and most cases are evident within a few months of root fracture injuries [15].

Another finding seen in horizontal root fractured teeth is the display of transient external resorption around the fracture line, which occurs one to two months after the dental trauma and appears to be self-limiting [23]. The resorptive process was found in approximately 60% of 95 root fractured permanent incisors [22]. The resorption represents the healing response to a localized injury in the PDL, affecting the cells next to the root surface [16]. However, another type of resorption, external inflammatory root resorption was also observed in all teeth with pulp necrosis, but endodontic treatment reversed it in all cases [22]. A small percentage of apical third root fractured teeth displayed replacement resorption in their apical fragments, but the resorption was not serious enough to extract the tooth [23].

After assessing the clinical and radiographic information, the options for dental trauma management are[16] either to continue evaluation (when a positive response to pulp testing is evident and there are signs of repair of fractured segments), or to start endodontic therapy (when a negative response to pulp testing and evidence of a radiolucency adjacent to fracture line are confirmed).

LOCATION OF THE HORIZONTAL ROOT FRACTURE

A) Cervical Root Fracture

Root fractures at the cervical margin are considered to have a very poor prognosis [24]. Therefore, a preferable treatment is usually thought to be the removal of the coronal fragment and subsequent orthodontic, crown lengthening or surgical extrusion of the remaining apical fragment [25]. Extraction of the tooth should also be considered. There are two types of cervical root fracture [26]: transverse fracture (restricted to the cervical third of the root), and oblique fracture (involving both the cervical and middle third parts of the root). The pattern and frequency of healing remain the same, regardless of the location of the root fracture in relation to the gingival crevice. However, the long-term prognosis for teeth with oblique fracture was found to be significantly better than for teeth with transverse fracture.

B) Middle and Apical Root Fracture

In most cases, the pulpal lumen is wide at the apical extent of the coronal fragment, so long-term calcium hydroxide treatment is indicated [16]. Mineral trioxide aggregate (MTA) can also be used to create a physical barrier at the fracture site [8]. Care must be taken to never advance an endodontic instrument through the fracture site [12]. Cvek [27] showed root filling only the coronal fragment could be a successful procedure with a reported 86% frequency of healing. Healing is considered having occurred when the radiograph shows a periodontal space or normal width surrounded by a periradicular lamina dura. When the apical fragment shows signs of necrosis, extirpate and obturate the coronal fragment, followed by periapical surgery, to remove the apical fragment [8].

Prognosis

Any dental trauma to the permanent dentition may pose long-term problems for a patient's dental health and personal well-being [28]. It appears that GT could be diagnosed after approximately three weeks, while HT and CT could be diagnosed approximately six weeks after trauma [9]. In a retrospective study [10] comprising 400 root fractured incisors treated in the period between 1959-1995, the clinical and radiographic findings show that: 1. 30% were healed by hard tissue fusion of the fragments; 2. 5% had interposition of PDL and bone between the fragments; 3. 43% had interposition of PDL alone; and 4. 22% were non-healing, with PN and inflammatory changes between the fragments. Thus, the overall healing rate of 78% (HT, HT+CT, and CT) demonstrates that root fractures have a reasonably good prognosis [19].

Although the prognosis for managing horizontal root factures looks promising, with only a few new dental traumatic injuries occurring annually, dentists [28] and medical doctors [29] may not be competent in providing appropriate emergency care, and this will affect the standard of treatment care provided to dental trauma victims.

The learning points from this brief overview are: 1. Dentists would benefit from knowing how to diagnose and manage horizontal root fractures. 2. Dentists play an important role in repositioning a displaced root fractured tooth. 3. Dentists should practice the concept of immediate stabilization in their management plan because this will affect the long-term prognosis. 4. Dentists who are competent in managing horizontal root fracture procedures in dental trauma can provide a higher standard of treatment care.

CONCLUSION

The principles of treating permanent teeth with horizontal root fractures include repositioning and stabilization for a sufficient period to ensure unification of the root

fragments with hard tissue. The most significant factors determining healing events appear to be the stage of the root development at the time of injury and the extent of initial displacement (luxation) of the coronal fragment. The complications likely to develop following horizontal root fractures can be diagnosed by periodic clinical and radiographic examination of the patient. Since the initial trauma management directly impacts tooth retention in the long-term, the immediate actions of dentists or medical doctors may greatly affect outcomes for the patient presenting with horizontal root fractures.

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