



## Case report

# Two horizontal root fractures of a permanent central incisor tooth: A case report

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## ABSTRACT

Traditionally, teeth with horizontal root fractures resulting in pulp infections have been managed with conventional root canal therapy; however, this technique is associated with a limited success rate. This study presents an unusual case of multiple horizontal root fractures of the maxillary central incisor caused by a traumatic injury. The preservation of vital dental pulp is advantageous for healing root fractures. Therefore, we performed a pulpotomy to maintain vitality of the root pulp. The tooth exhibited no clinical symptoms and regained its normal color. In cases of traumatic root fractures, prompt treatment is important once pulpitis is confirmed. Pulpotomy is highly recommended as this procedure preserves the remaining vital root pulp, thereby enhancing the potential for improved healing. The purpose of this study was to emphasize the difficulty associated with diagnosing multiple root fractures and the value of preserving the biological tissue.

## 1. Introduction

The prognosis of traumatized teeth largely depends on the fate of the pulp and its treatment [1]. The vital pulp performs crucial functionality throughout the lifespan of the teeth, including nutrition, defensive responses, the transmission of sensation and the development of the dentin [2-3]. However, dental trauma has the potential to exert adverse effects on the health of the pulp, thus leading to conditions such as pulpitis and permanent necrosis. Sustaining the vitality of the dental pulp plays a crucial role in facilitating the recovery of teeth following root fractures. Histopathological evidence suggests that pulp tissue typically remains non-inflamed within a few millimeters of the inflamed pulp tissue [4,5]. Pulpotomy is a minimally invasive technique, which involves the removal of inflamed pulp tissue and the subsequent coverage of the remaining healthy pulp with biocompatible materials. The preservation of normal functionality in the remaining pulp tissue can be achieved by controlling the scope of pulp infection, thereby promoting the healing of root fractures.

The efficacy of root canal treatment is uncertain when pulpitis is accompanied by two root fractures. Therefore, pulp preservation is even more crucial with multiple root fractures. This case was treated successfully by pulpotomy to maintain the vitality of the pulp and promote root fractures healing.

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## 2. Case presentation

### 2.1. The first visit (3h post-trauma)

A 34-year-old male patient presented to the Hospital of Stomatology having suffered an injury to his maxillary anterior teeth 3 h previously. The patient complained that the traumatized teeth were loose. There were no symptoms of dizziness or loss of consciousness following the trauma. Clinical examination revealed that the left maxillary central incisor was slightly displaced in the coronal direction and exhibited grade I mobility. The tooth demonstrated sensitivity to percussion in both horizontal and vertical orientations. Electrical pulp and cold tests revealed a positive response in the left maxillary central incisor. Examination of the left maxillary lateral incisor revealed moderate pain on percussion, and the fragment exhibited slight displacement with grade II mobility. The left maxillary lateral incisor was sensitive to both electric pulp testing and cold testing.

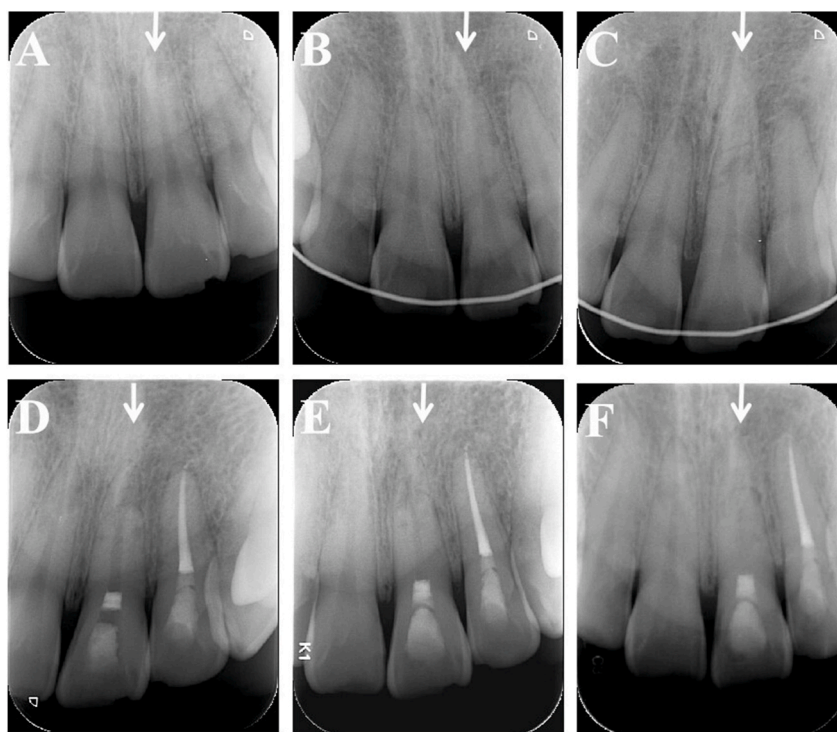
A preoperative radiograph revealed an unclear fracture line with adjacent bone loss in the left maxillary central incisor, which raised the suspicion of a root fracture (Fig. 1A). Next, cone-beam computed tomography (CBCT) imaging was conducted for further evaluation; this revealed two transverse fractures in the apical third of the left maxillary central incisor (Fig. 2A).

This study was approved by the ethics committee of our hospital (No: 2019. 39), and the patient signed an informed consent form before treatment.

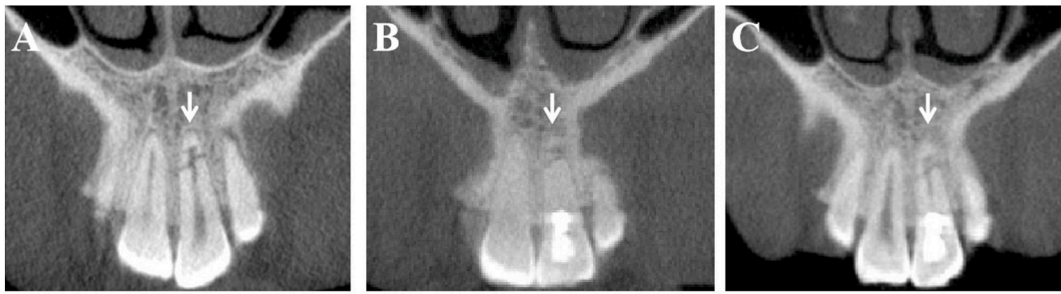
The initial treatment plan involved repositioning and stabilization of the upper anterior teeth using a flexible splint for a duration of four weeks. Following the administration of local anesthesia, the left maxillary central incisor was gently repositioned by finger pressure and splinted. The specific treatment involved the placement of a periodontal flexible splint that was fixated with light-cured composite resin to the labial surface of the left maxillary canine to the right maxillary canine. Following fixation, there were no movement of the coronal fragment. Radiographic evaluation revealed faint but identifiable fracture lines in the left maxillary central incisor (Fig. 1B).

### 2.2. The second visit (6 weeks post-trauma)

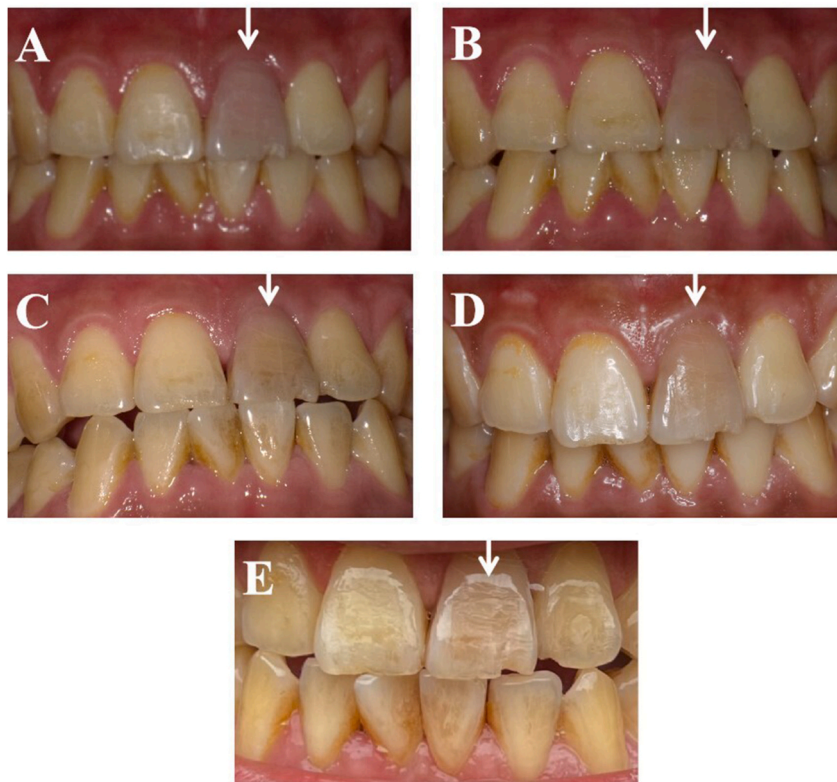
The patient failed to attend the initial follow-up visit after 4 weeks and instead presented with severe pain to touch and bite in the left maxillary central incisor during an emergency visit 6 weeks later. Clinical examination revealed the presence of obvious discoloration of the left maxillary central incisor (Fig. 3A). The patient also exhibited persistent pain to cold testing. The gingival color was normal and the tooth had normal mobility. The 6-week follow-up radiograph revealed two distinct root fracture lines of the left maxillary central incisor, and apical lesions of the left maxillary lateral incisor (Fig. 1C).



**Fig. 1.** Radiographs showing the progression of treatment and follow-up for the left maxillary central incisor (white arrow): (A) prior to treatment; (B) after flexible splint fixation; (C) after a six-week follow-up period; (D) following pulpotomy; (E) after a three-month follow-up period; (F) after a three-year follow-up period.



**Fig. 2.** CBCT scans of the left maxillary central incisor (white arrow): (A) 3 h after trauma; (B) one year after trauma; (C) two-years after trauma.



**Fig. 3.** Clinical photographs specifically focusing on the left maxillary central incisor (white arrow). These photographs illustrate the progression of the tooth color: (A) the discoloration observed six weeks post-trauma; (B) the discoloration showed no significant improvement after three months; (C) the discoloration showed slight improvement after one year; (D) the discoloration had obvious improvement after two years. (E) the color was similar to the control tooth after three years.

Owing to the development of symptomatic acute pulpitis in the left maxillary central incisor, we deemed it necessary to access the pulp chamber of the tooth after local anesthesia administration. Subsequently, the treatment modality was selected based on specific assessment of the pulp condition. Informed consent was obtained from the patient prior to treatment. When the duration of the splint fixation had expired, the splint was removed and a rubber dam was applied. Following the removal of the roof of the pulp chamber, an Er:YAG laser (Fotona, Germany) was used to amputate the infected pulp. Then the pulp state was observed under a microscope. Haemostasis of pulpal bleeding was achieved within 5 min using cotton pellets soaked in a 2 % sodium hypochlorite solution. Consequently, we performed pulpotomy to preserve the viable pulp. IRoot BP (Innovative Bio Ceramix, Canada) was placed on the blood clots. The tooth was restored using glass ionomer cement (Fuji IX, GC, Tokyo, Japan). A radiograph was taken to verify the location of the coronal seal of the left maxillary central incisor after pulpotomy, root canal treatment was performed on the left maxillary lateral incisor (Fig. 1D).

### 2.3. Follow-up

At the 3-month follow-up, the patient did not report any clinical symptoms of the left maxillary central incisor. Clinical examination revealed no tenderness to palpation of the soft tissues or pain to percussion. There was no significant improvement in tooth discoloration from the clinical images (Fig. 3B). The tooth responded negatively to electric pulp and cold tests. Radiograph examination revealed no periapical lesions. It still showed two obvious root fracture lines (Fig. 1E). Subsequently, the left maxillary central incisor was restored using composite resin (3M, USA).

At the 1-year follow-up, the patient was asymptomatic. Clinical examination revealed there was no mobility or pain to percussion and palpation. The tooth discoloration had slightly improved and looked less gray (Fig. 3C). It showed positive responses to the electric pulp and cold tests. CBCT revealed the healing with calcified tissue in the fracture lines. There was no periapical pathology in the tooth (Fig. 2B).

At the 2-year follow-up, the tooth was asymptomatic. The clinical photograph revealed obvious improvement in traumatized tooth discoloration (Fig. 3D). The tooth responded positively to electric pulp and cold tests, and no symptomatic responses to percussion and palpation. CBCT acquired around the periphery of the roots of the left maxillary central incisor indicated the presence of a healthy periodontal ligament and observable hard-tissue healing of the fracture at the tip of the root (Fig. 2C).

At the 3-year follow-up, the left maxillary central incisor was asymptomatic and functional. The clinical examination showed the color of this tooth was similar to the normal control tooth (right maxillary central incisor) and the gingiva showed no inflammation or fistulae (Fig. 3E). The tooth gave positively to electric pulp and cold tests. There was no mobility and no symptomatic responses to percussion or palpation. Radiography showed no radiolucent line between fragments at the apical root fracture of the left maxillary central incisor, suggesting that the fracture had healed with the interposition of hard tissue. There was a radiolucent line between fragments of the middle third root fracture, but the fracture line healed with connective tissue (Fig. 1F).

### 3. Discussion

Root fractures account for approximately 0.5–7% of all traumatic injuries to the permanent dentition [6]. The incidence of dual root fractures is reported only rarely and can be difficult to diagnose. In this particular case, the first X-ray did not reveal any obvious fractures. Periapical radiography may not always detect fractures, especially when a fracture is parallel to the X-ray beam. Multiple angles and bite pieces may be required for accurate detection. Moreover, the use of CBCT allows for accurate visualization of fracture details without affecting nearby structures, thus facilitating the diagnosis of root fracture [7,8]. However, the under-utilization of CBCT in clinical practice can lead to diagnostic mistakes. Based on published dental traumatology guidelines [9], the recommended emergency intervention for a horizontal root fracture involves the prompt repositioning of the affected area, the application of a splint for a duration of at least four weeks, and close monitoring of the healing progress around the fracture line.

Previous research showed that 20–44 % of cases involving horizontal root fractures with necrotic pulp require root canal treatment [10]. The apical fragment pulp remains vital in most cases, while the pulp tissue on the coronal segment can develop necrosis [11,12]. Consequently, endodontic treatment is typically only performed on the coronal segment by filling with gutta-percha or placing a bioceramic material as an apical barrier technique [12,13]. The primary limitations of this technique include the extrusion of filling material from the root canal, the need for numerous scheduled appointments and the vulnerability of treated canals to reinfection. Pulpotomy has been demonstrated as an effective treatment option for mature permanent teeth diagnosed as irreversible pulpitis, with success rates exceeding 90 % [14–16]. Based on the available evidence, it is obvious that state of the pulp can significantly impact the outcomes of pulpotomy. In our case, pulpotomy was considered because the root pulp was in good condition according to the color, bleeding amount, bleeding time and hemostasis time when examined by microscope. This approach helps to prevent the filling material out of the root canal and minimizes the risk of root infections. Furthermore, pulpotomy offers several advantages in terms of efficiency, technical simplicity, and cost-effectiveness [17–19].

Pulp exposures secondary to traumatic dental injuries of an immature permanent tooth are amenable to conservative pulp therapies, which aim to maintain the pulp and allow for continued root development. Therefore, pulpotomy in traumatic dental injuries should mainly be used for cases of crown fractures and complicated crown-root fractures of pulp exposures with immature teeth, but can also be used on mature teeth [20]. The treatment for mature root fractures associated with pulp necrosis is root canal treatment. Pulpotomy and regenerative endodontic treatment can be considered if pulp infection occurs in immature root fractures. However, there has been no documented case of pulpotomy being employed for the management of multiple horizontal root fractures of mature teeth. Our case presented us with an opportunity to investigate the feasibility of using pulpotomy for the treatment of mature teeth with two root fractures.

Many factors may influence the efficacy of pulpotomy, including the inflammatory status of the pulp before treatment, the capping material and restorative status; other factors are less important including patient age, gender, and tooth type [21]. Assessment of the severity and extent of pulpitis holds significant importance in terms of the efficacy of pulpotomy. Nevertheless, the pulpitis status cannot be precisely established from symptoms or thermal and electric pulp testing alone, as these methods lack a quantitative approach and rely on subjective perceptions provided by the patient. Experts collectively agreed that the evaluation of pulpitis should be based on the quantity and duration of pulpal bleeding observed during the surgical procedure itself [22]. In this case, our patient expressed a strong desire to maintain the health of the pulp. It was determined that the decision between pulpotomy or pulpectomy would need to be made during the surgical procedure. According to the consensus of an expert committee, preservation of pulp tissue can be achieved if hemorrhage is effectively managed within a 5-min timeframe using chlorhexidine (0.2%–2%) or sodium hypochlorite (0.5%–5%) [20]. In our specific case, a 2 % solution of sodium hypochlorite was utilized; this successfully controlled pulpal

bleeding within the designated 5-min period. In addition, to prevent the introduction of new infections, it is imperative that this form of surgery is conducted in an aseptic manner with the use of a rubber dam, laser and the capping material of iRoot BP.

A previous study suggested that most discolorations occur shortly after injury can be reversible within 4–8 weeks [4]. The occurrence of crown color changes shortly after trauma can be attributed to intra-pulpal hemorrhage and the accumulation of metabolites [23,24]. The discoloration in our case occurred in the week 6 and returned to normal after 3 years, possibly due to the prolonged recovery time of the pulp after pulpotomy. In contrast to root canal treatment, pulpotomy preserves a certain portion of the vital pulp, thus allowing for the removal of metabolites present in the dentinal tubules and the pulp chamber *via* the action of macrophages and newly formed vascular tissue [4]. Andreassen et al. proposed a classification system for root fracture healing that included hard tissue healing, connective tissue healing, bone and connective tissue healing, and infectious or non-healing [25,26]. Pulp healing can facilitate the healing of fractures; a previous study reported the connective tissue healing of multiple horizontal root fractures following regenerative endodontic procedures [27]. In our case, the apical root fracture of the traumatic tooth showed hard tissue healing, which is the most favorable healing outcome [9]. The healing process of the other root fracture involved the formation of connective tissue, thus resulting in its obliteration.

Further clinical studies are now needed to confirm the treatment results arising from the use of pulpotomy to treat horizontal root fractures. The follow-up period was three years in our case; it was imperative to maintain the continuation of follow-up appointments so that we could assess the long-term healing of the pulp and fractures. Our patient expressed a high level of satisfaction with treatment efficacy and confirmed his commitment to timely follow-up in the subsequent stages.

#### 4. Conclusion

Pulpotomy is being increasingly used in the treatment of mature teeth with irreversible pulpitis. In this case report, we describe the successful healing of root fractures with irreversible pulpitis by pulpotomy. For root fractures with irreversible pulpitis, pulpotomy can be attempted as long as there is viable pulp in root canal. Further clinical studies with larger sample sizes are now required to validate our recommendation.

#### CRedit authorship contribution statement

**Guoying Lu:** Writing – review & editing, Writing – original draft, Data curation, Conceptualization. **Xiuqing Wang:** Writing – review & editing, Writing – original draft, Data curation. **Jia Hu:** Writing – original draft, Data curation. **Yuemin Chen:** Writing – original draft. **Xiaojing Huang:** Writing – review & editing, Writing – original draft, Conceptualization.

#### Ethics and consent statement

This study was reviewed and approved by the Ethics Committee at School and Hospital of Stomatology, Fujian Medical University with the approval number: [2019–32], dated [2019]. All patients provided written informed consent to participate in the study and for their data to be published.

#### Data availability statement

Data associated with this study has not been deposited into a publicly available repository. Due to the nature of this case report, the participant of this article does not agree for their data to be shared publicly. Therefore, supporting data is not available.

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#### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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