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Bridging the Break: Three Approaches to Root Fracture Management Using Bioactive Glass Material, Fiber Post, and Orthodontic Stabilization: A Case Series

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Abstract

Dental trauma is a common clinical presentation and may involve injury to the crown, root, or supporting periodontal tissues. Horizontal root fractures affect dentin, cementum, and the pulp and present significant diagnostic and therapeutic challenges. Inappropriate or delayed management may lead to pulp necrosis, internal or external root resorption, displacement of the affected tooth, and loss of functional arch continuity. The management of horizontal radicular fractures is often complex and frequently requires a multidisciplinary approach involving endodontic, periodontal, prosthodontic, and orthodontic procedures to achieve adequate stabilization and healing. This case series reports three cases of horizontal root fractures, each managed using a different treatment modality, including a bioactive glass–based sealer in putty consistency, fiberglass post reinforcement, and orthodontic wire stabilization. The treatment approach in each case was selected based on fracture location, degree of mobility, and overall clinical presentation. Early diagnosis combined with an individualized and well-planned treatment strategy can enhance healing and preserve the affected tooth. These cases emphasize the importance of case-specific management in achieving favorable and predictable clinical outcomes.

Keywords: Bioactive Glass Material; Dental Trauma; Impact Injuries; Internal Reinforcement; Orthodontic Stabilization

Introduction

Traumatic dental injuries (TDIs) have a reported prevalence of approximately 18% in the permanent dentition and represent the third most common cause for seeking emergency dental care[1, 2]. These injuries range from minor enamel fractures to complete tooth avulsion. Root fractures account for about 0.5-7% of dental injuries and involve dentin, cementum, and pulp, often accompanied by damage to the periodontal ligament and alveolar bone [3].

The management of root fractures is influenced by the location of the fracture line, the degree of mobility, and pulpal status. Radicular fractures are broadly classified as horizontal or vertical. Horizontal root fractures, particularly those involving the middle or apical third, are frequently asymptomatic and may undergo spontaneous healing; however, some cases present with pain, mobility, or periodontal bleeding [4, 5]. Diagnosis relies on radiographic examination supported by pulp vitality (sensibility) testing [6].

Management of horizontal root fractures does not follow a universally standardized treatment protocol and should be guided by case-specific biological and biomechanical considerations. Treatment selection depends primarily on fracture location, degree of fragment mobility, pulpal status, remaining coronal tooth structure, and the ability to achieve functional stability while preserving dental tissues. In cases with minimal fragment mobility, conservative endodontic management alone may be sufficient to permit biological healing. When the coronal fragment is structurally compromised, internal reinforcement may

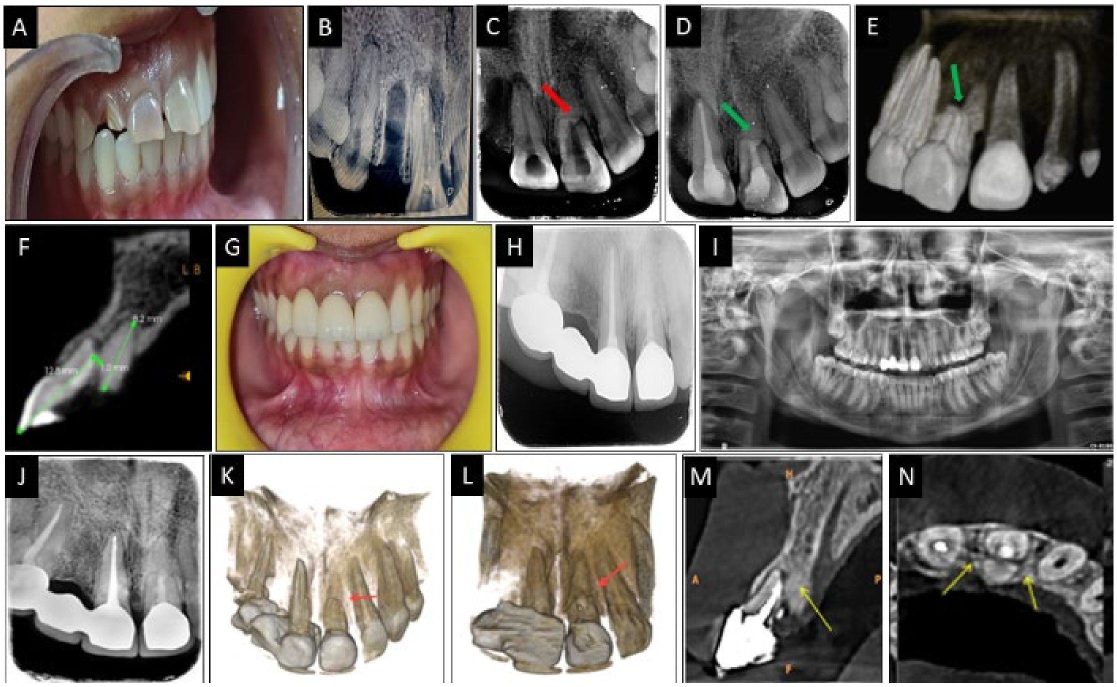

Figure 1. *A)* Preoperative intraoral image showing root stump in tooth #12, Ellis Class IV fractures in teeth #11 and #21, and deep mesio-proximal caries in tooth #13; *B)* Preoperative IOPAR showing previously initiated root canal treatment in tooth #11, extracted root stump of tooth #12, and deep mesio-proximal caries in tooth #13; *C)* Preoperative Intraoral Periapical Radiograph showing a horizontal root fracture in tooth #21 (red arrow); *D)* Postoperative IOPAR showing root canal obturated with Nishika Canal Sealer BG Multi (bioactive glass, putty form) in tooth #21; *E, F)* Postoperative CBCT images demonstrating buccal displacement of tooth #21 (green arrow); *G, H)* Postoperative intraoral image and IOPAR following prosthetic rehabilitation of teeth #11, #12, #13, and #21; *I)* One-year follow-up orthopantomogram; *J)* Three-year follow-up IOPAR of tooth #21 showing continued healing; *K–N)* Four-year follow-up CBCT images including 3D, cross-sectional, and axial views of tooth #21

be considered to improve stress distribution under functional loading. Alternatively, when conventional external splinting is impractical or unnecessary, intracoronal stabilization approaches may be employed to reduce functional displacement of the coronal segment. The present case series demonstrates three treatment strategies selected according to these clinical decision-making principles rather than proposing a universal therapeutic protocol.

Case Presentation

The entire procedure was explained to all patients in their vernacular language, and written informed consent was obtained from each patient. Written informed consent was also obtained from all patients for the publication of this case series and the accompanying images.

Case No. 1

A 25-year-old healthy female reported a history of trauma to the maxillary anterior region and complained of fractured and discoloured upper front teeth for the past two years. Clinical examination revealed Ellis Class IV fractures in teeth #11 and #21, a root stump in tooth #12, and deep mesio-proximal caries in tooth #13 (Fig. 1A) [7]. Teeth #11 and #21 showed buccal displacement without mobility or tenderness. Pulp sensibility tests for teeth #11, #21, and #13 were negative. Radiographic examination revealed a horizontal root fracture in the middle third of tooth #21 with slight buccal displacement of the coronal fragment (Fig. 1C). The periodontal probing depths of the abovementioned teeth were within physiological limits, with no isolated periodontal pockets or clinical signs of periodontal disease. No periapical pathology was evident, and the periodontal ligament space was intact. The apical fragment showed canal obliteration. Tooth #21 was diagnosed with a horizontal root fracture associated with pulp necrosis. Previously initiated root canal treatment was noted in tooth #11 (Fig. 1C), and tooth #13 showed pulp necrosis with asymptomatic apical periodontitis. After obtaining informed consent, the extraction of the root stump of tooth #12 was done, and after one week, endodontic treatment was initiated (Fig. 1B). Root canal treatment in tooth #21 was limited to the coronal fragment, with the working length established 1 mm short of the fracture line. Conventional endodontic treatment was performed for teeth #11 and #13. The canals were irrigated with 3% sodium hypochlorite, saline, and 2% chlorhexidine, followed by placement of triple antibiotic paste as an intracanal medicament. At the subsequent visit, tooth

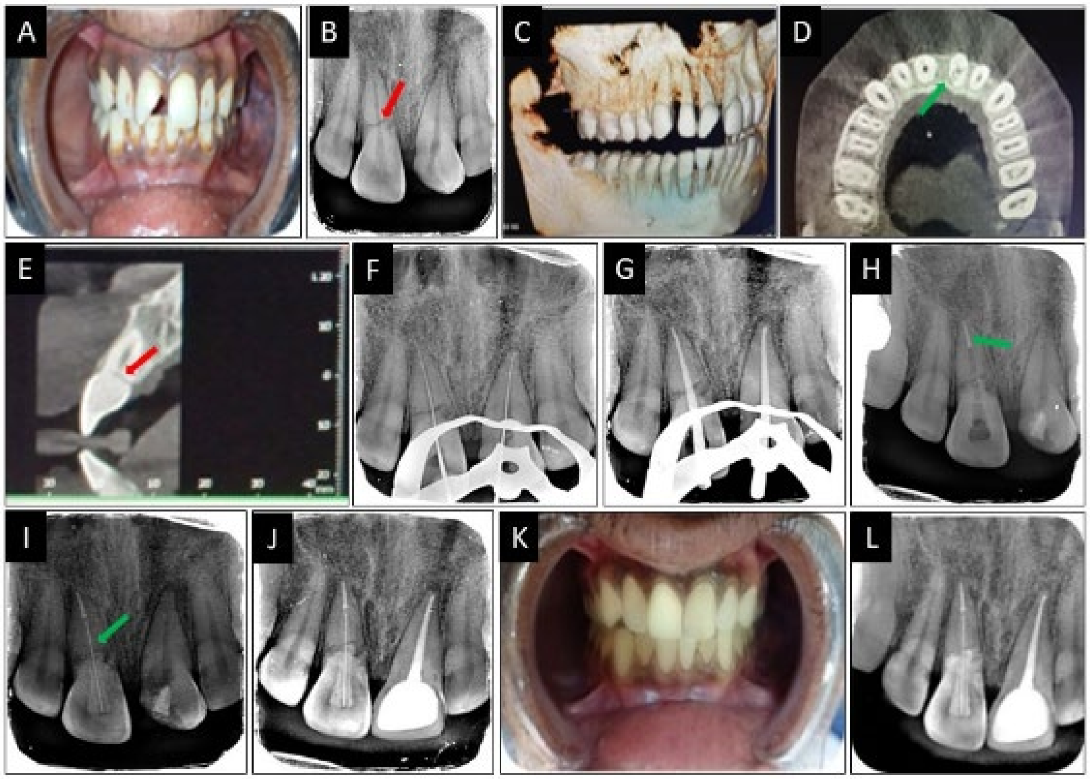

Figure 2. *A)* Preoperative intraoral image showing an Ellis Class III fracture in tooth #11; *B)* Preoperative IOPAR showing a horizontal root fracture in tooth #21 (red arrow); *C)* Preoperative CBCT 3D views revealed Ellis Class III fracture in tooth #11; *D)* Preoperative CBCT axial view showing a horizontal root fracture in tooth #21 (green arrow); *E)* Preoperative CBCT cross-sectional image showing incomplete horizontal root fracture in tooth #21 (red arrow); *F, G)* Working length and master cone; *H)* Sectional obturation and post-space preparation in tooth # 21; *I)* Internal reinforcement was carried out using a glass fiber-reinforced post in tooth # 21 (green arrow); *J, K)* Tooth #11 restored with a porcelain-fused-to-metal crown: radiograph and intraoral image; *L)* Two-year follow-up

#21 was obturated with Nishika Canal Sealer BG Multi (bioactive glass, putty form) (Nippon Shika Yakuhin, Yamaguchi, Japan), because the fractured segments exhibited no mobility and adequate remaining coronal tooth structure, additional mechanical reinforcement using a fiber post was considered unnecessary. A bioactive glass putty material was therefore selected to achieve sealing of the coronal fragment while preserving dentin and supporting biological healing without further structural compromise, while teeth #11 and #13 were obturated using a single-cone technique with Nishika Canal Sealer BG in flowable form (F-NBG) (Fig. 1D). Post-endodontic composite restorations were completed, followed by prosthetic rehabilitation (Figs. 1G & 1H).

At 1, 3 and 4 years of follow-up, the patient remained asymptomatic. Radiographs demonstrated satisfactory healing with reduced radiolucency at the fracture line and no functional or esthetic complications (Figs. 1I-1N).

Case No. 2

A 29-year-old healthy male presented with a history of trauma to the maxillary anterior region and complained of a fractured upper front tooth for the past three years. Clinical examination revealed an Ellis Class III fracture in tooth #11, with minimal clinical mobility and absence of tenderness to percussion (Fig. 2A) [7]. Pulp sensibility tests for teeth #11 and #21 were negative. Radiographic examination revealed a horizontal root fracture in the middle third of tooth #21, with no displacement of fragments or periapical pathology. The periodontal probing depths of the abovementioned teeth were within physiological limits, with no isolated periodontal pockets or clinical signs of periodontal disease. Widening of the fracture line was noted, with an intact periodontal ligament space (Fig. 2B). Tooth #21 was diagnosed with a horizontal root fracture associated with pulp necrosis, while tooth #11 showed pulp necrosis with asymptomatic apical periodontitis. Although extraction of tooth #21 was advised, the patient opted for tooth preservation. Following informed consent, nonsurgical endodontic treatment was initiated for teeth #11 and #21 (Fig. 2F). Endodontic therapy was performed for both coronal and apical segments of tooth #21 under rubber dam isolation. Canals were instrumented and irrigated with 3% sodium hypochlorite, saline, and 2%

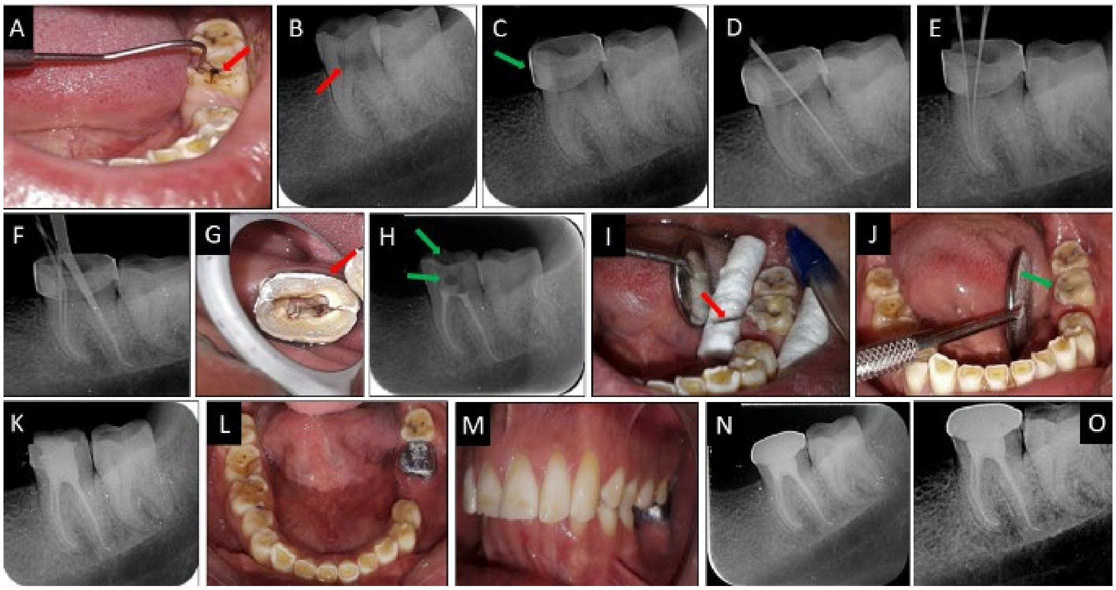

Figure 3. *A*) Preoperative intraoral image showing crown fracture involving enamel and dentin in tooth #37 (red arrow); *B*) Preoperative radiograph showing crown and root fracture in tooth #37 (red arrow); *C*) Stabilization using a metal molar band; *D, E*) Working length; *F*) Master cone; *G*) Intraoral view showing metal molar band stabilization (red arrow) and obturation; *H*) Coronal holes on the buccal and lingual walls were prepared (green arrows); *I*) Intracoronal splinting using a 20-gauge orthodontic wire (red arrow); *J*) Orthodontic wire secured within a prepared intracoronal channel and covered with a post-endodontic restorative material; *K*) Postoperative radiograph; *L, M*) Postoperative intraoral image (occlusal and lateral) following prosthetic rehabilitation of tooth #36 with a full-coverage metal crown; *N, O*) Postoperative and nine-month follow-up

chlorhexidine, followed by placement of calcium hydroxide as an intracanal medicament. At the second visit, sectional obturation of tooth #21 was performed using gutta-percha, while tooth #11 was obturated using a single-cone technique with a Nishika Canal Sealer BG in flowable form (F-NBG) (Nippon Shika Yakuhin, Yamaguchi, Japan) (Figs. 2G & 2H). Post space preparation and internal reinforcement of tooth #21 were carried out using a glass fiber–reinforced post, followed by composite core build-up (Fig. 2I). Although minimal clinical mobility of the coronal fragment was observed and no structural compromise, the presence of a horizontal root fracture together with endodontic treatment increases susceptibility to stress concentration during functional loading. Therefore, a glass fiber-reinforced post was placed to improve stress distribution within the tooth-restoration complex and to minimize potential functional micro-movement at the fracture interface rather than to act as a rigid splint. Tooth #11 was restored with a porcelain-fused-to-metal crown (Fig. 2J).

At the 2-year follow-up, the patient was asymptomatic. Radiographic evaluation demonstrated satisfactory healing with reduced radiolucency at the fracture line and no functional or esthetic complications (Figs 2K& 2L).

Case No. 3

A 31-year-old healthy male presented with a history of trauma to the left mandibular posterior region and complained of a fractured mandibular left second molar (tooth #37) for the past two days. Clinical examination revealed an Ellis Class III fracture in tooth #37 (Fig. 3A) [7]. The periodontal probing depths of the abovementioned teeth were within physiological limits, with no isolated periodontal pockets or clinical signs of periodontal disease. The periodontal status was healthy. Pulp sensibility testing was negative.

Radiographic examination revealed an oblique root fracture extending from the occlusal surface to the middle third of the root, with widening of the fracture line. However, there was no mobility of the fractured segment or evidence of periapical pathology, and no widening of the periodontal ligament space was observed (Fig. 3B). Pulpal necrosis was suspected in tooth #37 based on negative sensibility testing and clinical findings; however, a definitive pulpal diagnosis was not established immediately after the trauma. Definitive pulpal diagnosis following traumatic injuries often requires longitudinal reassessment. Therefore, treatment decisions in the present case were based on a combination of clinical findings and radiographic indicators rather than on a single time-point evaluation.

Nonsurgical endodontic treatment followed by intracoronal splinting was planned. The fractured segment was initially stabilized with a molar band (Fig. 3C). Root canal instrumentation was performed under rubber dam isolation, with irrigation using 3% sodium hypochlorite, saline, and 2% chlorhexidine. Calcium hydroxide was placed as an intracanal medicament. At the second visit, obturation was completed using gutta-percha with a Nishika Canal Sealer BG in flowable form (F-NBG) (Fig. 3G). The molar band was then cut and removed, followed by preparation of coronal holes on the buccal and lingual walls (Fig. 3H). Intracoronal splinting was achieved using a 20-gauge orthodontic wire secured within a prepared intracoronal channel and covered with a post-endodontic restorative material (Figs. 3I & 3J). The tooth was subsequently restored with a full-coverage metal crown (Figs 3L-3N).

At the nine-month follow-up, the tooth remained asymptomatic with radiographic evidence suggestive of healing and reduction in periapical radiolucency; however, long-term outcome cannot yet be confirmed due to the limited follow-up period and absence of standardized outcome measures (Fig. 3O).

Discussion

Healing following root fracture is a biologically mediated process dependent on preservation of pulp vitality, periodontal ligament integrity, and adequate stabilization of fractured segments. Histologic studies have demonstrated that root fractures may heal through calcified tissue union, connective tissue interposition, or combined bone and connective tissue repair when mobility and bacterial contamination are minimized. Stabilization reduces interfragmentary movement and promotes periodontal and pulpal healing, facilitating hard tissue repair at the fracture interface. Contemporary trauma guidelines further emphasize that controlled stabilization and effective coronal sealing are critical determinants for favorable healing outcomes. Therefore, stabilization performed in the present case aimed to create favorable biological conditions for fracture healing rather than introduce a new treatment modality [8-11].

The biomechanical role of the techniques used in this case series should be interpreted as adjunctive functional support rather than direct stabilization of the fracture line. In Case 1, the use of a bioactive glass–based material was primarily intended to achieve sealing of the coronal fragment and promote biological healing without additional structural intervention, as the tooth exhibited adequate stability and minimal need for reinforcement. In Case 2, fiber post placement was used to provide internal reinforcement and improve stress distribution within the coronal tooth–restoration complex, rather than acting as a rigid splint across the fracture interface. Similarly, in Case 3, intracoronal wire stabilization functioned to reduce coronal segment flexure and occlusal stress transmission without immobilizing apically separated root fragments or altering physiological periodontal ligament movement. The International Association of Dental Traumatology (IADT) guidelines recommend flexible external splinting primarily for mobile teeth following traumatic injuries [11]. In the present case, no clinical mobility or displacement was observed and periodontal support remained intact; therefore, external splinting was considered unnecessary. Intracoronal stabilization using an orthodontic wire was performed to reduce functional cuspal flexure and improve stress distribution within the coronal segment while preserving physiological periodontal ligament movement. This approach provided internal functional stabilization based on fracture configuration and clinical findings, representing a case-specific modification rather than a deviation from established trauma management principles.

Healing of horizontal root fractures is primarily dependent on biological repair following adequate endodontic disinfection and favorable periodontal conditions. Therefore, the outcomes observed in all three cases should be attributed mainly to biological healing potential, with the described techniques serving only as supportive measures to enhance functional stability.

Horizontal root fractures often present with complex healing patterns and may be overlooked on conventional two-dimensional radiographs; therefore, accurate diagnosis requires three-dimensional imaging in conjunction with percussion and pulp vitality tests [12]. Management should aim to preserve both tooth function and patient well-being. In recent years, bioactive glass (BG)–containing endodontic cements have been developed and introduced into clinical practice. Nishika Canal Sealer BG Multi (NBG) is a newly developed BG-containing cement. NBG is available in a semi-liquid, flowable consistency and can be used with single cone, multi-cone technique, lateral condensation, vertical condensation or as sealer-only obturation material. It can also be converted into a putty-like consistency by mixing the flowable NBG (F-NBG) with a designated BG-based powder (Nippon Shika Yakuhin). This putty-like consistency facilitates easier handling during pulp capping, pulpotomy, perforation repair, and root end filling procedures.

Although mineral trioxide aggregate (MTA) is considered the gold standard for root fracture repair due to its proven sealing ability and biocompatibility [13, 14]. Nishika Canal Sealer BG Multi in putty form was used in the present cases. Unlike MTA, which sets through a hydration reaction, Nishika Multi BG sets *via* an acid–base reaction involving fatty acids, magnesium oxide, and calcium hydroxide, providing ease of handling, consistent putty-like form, predictable setting time, and resistance to washout. These characteristics facilitated precise placement in the fracture site. While no direct clinical comparison between MTA and Nishika Multi BS exists for horizontal root fractures, studies on bioactive glass-based endodontic materials show favorable biocompatibility, minimal postoperative pain, bioactivity, and clinical outcomes comparable to MTA [15, 16]. Therefore, the material should be considered a potentially useful biologically active alternative rather than an equivalent substitute to MTA. The present findings are limited to clinical observations from individual cases and must be interpreted within the inherent limitations of a case series design.

Although AH-Plus (Dentsply De Trey, Konstanz, Germany) has long been considered the gold standard, Nishika Canal Sealer BG in flowable form (F-NBG) was used as a root canal sealer in the present cases based on clinical and experimental evidence. Previous studies have demonstrated that calcium silicate-based sealers, including CS-BG, are associated with significantly lower postoperative pain compared with epoxy resin-based sealers such as AH-Plus [16, 17]. The incorporation of bioactive glass into calcium silicate–based sealers has been shown to enhance mechanical properties, reduce solubility, and improve bioactivity [18]. *In vitro* investigations have reported superior apical sealing ability and greater dentinal tubule penetration of CS-BG compared with CeraSeal and AH-Plus [19]. Furthermore, available literature supports the potential use of bioactive glass–based cement as a root canal filling material even in the absence of a semisolid core material [20].

The use of triple antibiotic paste as an intracanal medicament was aimed at achieving enhanced disinfection in traumatic cases with suspected pulpal necrosis, where microbial contamination may be complex and not fully predictable. Its application between treatment sessions helps reduce residual bacterial load within the root canal system, thereby creating a more favorable environment for healing prior to obturation [21, 22].

Fiber-reinforced posts offer advantages over conventional posts due to their dentin-like modulus of elasticity, minimal tooth preparation, and favorable stress distribution [23]. Their adhesive and elastic properties allow the post–tooth complex to function as a single unit. In the present case, glass fiber posts provided effective intra-radicular stabilization, with favorable clinical and radiographic outcomes at the two-year follow-up.

Crown fractures are among the most common traumatic dental injuries. Various splinting techniques, including flexible and rigid splints, have been described in the literature [11, 24]. Although orthodontic wires are commonly used for splinting mobile teeth, their use in managing fractured teeth is limited [25, 26]. The use of orthodontic wire in this case was not intended to propose a novel material-based technique, but to apply the established principle of intracoronal splinting for reinforcement of a structurally compromised tooth. Similar biomechanical concepts have been well documented using fiber-reinforced systems, such as ribbond, for the stabilization of fractured cusps and weakened coronal structures. In the present case, orthodontic wire was used as a resource-adapted alternative to provide interim intracoronal stabilization, based on the same reinforcement principle to improve structural integrity prior to definitive restoration [27]. In the present case, nonsurgical endodontic treatment combined with intracoronal splinting resulted in satisfactory healing without complications. Despite advances in implant dentistry, conservative and minimally invasive approaches remain underutilized, highlighting the need to emphasize tooth-preserving treatment strategies in contemporary practice.

This case series is limited by the small number of cases, lack of standardized outcome measures, and relatively short follow-up in Case 3. Therefore, the findings should be interpreted as descriptive clinical observations and cannot be generalized as evidence of treatment efficacy.

Conclusion

This case series highlights three individualized and distinct treatment approaches for managing radicular fractures, emphasizing the preservation of the remaining tooth structure. Reinforcement of the residual tooth structure, appropriate material selection based on the site, extent, and type of fracture, and regular follow-up are critical factors for achieving long-term treatment success.

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Conflict of interest

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Authors' contributions

Conceptualization: SB/SKD; Methodology: SB/SKD/DB; Formal Analysis and Investigation: SB/SKD/TS; Writing-Original Draft Preparation: SB; Writing-Review and Editing: SB/SKD/DB; Supervision: SB//TS. All authors read and approved the final manuscript.

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