



Re-attachment of a Fractured Maxillary Central Incisor: A Case with Two Years Follow-up

Muhammad Khiratti Mat Zainal ^a , Dalia Abdullah ^{b*} 

^a Hospital Angkatan Tentera Tuanku Mizan, Dental Specialist Clinic, Wangsa Maju, Kuala Lumpur, Malaysia; ^b Department of Restorative Dentistry, Faculty of Dentistry, Universiti Kebangsaan, Malaysia

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*Corresponding author: Dalia Abdullah, Department of Restorative Dentistry, Faculty of Dentistry, Universiti Kebangsaan Malaysia, Malaysia.

E-mail: daliaabdullah@ukm.edu.my



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ABSTRACT

Crown re-attachment is the most conservative treatment that can be used to restore fractured tooth, even in an emergency situation. The re-attachment maintains original contour and incisal translucency of the tooth, and reduces the chair time and cost. In case of crown fracture with pin-point pulp exposure, irritation to the pulp should be minimised and consideration must be taken for pre-treatment pulpal status, choice of pulp capping material, choice of bonding system and treatment sequence during crown re-attachment procedures. This article reported a crown fracture case with pin-point pulp exposure that was treated using crown re-attachment with direct pulp capping. At two-year follow-up, the tooth was asymptomatic, remained functional, vital, and the appearance of restoration was acceptable with no colour change to the crown.

Keywords: Dental Pulp Capping; Dental Pulp Exposure; Dental Trauma; Permanent Tooth

Introduction

Complicated crown fracture can be defined as a fracture of the crown involving enamel, dentine and exposes the dental pulp [1]. The incidence of complicated crown fractures varies from 2% to 13% of all dental injuries and the most frequently involved tooth is the maxillary central incisor [2]. Falls, traffic accidents, domestic violence, fights, and sports are the most common causes [2, 3].

However, complicated crown fractures of permanent teeth possess both endodontic and restorative challenges [4]. The type of pulpal therapy to be performed relies on the root development stage, the size of the exposure, and the time elapsed between the injury and the emergency treatment. Several other variables, such as the health of the pulp before the trauma, the patient's age, the presence of a concomitant luxation injury, the effect of the surgical procedures, and the type of pulp-capping agent used may also affect the selection of the most suitable treatment [5]. The degree of pulp exposure may differ from a minute pinpoint exposure to

complete coronal pulp exposure. Thus, the aim of pulpal treatment should be the preservation of a vital, non-inflamed pulp, biologically walled off by a continuous hard tissue barrier [4]. In most instances, this can be achieved by pulp capping, partial pulpotomy (Cvek) or full pulpotomy [1].

On the other side, at the restoration level, the choice of the aesthetic restorative treatment of fractured anterior teeth remains the greatest challenge for the dentist [6]. Different methods and techniques have been used to restore fractured teeth, including pin retained resin, orthodontic bands, stainless steel crowns, porcelain jacket crowns, and complex ceramic restorations. All of these restorations, however, require substantial tooth preparation and were not aesthetically adequate; in addition, they cannot be used in an emergency aesthetic condition [7].

Re-attachment of the fractured coronal fragment to the remaining tooth structure has been shown to be an excellent alternative to conventional restorations such as resin composite build-up, veneer, or crown [8]. This procedure may offer several benefits such as improved aesthetics since enamel's original



Figure 1. A) Frontal view showing the fractured tooth #11; B) Palatal view showing a small pulp exposure of approximately 1 mm; C) The fractured fragment of tooth #11 brought in by the patient; D) Pre-operative periapical radiograph showing the level of the fractured crown; no sign of periapical infection was noted

shape and colour, brightness and surface texture are preserved [9]. Besides, the incisal edge wears at a similar rate to adjacent teeth, whereas, a composite restoration will likely wear more rapidly [10]. Furthermore, this technique is less time-consuming and provides more predictable long-term wear, and results in a positive psychological response. It also allows restoration of the tooth with minimal sacrifice of the remaining tooth structure [5]. Despite the latest developments in adhesive materials and restorative techniques, there is no restorative material that can reproduce the aesthetic, functional needs and the natural dental structures [11]. Therefore, re-attachment should be regarded the treatment of choice as the most conservative therapy strategy when the broken fragment is available [10].

Case Report

An 18-year-old female patient attended the Primary Care Clinic of Universiti Kebangsaan Malaysia (UKM) with a chief complaint of a crown fracture of the right maxillary central incisor. She sustained the injury as a result of a fall on the slippery floor at her college, 4 h prior to the visit. The fractured tooth segment was recovered at the site of the injury and was kept in her handkerchief. Past medical history was non-contributory. At her last dental visit, she had been advised by her orthodontist to undergo the orthodontic treatment to correct her malocclusion.

Extraorally, there was no apparent sign of trauma to the soft tissues. Intraoral clinical examination revealed a complicated crown fracture (incisal one-third) of the right maxillary central incisor (Figure 1A), with a small pulp exposure of approximately 1 mm (Figure 1B). Tooth #11 was not tender both on palpation and percussion, and responded to cold test Endo-Frost Cold Spray (Roeko, Langenau, Germany) and electric pulp test Digitest™ Pulp Vitality Tester (Parkell Inc, New York, USA). The remaining maxillary and mandibular anterior teeth were all intact. All anterior maxillary teeth were tested for pulp sensibility tests and they all responded to cold and electrical pulp tests. Soft tissue around the affected tooth and adjacent teeth was normal without any swelling, abscess, draining sinus or loss of stippling of gingiva. There was no

bleeding on probing and the periodontal probing depth was within normal limit (2-3 mm) with no mobility. The crown fragment was in good condition and it fitted reasonably well on the fractured tooth (Figure 1C). Periapical radiographic examination revealed horizontal fracture line on the crown of the tooth, complete root development, closed apices, no periapical pathology, and absence of root or alveolar bone fractures (Figure 1D). After history taking and examination, the patient and the mother were provided with several treatment options and associated benefits and disadvantages of each. They opted to have the crown fragment re-attachment with direct pulp capping. The procedure was explained to them and informed consent was obtained.

The treatment was initiated by administering one cartridge of local anesthesia (2% Scandonest with 1:20,000 levonordefrin) *via* buccal infiltration. The affected tooth and adjacent teeth were isolated with rubber dam (Figure 2A). The pulp exposure was carefully irrigated with alternate solutions of normal saline and 0.12% chlorhexidine gluconate (PerioGard Oral Rinse; Colgate, Canton, MA, USA). Direct pulp capping was performed by applying self-hardening calcium hydroxide (CaOH) (Dycal; Dentsply Caulk, Milford, DE, USA) on the exposed pulp (Figure 2A). A layer of resin-modified RMGIC (Vitrebond; 3M Espe, St Paul, MN, USA) was placed over the pulp capping material and then photo polymerized for 40 sec. The remaining tooth structure was acid etched using 37% orthophosphoric acid (Ultra-Etch; Ultradent, SJ, UT, USA) for 15 sec. The acid was removed by rinsing with water, and the surface was gently dried with cotton pellets. A bonding agent was applied on the tooth structure with an ethanol-based total-etch adhesive system (Adper Single Bond Plus, 3M ESPE, St. Paul, MN, USA) and was cured with visible light for 10 sec [12]. Most attention was given to the dentin bonding agent so as not to cause any thickening on the surface.

Tooth fragment was stored in distilled water for 30 min before being repositioned to rehydrate it [13]. To ease the handling, it was secured by a “pick-and-stick” device (the palatal surface of the fractured segments was glued with to a handbrush using sticky wax (Figure 2B). The fractured surface was treated with 37%

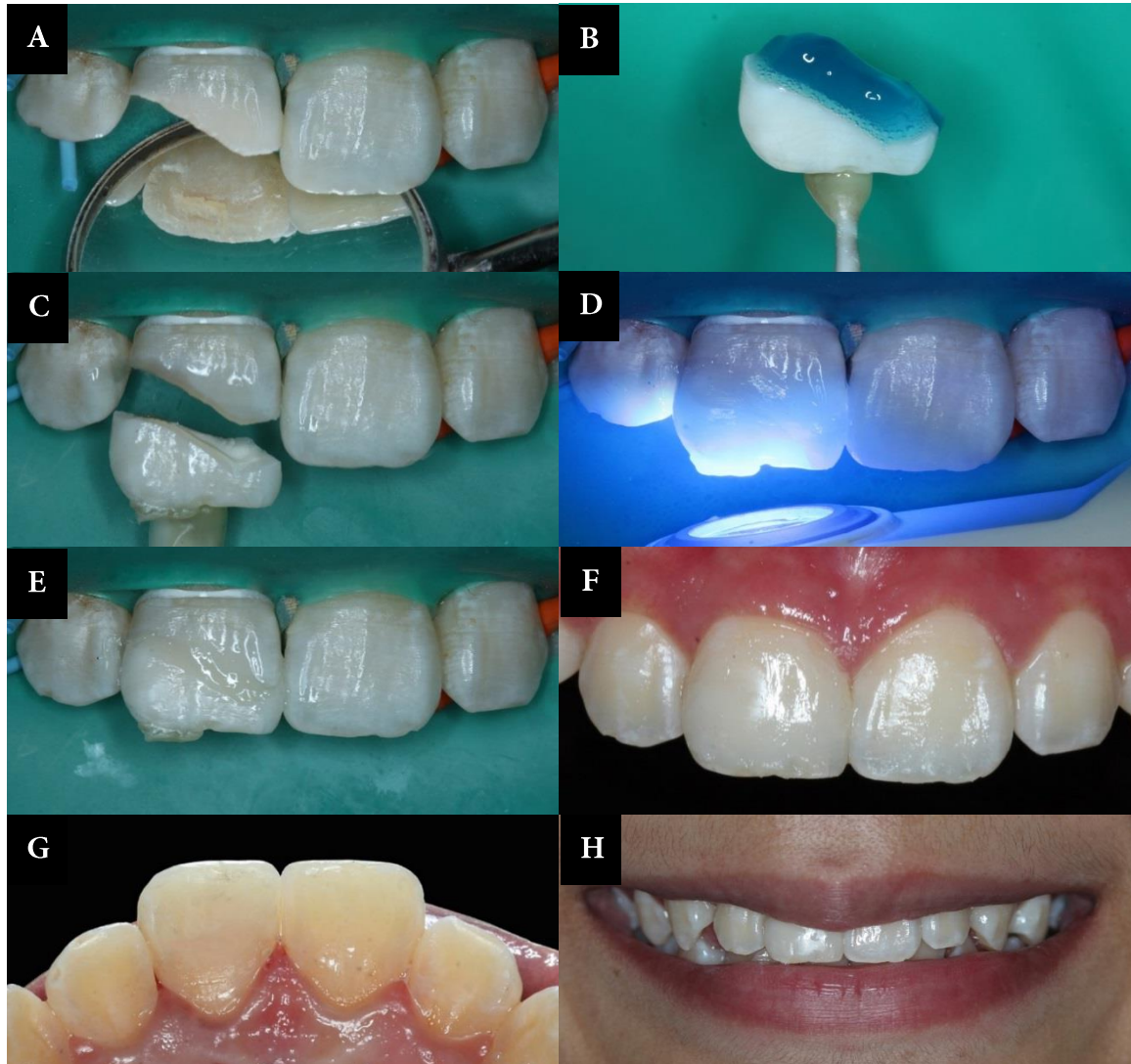


Figure 2. A) Operating field isolation by a rubber dam (multiple isolation) and CaOH placed; B) Fragment attached to a “pick-and-stick” device and etched; C) Fractured fragment repositioned exactly in its original place; D) Flowable composite resin was injected between the tooth and fragment and light-cured for 20 seconds on each surface. This effectively attached the fragment in place; E) A V-shaped external ‘double chamfer’ margin of 1mm coronally and apically to the fracture line was created using a diamond round bur. A transparent A2 shade of composite resin is then applied and cured along the fracture line; F) Frontal view of tooth #11 after polishing of the composite surface; G) Palatal view of tooth #11 after polishing of the composite surface; H) Smile view of tooth #11 after the completion of re-attachment procedure

phosphoric acid gel for 30 sec (Figure 2B), followed by delicate rinsing [12]. The adhesive system was then applied to the etched surface and was light cured for 10 sec [12]. The fractured segment was then accurately placed on the tooth, paying special attention to the fit between the segments (Figure 2C). When the original position had been re-established, the flowable composite resin (Tetric Flow; Ivoclar Vivadent, Schaan, Liechtensien) was applied to the fracture surfaces of both parts, spread over the surface with a dental probe, and the fragments were reattached to their places. The overflowing resin composite was removed and cured with visible light for 20 sec from both the labial and palatal surfaces (Figure 2D) [14]. Subsequently, 1 mm coronal and apical to the fracture line, a

V-shaped external ‘double chamfer’ margin was created using a diamond round bur (Figure 2E). The double chamfer was etched, applied with adhesive resin and restored with a composite resin (Filtek Z350 XT, A2 shade, 3M ESPE, St. Paul, MN, USA). The composite was cured for a time of 20 sec per increment [15].

The margins were polished with diamond burs and a series of Sof-Lex disks (3M ESPE, St. Paul, MN, USA) and polishing paste (Diamond Polish; Ultradent Products, SJ, UT, USA) (Figures 2F-H). The occlusion was checked and adjusted, and the patient was dismissed after receiving instructions to avoid exerting heavy function on this tooth. The patient and the patient’s mother were informed that the re-attachment line might be visible, and, if



Figure 3. A) Radiographic image of the tooth after six-month showing no sign of periapical infection; B) Two-year follow-up showing tooth #11 with surrounding healthy soft tissues. Patient had undergone orthodontic treatment at this time to improve her occlusion; C) Radiographic image of the tooth after two-year review. No sign of periapical infection was detected

necessary, this could be managed in future visits. The patient was reviewed after one week, one month, six months (Figure 3A) and two years after treatment. After two years, the restoration was functional and aesthetically acceptable. Fixed orthodontic bracket was attached on labial surface of tooth #11. Tooth #11 was found to be vital by pulp sensibility tests, and there was no sign of periodontal or periapical pathology in the periapical radiograph (Figure 3B, 3C).

Discussion

The complicated crown fracture in this case requires careful consideration regarding the pulpal status and pulp capping materials during crown's re-attachment procedures besides crown re-attachment procedures itself. The options to treat the exposed pulp of complicated crown fracture with a closed apex include; direct pulp capping, partial pulpotomy or full pulpotomy followed by root canal treatment [1]. Partial pulpotomy is the preferred choice of treatment when the pulp exposure is large (0.5- 4.0 mm) [16, 17] and there is difficulty to assess the signs and level of pulp inflammation [16, 18]. Cvek reported a 96% success rate in cases of complicated crown fractures treated by partial pulpotomy with 30 h between trauma and treatment and a follow-up of the cases between 14 and 60 months [19]. Direct pulp capping is indicated mostly in the case of a very small pulpal exposure in which the procedure can be carried out shortly after the injury, *i.e* within 24 h [20]. Success rate for direct pulp capping has been reported to be lower compared to partial pulpotomy [18] but this could be due to insufficient removal of the contaminated superficial layer and lack of disinfection of the exposed pulp [18].

In the present case, direct pulp capping procedure was chosen and was performed by placing CaOH directly over the exposed pulp tissue. This procedure was indicated because it is conservative, the pulpal exposure was small and the time elapsed from the exposure to the treatment was within 24 h. This procedure was also chosen considering the age of the patient, with no concomitant luxation injury and maturity of the root [5]. To

ensure a good outcome for direct pulp capping, this procedure has several clinical steps. The first step is ensuring a dry operative field by placing rubber dam to isolate the tooth being treated. This is to prevent any bacterial contamination which could further cause pulpal irritation and subsequently pulpal necrosis [21] and also prevent saliva contamination that can affect the bonding process of re-attachment [22]. The area of exposed pulp was carefully irrigated with alternate solutions of normal saline and 0.12% chlorhexidine gluconate [23].

The most commonly used pulp capping is CaOH. Its high pH and low water solubility are responsible for its antimicrobial activity and its ability to induce hard tissue formation [24]. When placed over the vital pulp, pure CaOH causes a superficial tissue necrosis, approximately 1-1.5 mm in depth [24]. This low-grade irritation from coagulation necrosis will induce defensive reactions in the pulp, resulting in formation of a demarcating hard-tissue barrier [23, 24]. The underlying tissue seems to react to this irritation by producing collagen that is subsequently mineralized, while the coagulated tissue is calcified, which is later followed by differentiation of dentin. However, pulp healing may be threatened by microleakage of defective restorations, since all CaOH compounds gradually lose their antibacterial ability [23]. To encounter this problem, in this case, CaOH was placed over vital tissue and then covered with resin-modified glass-ionomer cement (RMGIC) liner to protect the material. Mineral trioxide aggregate (MTA), a bioactive material has become a frequently used pulp capping material due to its biocompatibility and hard tissue conductive and inductive properties which a good protective barrier against bacterial penetration [23]. Bioactive property of MTA is found to be superior (when compared with CaOH and other materials) in dentin bridge formation after pulp capping and pulpotomy procedures [24]. However, because of the unavailability of the material in the clinic during that time, CaOH was a suitable option and well-tested pulp dressing agent which repeatedly had predictable results in a non-inflamed pulp under a well-formed hard-tissue barrier [24].

If the pulp is minimally exposed, acidic etchant should not be in direct contact with pulp. When the etchant is in contact with the exposed pulp, hemostatic effectiveness and resin sealing is found to be greatly reduced [25]. Thus, in this case, acidic etchant was applied after placement of self-hardening CaOH (Dycal) and RMGIC. The layer of RMGIC provides protection to the CaOH lining. RMGIC can be etched as it provides an added micromechanical retention for composite resin [27].

Re-attachment of the fractured tooth segment is one of the best techniques for the restoration of a fractured anterior tooth [9]. It is aesthetically more predictable for translucency, opalescence, fluorescence, characterizations and texture of the natural tooth surface [9]. In addition, it is less time-consuming compared with other direct and indirect restorations. The rate of wear and abrasiveness is the same as that for the intact tooth, while composite resin will be abraded more quickly than enamel by the opposing dentition [26]. Moreover, the technique also restores stress resistance comparable to intact tooth tissue and, thus, in case of further dental trauma, is preferable to composite restoration [27]. The technique also prevents the patient, especially children and young adolescent and their parents, from an emotional trauma of loss of a body part. They are at least satisfied of the original fragment being used in the restoration of their fractured tooth [28].

In this case, a flowable composite resin was used to re-attach the fractured incisal part to the tooth. An external double chamfer technique along the fracture line was then created and filled with composite resin. This procedure has been shown to provide better strength compared to simple re-attachment and prevents fragment detachment [23, 29]. It has been shown that a simple re-attachment with no further preparation of the fragment or tooth was able to restore only 37.1% of the intact tooth's fracture resistance, whereas a buccal chamfer recovered 60.6% of that fracture resistance; in addition, bonding with an over-contour and placement of an internal groove recovered 97.2 and 90.5% of the intact tooth fracture strength, respectively [30].

Most *in vitro* studies on adhesive systems have shown that the type of adhesive system used altered the fracture strength of the re-attached teeth which varied between 40-to 60% of the fracture strength of sound teeth [7, 8]. The sole use of an adhesive system or its combination with materials having higher mechanical properties, such as foldable resins, resin cements and resin composites have led to similar results when the fragment was reattached with no additional preparation [30].

The quality of adaptability and integration between segments is an important factor to be considered in this technique. Regardless of which method is selected, obtaining well-sealed margins between the tooth fragment, composite and tooth interface minimizes further irritation to the pulp. Creating a

double chamfer after the fragment is reattached causes minimal loss of fit as compared to techniques in which the fragment is manipulated before bonding [30]. Besides that, using 'pick-and-stick' device prior to bonding to tooth surface helps to stabilize the fragment to fit the attachment with tooth surface.

Aesthetic problems that might arise from re-attachment procedure include discolouration or degradation of the composite bonding materials at the fracture line or discolouration of the incisal fragment with time [31]. The problem of discolouration of the fracture line is most pronounced in earlier cases of bonding, due to discolouration of the catalyst system of the chemically-cured resin used [32]. This problem has been solved in part by the use of light-cured composite materials due to colour stability and more flexible working time. Besides that, aesthetic has also been enhanced by the use of a double-chamfer preparation along the fracture line after fragment bonding and restoration with a composite resin. Fragment discolouration, usually to a mat white colour, can occur is due to dehydration of the underlying dentin. Reported technique to rehydrate the tooth fragment was by keeping it either in tap water or physiological saline [13]. Re-attachment of the discoloured crown fragment kept in dry condition for 1 week can regain some of its original colour and translucency after 8 days [28]. This result suggests that the re-attachment of the crown fragment should be done even if the crown fragment is discoloured [27].

Studies have shown that prognosis of complicated crown fractures is good [33], and pulp survival following pulp capping varies between 72% and 88% [34]. Furthermore, fragment bonding apparently has not been found to lead to pulpal complications in a larger long-term study [32]. The few cases of pulp necrosis and pulp canal obliteration were all found in relation to concomitant luxation injuries [32]. This low reported complication rate is more likely to be a response to the injury itself than a response to the treatment procedure.

Conclusions

The re-attachment of fractured crown fragment with a bonding technique is an effective method for restoring anterior fractured teeth that offers advantages when compared to composite restorations or ceramic crowns. It provides a viable technique that restores function and aesthetics in a very conservative approach, and it should be considered when treating patients with coronal fractures of anterior teeth, especially younger patients. The best outcome could be expected when the crown fragment is in a single piece and can be re-approximated with its source (remaining tooth) with minimal loss of tooth structure.

Conflict of Interest: 'None declared'.

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