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Management of crown fractures with different pulp treatments and Re-attachment technique: case series

Tulin Tasdemir[1*], Pınar Serdar Eymirli[1], Tulin Ileri[1], Cansu Ozsin Ozler[1] and Melek Dilek Turgut[1]

Abstract

Background Crown fracture is a type of traumatic injury that mostly affects the maxillary incisors. Depending on the involvement of the pulp, crown fracture may occur as complicated or uncomplicated and constitutes 26–76% of dental injuries in the permanent teeth. The effective treatment of crown fractures should aim to gain optimal aesthetics and function by preserving the vitality of the tooth. There have been case reports in the literature regarding pulpotomy and reattachment techniques in traumatized teeth. However, there has been no case series presenting different endodontic treatments performed with different current materials along with the reattachment technique. The aim of the current case series is to present treatment approaches of 3 crown fracture cases with different pulp treatments and re-attachment technique.

Case presentation In all cases the patients were 8 years old boys. In the first and third cases, complicated crown fractures involved upper central incisors. After endodontic treatment with Cvek pulpotomy, the teeth were restored using Biodentine in case 1 and MTA in case 3. In the second case, uncomplicated crown fracture of the lower central incisor was treated with indirect pulp capping. In all cases, the fractured crown parts were re-attached and the patients were scheduled for recall appointments.

Conclusions Re-attachment technique offers aesthetic, functional and economic treatment option by long-term preserving the anatomic form, color and surface texture. The evaluation of the pulpal status before the reattachment technique and application of the proper pulpal treatment influences the prognosis of the tooth.

Keywords Reattachment, Traumatic dental injury, Vital pulp therapy

*Correspondence:
Tulin Tasdemir
dt.tulintasdemir@gmail.com
[1]Faculty of Dentistry, Department of Pediatric Dentistry, Hacettepe University, Altindag, Ankara 06100, Turkey

Introduction

Dental trauma is one of the most significant issues in pediatric dentistry. Traumatic dental injuries occur most frequently in preschool and school years as well as in young adults [1]. It has been estimated that about half of children may suffer a dental injury by the time they reach 18 years old [2]. Among the dental injuries in permanent teeth, 26–76% of them constitute crown fractures [3].

Crown fracture is a type of traumatic injury in which the maxillary anterior teeth are mostly involved whereas the mandibular incisors are rarely affected. While crown fractures involving enamel and dentin tissue are called uncomplicated crown fractures, crown fractures involving also pulp tissue are called complicated crown fractures [4]. Treatment options for complicated crown fractures include direct pulp capping, amputation (partial or cervical) and root canal therapy depending on the size of the exposed pulp, the time elapsed after trauma, the developmental stage and restorability of the tooth, and clinical and radiographic examination findings [5]. Regardless of the treatment option chosen, the main goal is focused on preserving tooth vitality in vital pulp treatment approaches including pulp capping, partial and total amputation procedures [6].

The International Association of Dental Traumatology, the European Society of Endodontology, and the American Academy of Pediatric Dentistry recommend vital pulp treatments, for complicated crown fractures in both mature and immature permanent teeth [5, 7, 8]. However, if the exposed area is larger than the head of a pin or the time after trauma is more than 24 h, partial or total pulpotomy should be preferred [9–11]. Different materials can be used for pulpotomy based on their biocompatibility, sealing ability and antimicrobial efficacy in contact with the dental pulp. Latest bioactive materials such as Mineral Trioxide Aggregate and Biodentine have excellent biocompatibility and sealing abilities with the added advantage of inducing proliferation of the pulpal cells [12].

After the endodontic treatment, direct or indirect composite restorations, ceramic or metal crowns can be used for the restoration of traumatized teeth [13, 14]. In case the fragments are intact, restoring the tooth with its own broken pieces (reattachment technique) is also one of the treatment options [15]. Reattachment technique preserves the anatomic form, color and surface texture of the tooth over time providing an aesthetic, functional and cost-effective treatment alternative. In addition, compared to resin restorations, the tooth restored with the reattachment technique is more resistant to stain and abrasion [16, 17].

Irrespective of the endodontic and restorative treatment applied, long-term evaluation of the fragment retention, tooth color, pulpal and periodontal health is essential [18]. There have been case reports in the literature regarding pulpotomy and reattachment techniques in traumatized teeth [19–23]. However, there has been no such case series presenting different endodontic treatments performed with different current materials along with the reattachment technique. The purpose of this case series is to present the long-term follow-up of crown fractures treated with different endodontic treatments and reattachment technique.

The present case series was written in accordance with the CARE guidelines [24]. Written informed consents were obtained from the parents. Images were acquired using Canon EOS 250D to document the course of the treatments. No modifications or enhancements were made to the images.

Case 1

A healthy 8-year-old boy was referred to the pediatric dentistry clinic after he had fallen down from his bicycle 2 h ago. In the clinical examination, it was determined that tooth #21 had complicated crown fracture, while tooth #11 had uncomplicated crown fracture (Fig. 1a, b). There was no sensitivity in percussion and palpation, or color change of the teeth. In the radiographic examination, incomplete root development of the teeth was observed without pathological findings (Fig. 1c).

The fractured fragment of tooth #21 was intact and had been kept in milk by the parents (Fig. 1d). In the treatment planning, it was decided to reattach the tooth #21 by using a silicone key in order to reattach the tooth easily and properly [25]. Following local anesthesia (Ultracain D-S, Sanofi-Aventis, Frankfurt, Germany), the fractured fragment was temporarily re-attached with a nanofilled composite (A2 body shade, Filtek Supreme Ultra, 3M ESPE, St Paul, MN, USA). By using vinyl polysiloxane putty (ZetaPlus Intro Kit L, Zhermack, Badia Polesine, Italy) a silicone key was prepared (Fig. 1e). Afterwards, the temporarily reattached fractured fragment was separated from the tooth. A narrow groove was created inside it with a round end tapered diamond bur (Frank Dental, Gmund, Germany) for retention. Cvek pulpotomy by using a silicate-based material Biodentine (Septodont, St Maur-des-Fosses, France) was performed. Type II glass ionomer cement (Nova Glass F, Imicryl, Konya, Turkey) were placed. Beveling was performed on the buccal and lingual surfaces of the tooth, and the fractured fragment was reattached by means of the silicone key, using Prime&Bond Universal (Dentsply Sirona, Konstanz, Germany) and a nanofilled composite resin (A2 body shade, Filtek Supreme Ultra, 3M ESPE, St Paul, MN, USA), (Fig. 1f). Tooth #11 was temporarily restored with a nanofilled composite resin (A2 body shade, Filtek Supreme Ultra, 3M ESPE, St Paul, MN, USA). In order to hide the fracture line, a groove was cut along the fracture

Fig. 1 **(a)** Initial intraoral view **(b)** Palatal view showing the pulp exposure of the tooth #21 **(c)** Periapical radiograph **(d)** The fractured fragment of the tooth #21 **(e)** Temporarily reattachment with the composite and the silicone key **(f)** Reattachment by means of the silicone key **(g)** Final restoration of the tooth #21and temporary restoration of the tooth #11 **(h)** Periapical radiograph after 1week **(i)** The wax-up of the tooth #11 **(j)** The silicone key **k.** Final restoration of the tooth #11 **l.** Periapical radiograph after the procedure **m.** Periapical radiograph after 12 months **n.** Periapical radiograph after 24 months **o.** Periapical radiograph after 30 months

line with a diamond round bur (Frank Dental, Gmund, Germany) and then it was restored with the composite (Fig. 1g). One week later, no pathological finding was found both in the clinical and radiographic examination (Fig. 1h). In the same session, it was decided to use the mock-up technique for the restoration of the tooth #11. A wax-up and a silicone index was prepared (Figs. 1i, j). The lingual matrix was first seated to ensure proper fit, followed by the application of a thin layer of a nanofilled composite resin (A2 body shade, Filtek Supreme Ultra, 3M ESPE, St Paul, MN, USA) onto the matrix and subsequently onto the tooth surface. The tooth was then incrementally restored with the composite resin. Finishing and polishing procedures were performed with Sof-Lex discs (3M ESPE, St Paul, MN, USA) (Fig. 1k, l). The patient was scheduled for regular follow-up appointments. In the 12th month follow-up radiograph, it was seen that apexogenesis of both teeth has continued (Fig. 1m). The root development of the teeth was completed after 24 months (Fig. 1n). After 30 months, the patient's clinical and radiographic examinations revealed no pathological findings (Fig. 1o).

Case 2

A healthy 8-year-old boy was referred to the pediatric dentistry clinic with the complaint of tooth fracture caused in a collision with his friend at school 2 h ago. Clinical examination revealed that tooth #31 had uncomplicated crown fracture and tooth #21 had enamel fracture (Fig. 2a). The teeth had no sensitivity in palpation or percussion and no mobility. In the radiographic examination incomplete root development of the tooth #31 was observed with no fracture or pathology. The fractured crown fragment had been kept in tap water until referral. In the treatment planning, indirect pulp capping followed by reattachment of the fractured fragment was planned. In the fractured fragment, a groove was created with a round end tapered diamond bur (Frank Dental, Gmund, Germany) for retention [26]. Following local anesthesia (Ultracain D-S, Sanofi-Aventis, Frankfurt, Germany), calcium hydroxide powder mixed with sterile saline solution (Merck, Darmstadt, Germany) was applied onto the reflected pulp. Beveling was performed on the buccal and lingual surfaces of the tooth, and the fractured fragment was reattached using Prime&Bond Universal (Dentsply

Fig. 2 **(a)** Initial intraoral view **(b)** Intraoral view after reattachment **(c)** Periapical radiograph after the procedure **(d)** Periapical radiograph after 3 months **(e)** Periapical radiograph after 12 months **(f)** Periapical radiograph after 24 months

Sirona, Konstanz, Germany) and a nanofilled composite resin (A2 body shade, Filtek Supreme Ultra, 3M ESPE, St Paul, MN, USA). The sharp edges of enamel fracture of the tooth #21 were smoothened (Fig. 2b, c). The patient was scheduled for regular follow-up appointments. During the 2-year follow-up, it was observed that the apex of tooth number #31 had closed and there was no clinical or radiographical pathology (Figs. 2d, e, f).

Case 3

A healthy 8-year-old boy was referred to the pediatric dentistry clinic within 2 h from dental trauma. Clinical and radiographical examination revealed complicated crown fracture involving tooth #11 (Fig. 3a, b, c). The fractured fragment had been kept in milk (Fig. 3d). Cvek pulpotomy and reattachment of the tooth fragment was planned. In order to increase the retention, a groove was created inside the fractured fragment with a round end tapered diamond bur (Frank Dental, Gmund, Germany), (Fig. 3e). After local anesthesia (Ultracain D-S, Sanofi-Aventis, Frankfurt, Germany), Cvek pulpotomy was performed (Fig. 3f). MTA (Angelus, Londrina, Brasil) and glass ionomer cement (Nova Glass F, Imicryl, Konya, Turkey) were placed on the pulp, respectively (Fig. 3g). Beveling was performed on the buccal and lingual surfaces of the tooth, and the fractured fragment was reattached using Prime&Bond Universal (Dentsply Sirona, Konstanz, Germany) and a nanofilled composite resin (A2 body shade, Filtek Supreme Ultra, 3M ESPE, St Paul, MN, USA),). In order to hide the fracture line, a groove was cut along the fracture line with a diamond round bur (Frank Dental, Gmund, Germany) and it was restored with the composite (Fig. 3h). The patient was recalled every six months for clinical and radiographical examination. After the end of one year, there was no clinical or radiographical pathology (Figs. 3i, j, k).

Discussion

It has been reported that maxillary central incisors are the most commonly affected teeth and boys are more prone to trauma than girls [27, 28]. In this case series, two traumatized teeth were maxillary central incisors, and all patients were boys, in accordance with the aforementioned results. In addition, many studies have revealed that children between the ages of 8–10 years are the most commonly affected by dental trauma [27, 29, 30]. In the current cases, all of the patients were 8 years of age, in consistent with the literature.

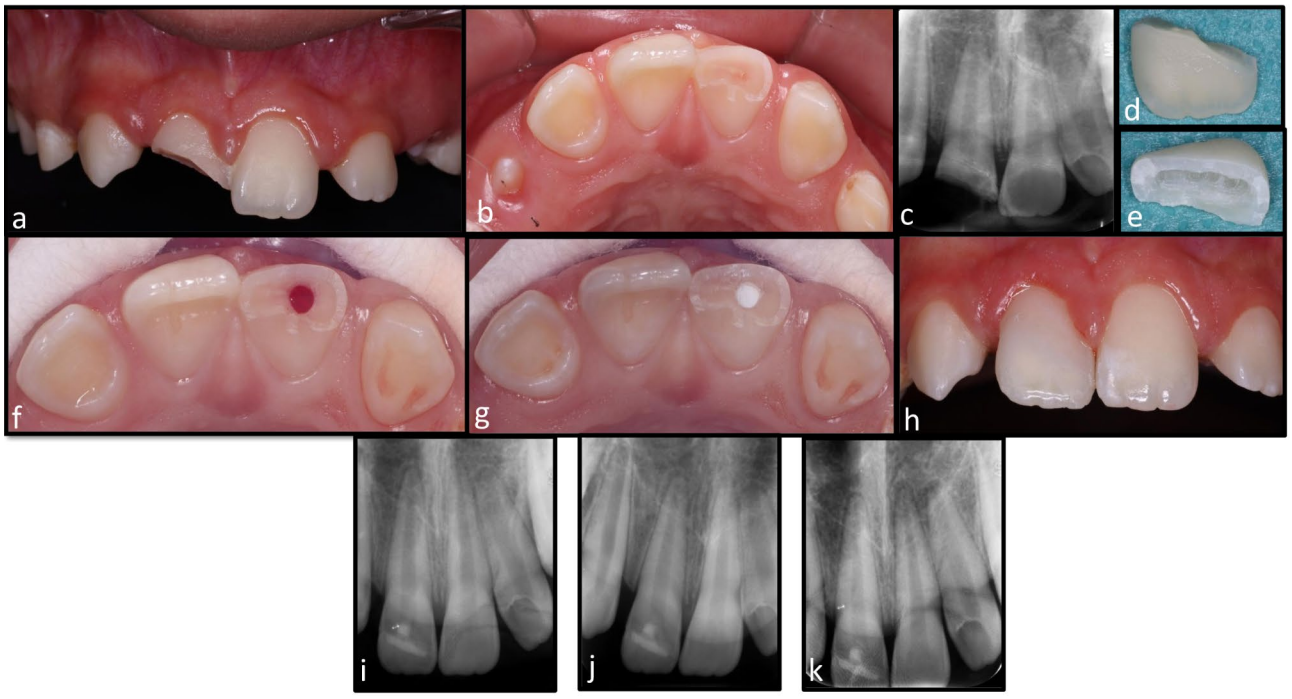

Fig. 3 **(a)** Initial intraoral view **(b)** Palatal view showing the pulp exposure of the tooth #11 **(c)** Periapical radiograph **(d)** The fractured fragment of the tooth #11 **(e)** Prepared groove inside the fractured fragment **(f)** Cvek pulpotomy **(g)** Placement of MTA and glass ionomer cement **(h)** Reattachment of the fractured fragment **(i)** Periapical radiograph after the procedure **(j)**Periapical radiograph after 3 months **k.** Periapical radiograph after 12 months.

In cases 1 and 3, the fractured fragments were kept in milk, while in case 2, it was kept in water. Trivedi et al. [31] evaluated the fracture resistance of reattached fragments with a nanohybrid flowable composite stored in different storage environments. In this study, milk and fresh tender coconut water were found as the best storage media. The authors attributed the result to the greater osmolality and higher content of water in milk causing better dentin wetting properties, thus resulting in the formation of better resin tags [32]. In all of the current cases no clinical or radiographical pathology was detected during the observation period. However, more cases with longer follow-up are needed to reach a conclusion.

By preserving the vitality of the teeth with incomplete root development, complete physiological apical closure, thickening of the root walls, and the ideal crown/root ratio are provided [9, 11]. The teeth get stronger and more resistant to trauma along with the continuing dentin formation and thickening of the dentinal walls [9]. It has been reported that partial pulpotomy provides preservation of cell-rich coronal pulp tissue, faster healing, and preservation of the physical bond between coronal dentin and pulp. It has been stated that the loss of the physical bond between the coronal pulp and dentin due to the removal of the coronal pulp by cervical pulpotomy increases the risk of cervical fracture [33]. Based on the aforementioned evidences, Cvek pulpotomy was preferred in two current cases with open and closed root apices. Both cases demonstrated no clinical or radiographical pathology during their follow up periods of 30 months and 1 year, respectively. This finding is in accordance with the consensus statement of the International Association of Dental Traumatology and the American Academy of Pediatric Dentistry recommending partial pulpotomy for complicated crown fractures [5, 34].

Calcium hydroxide and MTA are commonly preferred agents in the endodontic treatment of vital pulp [35]. Calcium hydroxide ions cause coagulation necrosis below the application area, then cells in the pulp tissue are differentiated from odontoblast-like cells and pre-dentine is synthesized. The effect of MTA on pulp and periapical tissue is similar to the effect of calcium hydroxide. However, it has been reported that the risk of pulp necrosis is less with MTA than that of calcium hydroxide due to bacterial invasion in the tunnel defects under calcium hydroxide. In addition, it has been revealed that when MTA is used, the dentine bridge is thicker and more regular, the rate of bridge formation is greater and the underlying tissues are better protected with less inflammation and hyperemia due to the excellent impermeability [36]. Disadvantages of MTA use include tooth discoloration, long hardening time and high cost [37]. Biodentine is considered a calcium silicate cement promoted as a "dentin replacement" material. A 91% success rate was reported for partial pulpotomy using Biodentine in 48 traumatized maxillary central teeth [38]. In their

study, Katge et al. reported that both MTA and Biodentine, used as direct pulp capping agents, showed success rate of 98% [39]. In another study, it was stated that vital pulp treatments with Biodentine in two cases with complicated crown fractures were successful both clinically and radiographically, without colour change in the 48-month follow-up. The authors concluded that Biodentine was a good alternative to MTA [40]. In the current cases, neither MTA nor Biodentine caused discoloration.

Various reattachment techniques have been described in the literature, such as simple reattachment without any additional preparation or reattachment following the preparation of circumferential chamfers and internal grooves in the dentin [41–43]. A systematic review concluded that simple reattachment can be considered the preferred technique when there is complete adaptation of the fractured fragment [42]. To the authors' knowledge, there has been two reports describing reattachment with a silicone key. It was reported that silicone key enabled better handling of the fragment [25, 44]. It may be speculated that a silicone key may be used as a guide especially in reattachment of the fragments presenting some structure loss and/or incomplete adaptation. Nevertheless, further clinical case reports and/or studies are required on this suggestion.

A variation of the simple reattachment technique consists of adding composite resin to the fracture line in case the line is still visible after reattachment [18]. Chazine et al. [45] reported that beveling performed on the vestibular and palatal surfaces of the teeth significantly increased the shear bond strength. In the present case series, beveling was performed on the buccal and lingual surfaces of the fractured teeth, and reattachment was made by creating a retention groove in the fractured fragments. Although composite resin was added to the fracture line in cases 1 and 3, this step could not be performed in case 2 because of the non-cooperative behavior of the patient. This may be considered as one of the limitations of the present case series although no pathology was detected both clinically and radiographically. Long-term clinical studies involving simple reattachment without any preparation and reattachment with preparation of chamfers or grooves are needed in order to reveal the clinical success of different reattachment techniques.

The other limitation of the current case series may be considered as the relatively short-term follow up of the case 3 compared to those of the other two cases. In a study where the follow-up period for traumatized teeth varied from 1 to 12 years, pulp necrosis was reported to be the common complication, occurring in 34.2% of cases, with the majority classified as late necrosis appearing several years after the injury [46, 47]. Although all teeth in the current cases responded normal to cold test and there were no clinical or radiographical pathology, it has been planned to follow up all patients for 4 years in terms of pulp necrosis, root resorptions or pulp canal obliterations, in accordance to the guideline of the European Society of Endodontology [48].

The advantages of the reattachment technique like providing more esthetic appearances, being faster and able to complete the treatment in a single appointment, and being more economical were underscored. In addition, the long-term clinical success achieved in all cases emphasized the critical importance of timely dental intervention within two hours of trauma-a goal often emphasized but not consistently achieved in practice. There have been case reports in the literature regarding pulpotomy and reattachment techniques in traumatized teeth [19–23]. However, there has been no such case series presenting different endodontic treatments performed with different current materials along with the reattachment technique. In this paper, we just aimed to present different clinical scenarios to highlight the complexity of managing both complicated and uncomplicated crown fractures in mature and immature teeth that a clinician can encounter in the daily practice, and provide guidelines for their approach.

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Conclusion

In this case series, the efficacious management of crown fractures in pediatric patients through conservative dental techniques, emphasizing the importance of timely intervention and follow-up was presented. Each case highlighted the successful application of restorative materials in association with different endodontic treatments and reattachment technique in order to promote healing and ensure structural integrity. The obtained successful clinical and radiographical outcomes demonstrated the viability of reattachment technique, even in complicated cases, preserving the anatomic form, color and surface texture of the crown fractures as well as facilitating continued root development. The evaluation of the pulpal status before the reattachment technique and application of the proper pulpal treatment influences the prognosis of the tooth positively.

Abbreviations

MTA Mineral Trioxide Aggregate
PRICE Preferred Reporting Items for Case Reports in Endodontics

Supplementary Information

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Supplementary Material 1

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Author contributions
Tulin Tasdemir, Pınar Serdar Eymirli and Melek Dilek Turgut contributed to the conception and design of the work. All authors contributed to the clinical treatment. Tulin Tasdemir contributed to the acquisition and drafted the manuscript. Pınar Serdar Eymirli, Tulin Ileri, Cansu Ozsin Ozler and Melek Dilek Turgut contributed to the analysis, interpretation of data and revised the manuscript. All authors approved the final manuscript.

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Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This case series were conducted in accordance with the Declaration of Helsinki regarding medical protocols and ethics. Clinical trial number: Not applicable.

Consent for publication
Informed consents were obtained from the parents to publish this case series.

Competing interests
The authors declare no competing interests.

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