CASE REPORT

Vital pulp therapy as a minimally invasive approach for root fracture in a mature maxillary central incisor: a case report

ABSTRACT

Aim *To describe the management of a horizontal root fracture in a mature maxillary central incisor with pulpal complications using vital pulp therapy as a conservative approach aimed at preserving pulp sensibility.*

Summary *A 22-year-old patient presented with a horizontal root fracture and symptomatic pulpitis of a mature maxillary central incisor following dental trauma. Initial emergency management included repositioning of the coronal fragment and stabilization with a flexible splint. As symptoms worsened, a full coronal pulpotomy was performed to remove the inflamed coronal pulp tissue, and a bioceramic material was placed over the remaining radicular pulp. During the three-year follow-up period, the tooth remained asymptomatic. Radiographic findings were consistent with a favorable healing pattern at the fracture site, indicating successful preservation of pulp sensibility and favorable tissue repair.*

Key learning points:

- *Pulpotomy may represent a conservative treatment option for selected mature teeth with horizontal root fractures and pulpal complications.*
- *Vital pulp therapy may allow preservation of the radicular pulp as an alternative to conventional root canal treatment of the coronal fragment.*
- *Preservation of vital radicular pulp tissue may be associated with favorable healing patterns in horizontal root fractures.*

Jessica Giannatiempo
Federica Romano
Elio Berutti

Department of Surgical Sciences, Dental School, University of Turin, Turin, Italy

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Corresponding Authors*
Jessica Giannatiempo, Department of Surgical Sciences, Dental School, University of Turin, Turin, Italy. Lecturer, University of Turin, Italy.
| jessica.giannatiempo@gmail.com |

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Introduction

The prognosis of traumatized permanent teeth depends largely on pulp vitality and the quality of subsequent treatment (1). The dental pulp provides nutrition, immune defense, sensory function and continuous dentin formation throughout the tooth's lifespan (2). Traumatic injuries can compromise pulp integrity, leading to pulpitis or necrosis and, ultimately, tooth loss if inadequately managed. Endodontic management plays a crucial role in the long-term prognosis of traumatized permanent teeth.

Horizontal root fractures are relatively uncommon but clinically significant injuries (3). Their prognosis depends on fracture location (apical, middle, or coronal third; subcrestal vs supracrestal), the degree of fragment displacement, and patient-related factors such as age (4). In many cases, the apical fragment remains vital, whereas the coronal segment may develop necrosis.

Conventional treatment typically involves root canal treatment (RCT) of the coronal fragment usually with gutta-percha or a bioceramic material as an apical barrier (5). However, preservation of pulp vitality may play a critical role in the biological healing of root fractures.

Pulpotomy is a vital pulp therapy that removes only the inflamed coronal pulp tissue, while preserving the remaining radicular pulp under a biocompatible capping material. Traditionally indicated for immature permanent teeth to allow continued root development, recent evidence supports pulpotomy as a definitive treatment for irreversible pulpitis in mature permanent teeth. When appropriate case selection and strict aseptic techniques are employed, reported success rates exceed 90% (6). However, the use of pulpotomy in mature teeth with horizontal root fractures has rarely been described in the literature (7).

This report describes the management of a mature maxillary central incisor with a horizontal root fracture and symptomatic pulpitis, treated with pulpotomy, resulting in favorable clinical and radiographic outcomes over a 3-year follow-up.

This case report was prepared in accordance with the PRICE guidelines, and the corresponding PRICE checklist was completed (8).

Report

A healthy 22-year-old male patient with a non-contributory medical history sustained oro-facial trauma to the upper anterior region, involving the maxillary incisors. Extraoral clinical examination revealed a laceration involving the upper and lower left lip associated with painful swelling (Figure 1A). Intraorally, tooth 22 showed grade 2 mobility and tooth 21 extrusive coronal displacement and grade 3 mobility (Figure 1B, C). Thermal and electric pulp tests were negative for both teeth. Transillumination revealed no enamel infractions. No relevant findings were detected for the other teeth in the second sextant.







Figure 1
Initial clinical presentation **(A)** Initial clinical appearance following trauma showing soft tissue injuries of the upper lip. **(B)** Frontal view demonstrating extrusive displacement of tooth 21 associated with soft tissue injuries of the surrounding oral mucosa. **(C)** Occlusal view of the area.

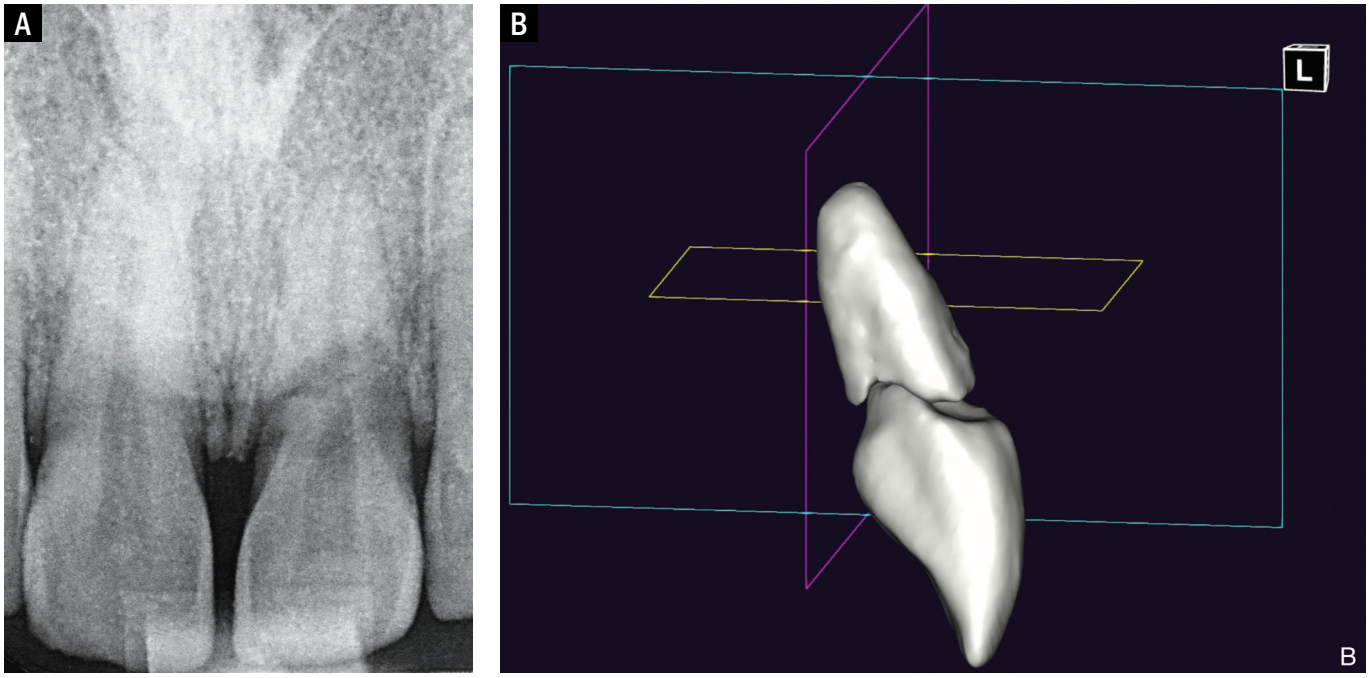


Figure 2
Radiologic assessment of the root fracture **(A)** Periapical radiograph of tooth 21. **(B)** Three-dimensional CBCT reconstruction showing a horizontal root fracture of tooth 21, with approximately 2 mm separation between the coronal and apical fragments.

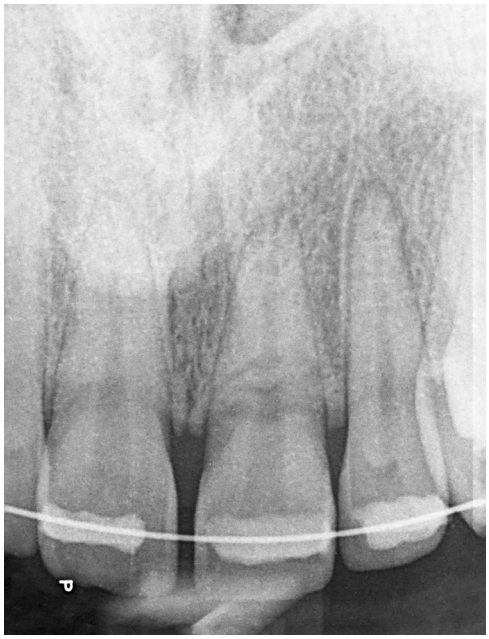
Figure 3
Stabilization of the traumatized teeth. Immediate postoperative view showing stabilization with a composite splint extending from canine to canine in the maxillary arch.

Figure 4
Radiologic findings at six-week follow-up. Periapical radiograph showing a moderate periapical radiolucency associated with tooth 21.

2D and 3D imaging confirmed a horizontal root fracture of tooth 21 (Figure 2). Following local anesthesia, gentle repositioning of the coronal fragment was performed, and a flexible splint was applied from the left to the right maxillary canine using light-cured composite resin on the labial surfaces (Figure 3). Once stabilized, the coronal fragment exhibited no pathological mobility. The splint was left in place for four weeks.

The patient missed the scheduled 4 week follow-up and returned at six weeks with severe spontaneous pain in tooth 21. The patient reported severe spontaneous pain. Clinical examination showed normal gingival appearance, no pathological probing, but intense response to cold testing that persisted after removal of the stimulus before subsiding, together with tenderness to percussion. A new periapical radiograph also revealed a moderate periapical radiolucency (Figure 4). Although transient apical breakdown was considered in the differential diagnosis of the periapical radiolucency, the clinical findings, including severe spontaneous pain, an intense and lingering response





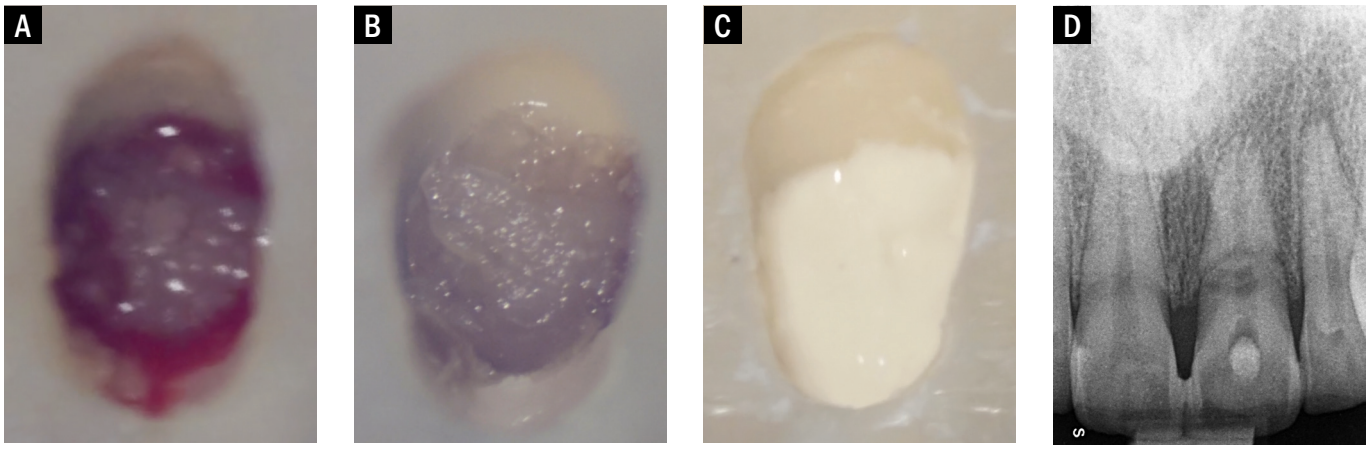


Figure 5
Vital pulp therapy procedure. **(A)** Intraoperative view under magnification following access cavity preparation and removal of the inflamed coronal pulp tissue prior to vital pulp therapy. **(B)** Hemostasis of the pulp stump achieved under magnification. **(C)** Intraoperative view showing coronal pulpotomy and direct pulp capping with Biodentine® (Septodont, Saint-Maur-des-Fossés, France) over the pulp exposure site. **(D)** Radiographic control at 1-week follow-up after placement of the pulp capping material and sealing of the access cavity.

to cold testing, and tenderness to percussion, supported a clinical diagnosis of symptomatic irreversible pulpitis with associated apical symptoms. The decision to access the pulp chamber under local anesthesia was therefore based on the overall clinical presentation rather than on the radiographic finding alone.
The treatment plan, including the option to attempt pulp preservation via pulpotomy, was discussed with the patient, and informed consent was obtained. After anesthetizing the region, the tooth was isolated with a rubber dam properly disinfected with 5% sodium hypochlorite. The roof of the pulp chamber was removed to gain access. Under magnification, a ceramic round bur under copious irrigation was used to remove the entire coronal pulp to the level of the root canal orifice (Figure 5A). Visual inspection of the remaining pulp tissue revealed no visible areas of necrosis. Hemostasis was achieved within five minutes using sterile cotton pellets soaked in 2% sodium hypochlorite. Both the clinical appearance of the tissue and its bleeding characteristics supported the decision to preserve the remaining radicular pulp and proceed with vital pulp therapy. These findings were considered compatible with clinically viable pulp tissue but could not establish the histological extent of inflammation (Figure 5B).
Thus, a full coronal pulpotomy was completed, preserving the radicular pulp. A bioceramic material (Biodentine®, Septodont, Saint-Maur-des-Fossés, France) was applied over the radicular pulp, followed by temporary restoration with a glass ionomer cement (EQUIA Forte®, GC Corporation) (Figure 5C). Tooth 22 underwent conventional RCT based on persistent negative responses to pulp sensibility testing and tenderness to percussion since the initial examination, together with a periapical radiolucency at the six-week visit. At the 7-day follow-up, the patient was asymptomatic, and a periapical radiograph confirmed an adequate coronal seal (Figure 5D). Definitive composite restoration and palatal fiber-reinforced splinting of teeth 21–22 were completed for long-term stabilization, because of slight residual mobility of tooth 21 and the cervical location of the root fracture. The diastema was simultaneously closed for esthetic purposes. At 3 months, the patient remained symptom-free, with no tenderness on percussion or palpation. Tooth 21 was non-responsive to both electric and cold testing. The radiographic examination showed a visible fracture line without signs of periapical pathology.
By 1 year, pulp sensibility had recovered, periodontal probing depths were within normal limits, and percussion and palpation tests were negative.. No clinically detectable mobility was observed with the palatal splint in place. The splint was not removed during follow-up; therefore, the independent mobility of tooth 21

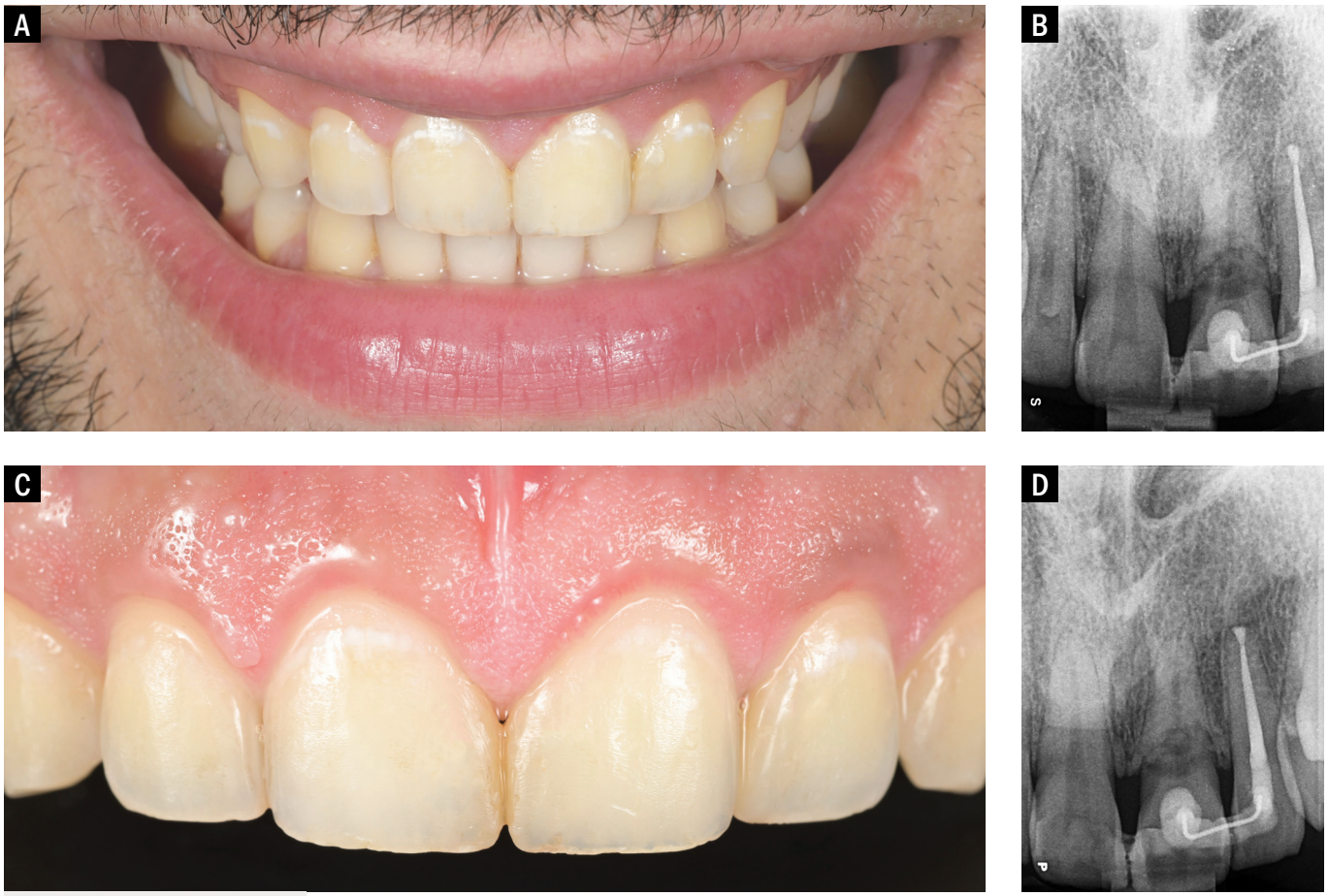


Figure 6 Long-term clinical and radiographic follow-up. **(A)** Clinical photograph at 1-year follow-up showing palatal fiber-reinforced stabilization and simultaneous closure of the diastema using composite resin for esthetic purposes. **(B)** Periapical radiograph at the 2-year follow-up demonstrating absence of periradicular radiolucency and stable healing of the horizontal root fracture. **(C)** Clinical appearance at the 3-year follow-up showing satisfactory esthetic integration and healthy periodontal tissues. **(D)** Periapical radiograph at 3-year follow-up confirming maintained healing of the root fracture and absence of periradicular pathology.

could not be assessed (Figure 6A). At 2 and 3 years, tooth 21 remained vital, functional, and asymptomatic, with stable periodontal parameters. Radiographic examination showed no apical radiolucency and a persistent radiolucent line at the fracture site, consistent with connective-tissue healing although the tissue type could not be confirmed histologically (Figure 6B-D).

Discussion

Approximately 20–44% of horizontally fractured teeth ultimately require RCT (9). Pulp pathosis may develop months or years after trauma, highlighting the need for long-term follow-up. Current International Association of Dental Traumatology guidelines recommend repositioning of displaced fragments, flexible splinting for at least four weeks in cases of horizontal root fracture, and careful clinical and radiographic monitoring over time to detect possible complications and assess healing patterns (10).
In most cases of root fracture associated with necrosis of the coronal pulp, treatment consists of RCT of the coronal segment, with obturation up to the fracture line using gutta-percha or a bioceramic apical barrier. Although this approach is well established and generally effective, it presents certain limitations, including the risk of overfilling into the fracture space, the need for multiple appointments, and the potential for reinfection over time. In contrast, pulpotomy aims to selectively remove the irreversibly inflamed coronal pulp tissue while preserving the vitality of the remaining radicular tissue.
In the present case, full coronal pulpotomy was performed in a mature perma-

nent tooth with horizontal root fracture, symptomatic pulpitis and periapical radiolucency. Transient apical breakdown should be considered in the differential diagnosis of a periapical radiolucency following dental trauma. This phenomenon has been described after luxation injuries and may resolve without endodontic intervention (11). In the present case, the radiographic finding alone was not considered conclusive evidence of an infected root canal system. The decision to perform vital pulp therapy was based on the overall clinical presentation, including severe spontaneous pain, an intense, lingering response to cold testing, and tenderness to percussion. Nevertheless, a transient post-traumatic contribution to the radiographic changes cannot be excluded, and the subsequent resolution following treatment does not establish their original aetiology.

Conventionally, pulpal complications in such cases are managed with RCT of the coronal fragment. However, maintaining pulp vitality may promote more favorable biological healing at the fracture interface by preserving odontoblastic activity, vascular supply and the local immune defense mechanisms. Additional potential advantages include shorter treatment time, maintenance of proprioception, preservation of tooth structure and long-term mechanical integrity (12). Preservation of functional pulp tissue may have biological relevance to repair; however, its contribution to fracture healing cannot be determined from this case. In this report, preservation of radicular pulp following full coronal pulpotomy was associated with favorable clinical and radiographic outcomes over a three-year follow-up period. Furthermore, the recovery of pulp sensibility observed at the one-year follow-up is consistent with the preservation of functional pulp tissue and suggests a capacity for pulpal healing even in mature teeth. However, these findings do not establish a causal relationship between the procedure and fracture healing or demonstrate superiority over conventional root canal treatment.

Previous studies have reported high success rates of pulpotomy in mature permanent teeth with irreversible pulpitis. However, its application in mature teeth with horizontal root fractures remains scarcely documented. To the best of our knowledge, only one case report has previously described pulpotomy as a treatment option in this specific clinical context, highlighting the novelty and potential clinical relevance of the present approach. The present report adds clinical documentation of a biologically conservative approach to managing pulpal complications in a mature permanent tooth with a horizontal root fracture, using a different operative protocol. Its contribution complements the previously published case without establishing treatment predictability or superiority over conventional root canal treatment.

Conclusion

In this case, the three-year follow-up showed that the patient remained asymptomatic, with no evidence of tooth mobility, pathological probing depths, or periapical alterations. Radiographic findings were consistent with a favorable healing pattern at the fracture site, supporting successful preservation of pulp sensibility and favorable tissue repair. When symptoms are promptly identified and appropriately managed, vital pulp therapy may represent a biologically oriented alternative to conventional RCT in selected cases of horizontal root fracture in mature teeth. Although further studies are required, this minimally invasive approach appears promising and may contribute to refining future treatment recommendations.

This report has inherent limitations, as it describes a single clinical case and therefore cannot establish causal relationships or generalizable clinical recommendations. Nevertheless, the favorable outcomes observed suggest that preserva-

tion of pulp sensibility may promote favorable healing patterns in root fractures. Further clinical studies are needed to clarify the potential role of vital pulp therapy in the management of horizontal root fractures in mature teeth.

Conflict of interest
The authors declare no conflicts of interest.

Funding
The authors received no specific funding for this work.

Ethical statement
This case report was conducted in accordance with the principles of the Declaration of Helsinki.

Patient consent
Written informed consent was obtained from the patient for publication of this case report and accompanying images.

Data Availability Statement
The data that support the findings of this study are available from the corresponding author upon reasonable request.

Image acquisition
All clinical photographs were obtained using a digital camera (Nikon Z5, Nikon Corporation, Tokyo, Japan) equipped with a 105-mm macro lens under standardized photographic conditions (ISO 100, shutter speed 1/125 s, aperture f/32) with bilateral lateral flash illumination (Godox, Shenzhen, China).
Periapical radiographs were obtained using a digital intraoral radiographic system with standardized exposure parameters and paralleling technique. Cone-beam computed tomography (CBCT) imaging was performed using an ORTHOPHOS XG unit (Sirona Dental Systems GmbH, Bensheim, Germany) to evaluate the location of the root fracture and the spatial relationship between the coronal and apical fragments because conventional periapical imaging did not adequately delineate the precise configuration of the root fracture. The acquisition parameters, including field of view, voxel size, tube voltage, tube current, and exposure time, could not be retrieved retrospectively.

Clinical and radiographic images were acquired and included to document the initial traumatic injury, support the diagnosis and treatment planning, illustrate the treatment procedures, and assess clinical and radiographic healing during follow-up.

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