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CASE REPORT

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Management of oblique root fracture in the middle third of two maxillary immature central incisors with severe caries in mixed dentitions: a case report

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Abstract

Mid-root fractures are rare injuries in young permanent teeth and tend to have poor prognoses. This study presents a case of oblique root fracture of both maxillary immature central incisors in the middle third accompanied by delayed dental visit and severe caries of all primary teeth. After restoring all the primary and permanent teeth that needed stabilization, the coronal fragments were repositioned and stabilized with a flexible splint consisting of orthodontic wire and composite resin. A comprehensive and sequential dental treatment for other oral diseases and oral hygiene instructions were provided. A 16-month follow-up revealed that the two injured young permanent incisors were healed, surrounded by hard tissues and continued to grow both in length of the root and thickness of the root canal wall, with significant improvement in oral hygiene. Based on the outcome of this case, initial stabilization without endodontic therapy could be considered a successful treatment modality for young permanent teeth with oblique root fracture due to the growth of fractured teeth with vital pulp and the maintenance of natural dentition.

Keywords

Immature incisor; Dental trauma; Root fracture; Caries

1. Introduction

Traumatic tooth injuries are one of the most prevalent emergencies in pediatric dentistry, frequently occurring during childhood and adolescence [1, 2]. About 50% of injuries affect the hard tissues in the oral cavity, while 36% impact the soft tissues [3]. The most frequent teeth involved are the maxillary central incisors, typically combined with several injuries [4, 5]. Traumatic root fractures are relatively rare, with studies demonstrating that in permanent dentition, the proportion of root fractures among all dental injuries ranges from 1.2% to 7.0% [6].

Root fractures occur when a tooth is fractured and involves the dentin, cementum and pulp [7]. These fractures are commonly categorized as vertical, horizontal or oblique (*i.e.*, more apical toward the palatal surface, more apical toward the labial surface, *etc.*). The orientation of the fracture can determine whether the tooth can be retained or must be extracted [6, 7]. Vertical fractures, which commonly result in tooth extraction and prosthetic replacement [6], will not be discussed in this article. Instead, the focus will be on horizontal and oblique root fractures since they have not been separately addressed in the latest guidelines for the management of traumatic dental injuries of the International Association of Dental Traumatology (IADT).

When subjected to frontal forces from various directions, such as labial, lingual and/or palatal, the compression zone can result in root fractures where the root is split into coronal and apical fragments [8]. However, the diagnosis of root fractures can be challenging as they mostly rely on radiographic examinations. In some cases, root fractures might not be timely diagnosed, especially if the coronal fragment is not displaced, as the root fracture may not always be visible immediately after the incident [6]. Since mobility and percussed pain are frequently evident when the coronal fragment is displaced [9, 10], the diagnosis can be made through clinical examinations and radiographic findings [11].

As for the treatment options, the displacement of the coronal fragment and the level of the root fracture may not be the most important factors, and the mobility and the vitality of the tooth should also be taken into consideration [6, 8]. Initial treatment for displaced coronal fragments should involve repositioning the pieces, followed by stabilization for 4 weeks (root fracture in the middle/apical third) to promote tissue repair around the fracture site and considering oral health conditions for accomplishing the stabilization. It is advisable to monitor the healing of the fracture and pulp for at least one year to adequately guide whether there is a need for endodontic treatment [12].

This case report aims to present a successful outcome in managing middle-third oblique root fracture with displaced fragments and poor stabilizing condition coupled with severe

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caries in young permanent maxillary incisors. Additionally, this case is notable for the continued growth of the teeth with vital pulp and a significant improvement in oral hygiene.

2. Case report

2.1 Patient characteristics

A 7-year-old girl who lived in a county 400 kilometers away from our hospital presented to our department one day after suffering from a traumatic injury to both maxillary central incisors while playing at school, leading to severe pain and mobility of both teeth while touching or biting.

2.2 History

A periapical radiograph was taken at her local hospital where the girl lived, which showed mid-root fracture of teeth #11 and 21 (Fig. 1). No procedures were performed after the accident prior to arriving at our department of pediatric dentistry (School and Hospital of Stomatology of Kunming Medical University). The patient reported no previous dental history and her past medical history was inquired before the treatment.

FIGURE 1. Preoperative periapical radiographic showed mid-root fracture line of teeth #11 and 21.

2.3 Preoperative intraoral characteristics

Intraoral examinations revealed that the crown of both maxillary central incisors were mobile and intact, while the crown of tooth #21 was slightly elongated compared to tooth #11 (Fig. 2A). A slightly intraoral swelling on the labial gingiva around both teeth and bleeding from the gingiva crevice of tooth #21 were also observed. Additionally, the pulp response to endodontic ice was lost, massive cavitated caries could be observed on all her primary teeth and pulp polyp in the cavity of teeth #55 and 54, and mobility of tooth #54 was categorized as class 1 (Fig. 2B–E), as well as premature eruption of teeth #24 and 25 (Fig. 2B).

2.4 Preoperative radiographic examination

Cone-beam computed tomographic (CBCT), using NNT Viewer software (vision 7.2, NewTom VGi dentalscan, Bologna, Italy), demonstrated the presence of oblique root fractures in the middle third of the roots of both maxillary central incisors and that these teeth were immature (Class VIII according to Nolla's classification of tooth development) (Fig. 3A,B). The overall oral health condition, in regard to caries, premature eruption, root stumps, *etc.*, is shown in Fig. 4.

2.5 Diagnosis of chief complaint

Based on clinical and radiographic examinations, the patient was diagnosed with an oblique root fracture (#11) and an oblique root fracture with extrusion of the coronal fragment (#21) in the middle third.

2.6 Treatment characteristics

The first treatment option for the two injured incisors usually comprises repositioning the displaced fragment and stabilizing the mobile coronal segment immediately. However, in this present case, her adjacent tooth structures were extensively destroyed by caries and mobility was affected. Thus, it was not feasible to stabilize the injured teeth. Thus, the treatment plan included retaining the traumatized tooth for as long as possible to aid continued alveolar development and oral rehabilitation.

Local anesthesia with 4% articaine containing 1:100,000 epinephrine was administered at the first visit. Then, the buccal surface of teeth #53, 54 and 55 were restored with composite resin for stabilization, and sequential treatment of the decayed teeth was also performed. The coronal fragment of tooth #21 was repositioned, and the mobile coronal segment of teeth #11 and 21 were stabilized with a flexible splint, which consisted of orthodontic stainless steel wire twisted by 4 pieces of wire in diameter of 0.025 mm and composite resin, through teeth #55, 54, 53, 11, 21, 22 and 26. Glass ionomer cement (GIC) was placed on teeth #36 and 46 to relieve the occlusal trauma of teeth #11 and 21 (Figs. 5,6A,B). Lastly, oral hygiene instructions after the treatment, especially with the splint, were clearly provided to the child and her parents.

At the second visit (1 week later), root canal therapy for teeth #55 and 54 was completed, and teeth #55 and 54 were restored with GIC. The swelling on the labial gingiva had healed by that time. Following evaluation 4 weeks after the initial treatment, teeth #11 and 21 had become asymptomatic to percussion and palpation, the pulp response to endodontic ice was less sensitive, and no clear radiolucency of apical inflammation or root resorption was visible on the periapical radiographic (Fig. 6C). After moving the splint, the mobility of teeth #11 and 21 was found to have decreased to class 1.

2.7 Follow-up characteristics

After 7 weeks of recovery, the mobility of teeth #11 and 21 were close to normal (Fig. 6D), and proper hygiene was observed at this time. Then, a mandibular lingual arch space maintainer was provided.

Three months after the trauma, teeth #11 and 21 remained

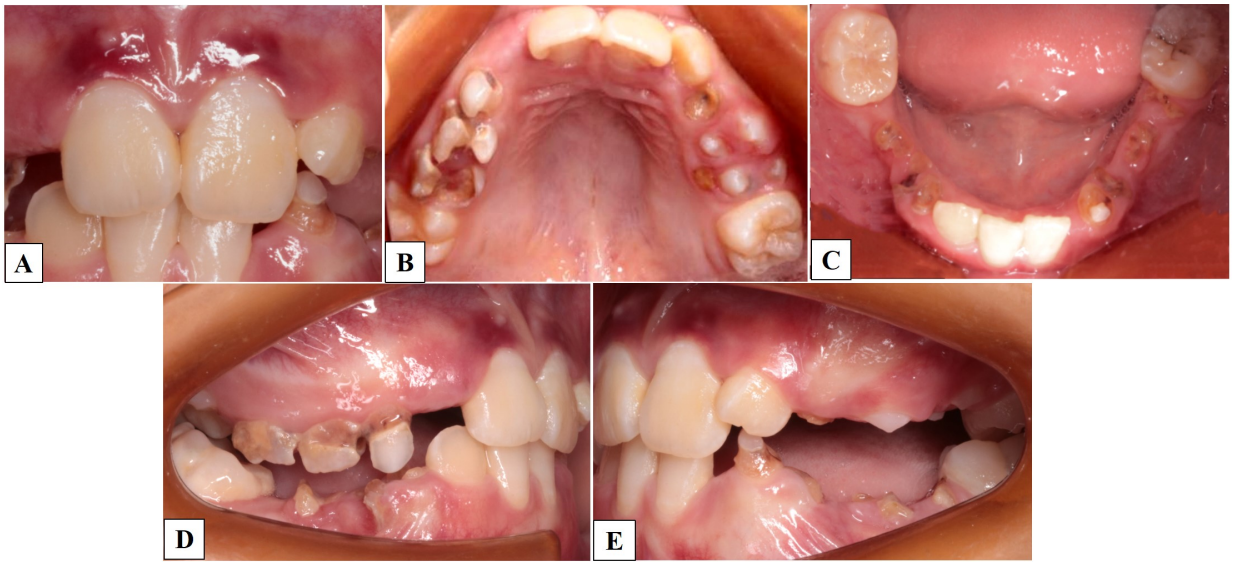

FIGURE 2. Preoperative intraoral view. (A) The crown of tooth #21 was slightly elongated compared to tooth #11; (B) Pulp polyp in the cavity of teeth #55, 54 and premature eruption of teeth #24, 25 could be observed; (B–E) Poor oral condition and massive cavitated caries of all primary teeth could be observed.

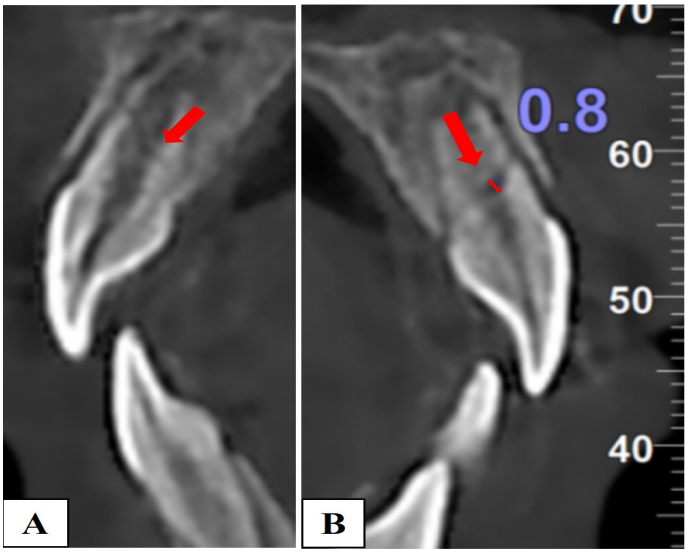

FIGURE 3. Preoperative CBCT image. (A) Oblique fracture line of tooth #11; (B) Oblique fracture line of tooth #21 and a 0.8 mm-width gap between the fragments.

FIGURE 4. CBCT image showing the root stumps (#63, 65, 74, 73, 83, 84 and 85) without evident apical inflammation, periapical periodontitis (#55 and 54), caries (#53, 16, 26, 36 and 46) and premature eruption (#24 and 25).

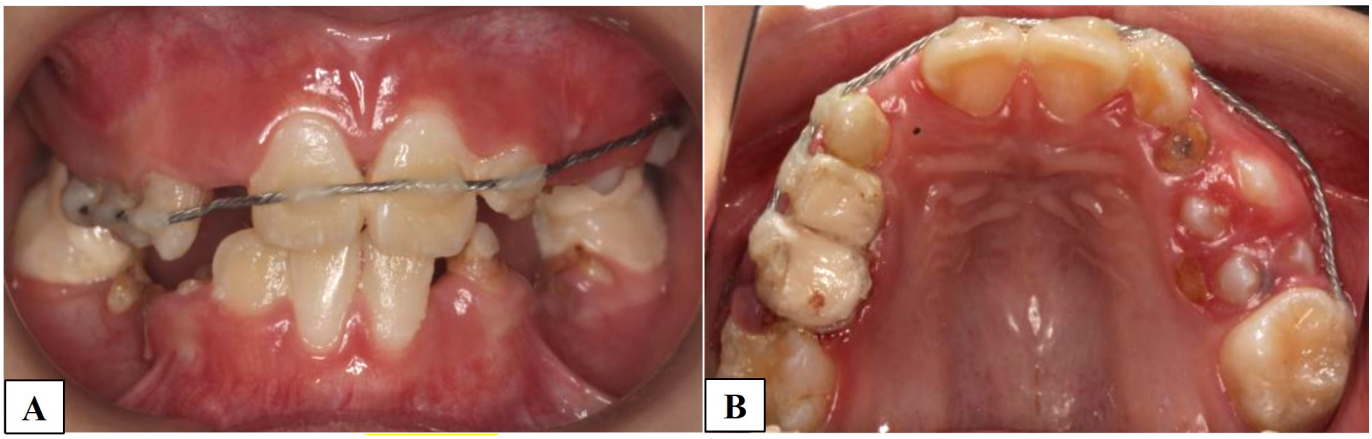

FIGURE 5. Intraoral view after the first treatment. (A) Repositioned the displaced fragment and stabilized the mobile coronal segment; (B) Teeth #53, 54 and 55 was restored temperorily.

asymptomatic with normal mobility. The pulp had a positive response to endodontic ice. Radiographically, the root demonstrated continued growth, and the fracture line showed signs of healing (Fig. 6E).

In routine follow-ups after 5 and 10 months, clinical examinations of teeth #11 and 21 showed normal mobility, and reactions to pulp sensitivity test were positive, periapical radiographs showed healthy periodontal tissues around both the fractured area and the apical fragments, and the teeth continued to mature, while the fracture site appeared to show possible hard-tissue repair, without clear diffuse calcification in root canal could be observed (Fig. 6F,G). Intraoral examination also revealed that all the restorations were intact, oral hygiene was good, and no new carious lesion was observed (Fig. 7).

At the 16-month follow-up visit, the parents mentioned that the mandibular lingual arch pace maintainer had fallen off 2 months ago and that the girl could not come for dental visit in time due to the COVID-19 pandemic restrictions and the long travel distance. During the examination, teeth #11 and 21 were asymptomatic with normal mobility, and the mesial inclination of tooth #46 was evident (Figs. 8,10). Sagittal CBCT images of different cross-sections revealed that the fracture line had healed with hard tissues and suspected partial calcification were observed at the fracture site, but the root canal of teeth #11 and 21 were still unobstructed, and the teeth continued to grow to stage Nolla IX (root length growth and root canal wall thickening). The root canal wall of tooth #21 seemed to be discontinuous, possibly due to the partial extrusion without accurate repositioning completely because of the delayed visit instead of internal resorption (Fig. 9). Hence, orthodontic treatment and long-term follow-up visit of the injured teeth would be arranged for this child.

3. Discussion

Root fractures can occur when a tooth is directly hit horizontally and frontally, typically by a hard object or during a fight [7, 13]. It is not uncommon for a tooth to sustain concurrent injuries such as root fractures and coronal piece displacement [6]. The displacement of the coronal piece of the root can stretch or completely cut (lacerated) at the fracture site [7, 14], leading to reduced or severed compromised supply to the tooth's coronal portion, resulting in pulp necrosis. Typically, the apical fragment of the tooth root is unharmed since all of the impact forces are absorbed in the fracture site [14].

Mid-root fracture was uncommon in young permanent teeth, and the involvement of both maxillary central incisors is much less common. In the present case report, the two injured incisors (#11 and 21) were supposed to be treated as recommended by the updated guidelines from the IADT [12] by repositioning and stabilizing as soon as possible during the initial emergency treatment.

The selection of treatment options and the sequence of the therapy can be challenging in cases of root fractures. First, the fractured teeth sustained with partial extrusion of the coronal fragment may have a negative influence on the prognosis and require immediate repositioning. Second, delayed treatment due to long-distance visits can also present challenges, although it has been reported that delayed treatment does not necessarily affect overall healing outcomes [15]. However, stretched and bruised pulp and blood clots at the fracture site due to concurrent injuries can lead to a poor prognosis if repositioning is more difficult. These underscore the importance of prompt treatment in cases of two injured teeth.

However, a significant obstacle was presented by the patient's severe caries and periapical disease of all primary teeth, preventing adequate support and stabilization retention. Therefore, the stabilization process could commence only after all primary maxillary teeth (at least the buccal walls) were restored. Furthermore, maintenance of good oral hygiene posed a challenge due to the need for an extended range of splinting for effective stabilization. Altogether, the repositioning and stabilization could only be done after the restoration as the final part of the first treatment, and the ideal healing of these two injured teeth was not initially expected.

Encouragingly, the two maxillary incisors were young permanent teeth, and the location of the fractures was subcrestal, which led to a comparatively better prognosis. Dental plaque in the gingival sulcus may be the source of infection if the fracture is supracrestally placed. Occasionally, subcrestal root fractures may also have a similar presentation [6]. The patient's age and the stage of root development, namely the

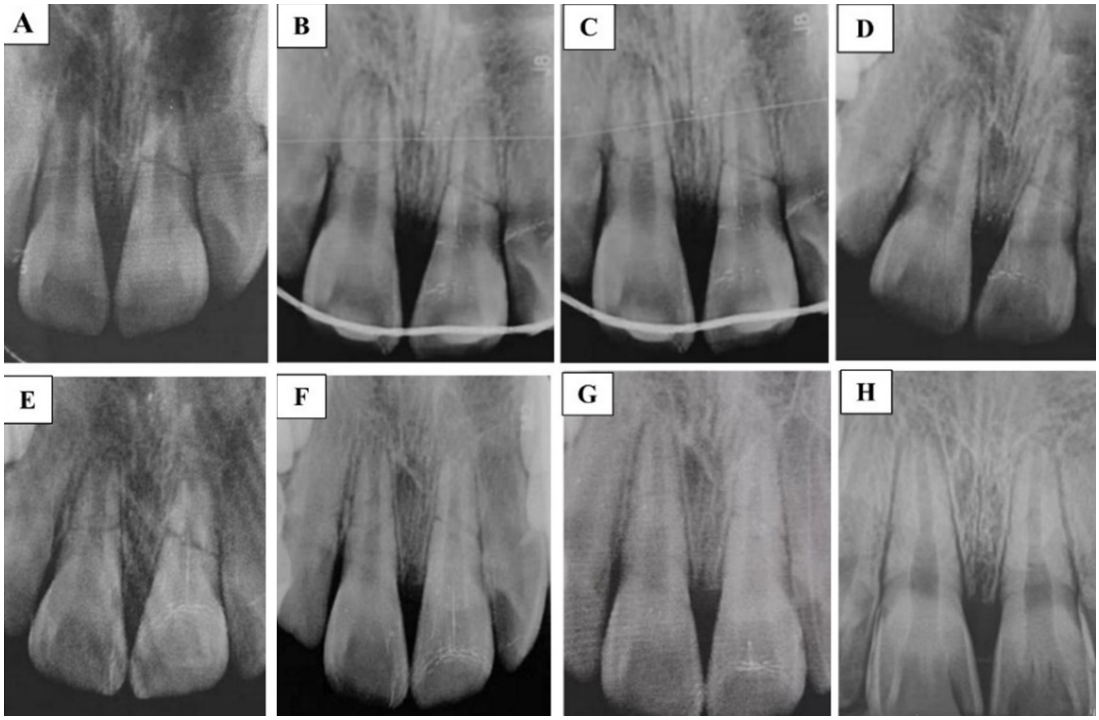

FIGURE 6. Preoperation and follow-up periapical radiographs: (A) Preoperation, (B) Postoperation, (C) 4 weeks, (D) 7 weeks, (E) 3 months, (F) 5 months, (G) 10 months, (H) 16 months' follow-up.

FIGURE 7. Intraoral view at the 10-month follow-up.

FIGURE 8. Intraoral view at the 16-month follow-up.

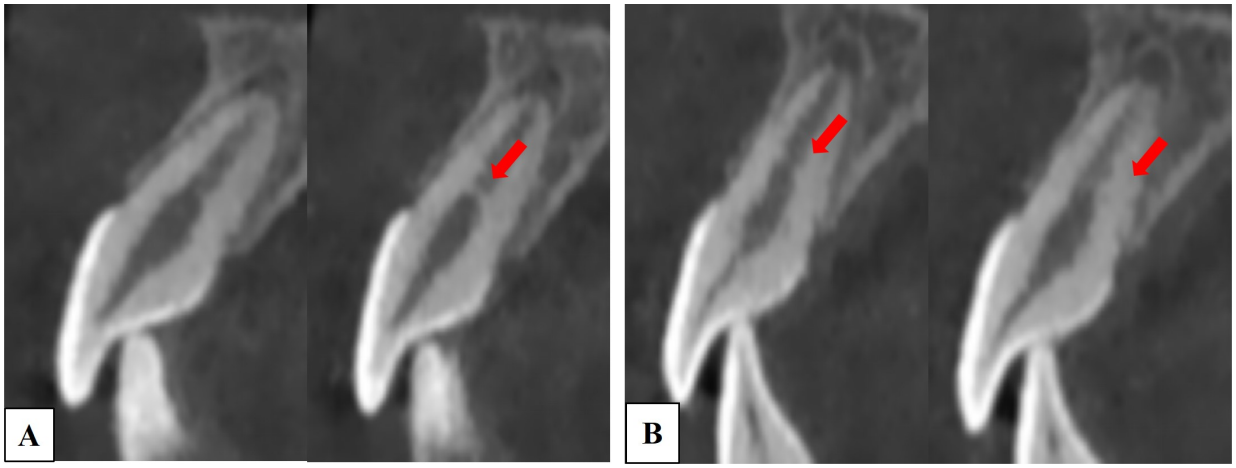

FIGURE 9. Sagittal CBCT images of different cross-sections of 16-month follow-up. The fracture line healed with hard tissues and suspected partial calcification at the fracture site in tooth #11 and 21. (A) Tooth #11; (B) Tooth #21.

FIGURE 10. Follow-up images at 16 months showing the panoramic radiography of the overall oral health condition and the mesial inclination of tooth #46.

diameter of the pulp lumen at the fracture site, are the main pre-injury factors influencing the healing of root fractures [16, 17]. This is probably due to the wider root canals and improved vascularity that help with pulp revascularization at the fracture site [6]. Hence, radiographs play a significant role in treating dental injuries, especially for CBCT, which can provide more distinct visualizations of the location, extension and direction of root fractures. CBCT can provide a basis for diagnosis and determining a treatment plan, as well as offering a point of reference for prognosis and comparison at follow-up visits [12]. Thus, CBCT is considered for follow-up examinations when necessary, in instances such as to determine the presence or absence of pulp and periodontium healing [18]. However, it should be noted that all professionals should follow the ALADAIP, which was introduced to state that the radiation exposure must be as low as Diagnostically Acceptable being Indication-oriented and Patient-specific [19]. Personalized optimization should be taken into consideration. In this case study, we only used CBCT twice at an interval of 16 months apart. The purpose was to confirm the direction of the fracture for a better treatment plan and prognosis at the first visit. The second time was to confirm the healing pattern for the consideration of further orthodontic treatment since the outcome was beyond expectation.

As for the healing responses, hard-tissue repair, which entails the union of the root pieces and restoration of original root length and periodontal support, is the ideal type of healing [20].

In a previously reported major study, the hard-tissue repair was found to occur in 30 percent of the 400 investigated teeth with fractured roots [15]. It is possible to identify this healing reaction six weeks after the injury [21]. Hard tissues that form in between fractured root segments usually have positive outcomes [22]. In our reported case, the 16-month follow-up CBCT images revealed evident hard-tissue repair in at least part of the intersegmental space, with ongoing root development, a healthy periodontal ligament and no large diffuse calcifications in the root canal. These results indicate a positive prognosis for both teeth.

Dental caries represents one of the most common oral diseases affecting people. They are more prevalent in younger

people and frequently occur in childhood [23]. In this present case, although the patient came for a dental visit due to the injured teeth, the treatment was not restricted to that area. The child's dental health was thoroughly evaluated to devise a comprehensive treatment plan. A dental restoration is typically necessary if a lesion has been cavitated, particularly if dentin is involved [24]. In our reported case, pulpectomies and restorations with composite resin or glass ionomer were performed to improve her oral health conditions. Additionally, a space maintainer was also placed to avoid space loss problems.

The success of the therapy largely depends on follow-up appointments [23], regardless of whether the issue is traumatized teeth or the state of oral health condition. Therefore, the significance of follow-up visits should be emphasized to parents [25]. We instructed the parents and children about the importance of oral health to foster good oral hygiene practices, quickly improve oral health conditions, and direct active and frequent follow-up visits starting from the first passive appointment for children with dental trauma. Emphasizing the importance of oral health care practices such as effective brushing, flossing and limiting the intake of sweet foods during follow-up visits can help the children and parents establish correct oral health habits.

4. Conclusion

In conclusion, conservative management of root fractures of young permanent teeth tends to yield a good prognosis. Preserving vital pulp, even in cases of delayed treatment, might be the first option for treating root-fractured teeth without evident signs of pulp inflammation, positively influencing the maintenance and growth of natural dentition. Treatment plans should consider overall health conditions, including instructions on oral hygiene to aid in healing root-fractured teeth and improve oral health.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

AUTHOR CONTRIBUTIONS

QS, JL, RZF, NQR and KW—developed the treatment plan. QS—performed the treatment. QS and NZ—wrote the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The need for ethical approval was waived by the Medical Ethics Committee of School and Hospital of Stomatology, Kunming Medical University, since this was a case report without researches or clinical trails. Written informed consent was obtained from the patient's parents.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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