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Clinical Technique/Case Report

Reestablishing Biology, Function, and Esthetics for Fractured, Immature Incisors

NIP Pini • JY Nagata • D Sundfeld-Neto
L Correr-Sobrinho • AdJ Soares • FHB Aguiar
DANL Lima

Clinical Relevance

Dental trauma is a challenge in clinical practice and often needs a multidisciplinary approach for a correct diagnosis and restorative therapy. Pulp revascularization and direct resin composite restorations successfully restored anterior teeth fractures with incompletely formed root apices.

SUMMARY

A seven-year-old boy with enamel-dentin fractures on both maxillary central incisors presented to the Piracicaba Dental School–UNICAMP seven days after the trauma. At the clinical evaluation, there were no clinical signs of pulp exposure, neither tooth was mobile, and both affected teeth presented a positive response to sensitivity tests and a negative response for percussion and palpation. The radiographic examination showed an undeveloped root and opened apex for both teeth. Indirect pulp capping was performed on the left maxillary central incisor, followed by a direct restoration. After one month, the patient complained of pain in the left central incisor, which responded negatively to sensitivity testing. Pulp revascularization was performed only on this tooth and was followed for 18 months. During this period, the left maxillary central incisor did not recover sensitivity, although radiographic examination showed apical closure, a slight increase in root length, and the formation of a mineralized barrier between the root canal and sealing material. The technique achieved its goal of restoring biological aspects,

Nubia Inocencya Pavesi Pini, DDS, MSD, PhD student, Piracicaba Dental School, University of Campinas–FOP/Unicamp, Department of Restorative Dentistry, São Paulo, Brazil

Juliana Yuri Nagata, DDS, MSD, PhD, professor, Federal University of Sergipe, Department of Dentistry, Endodontics Area, Lagarto, Brazil

Daniel Sundfeld-Neto, DDS, MSD, PhD student, Piracicaba Dental School, University of Campinas, Department of Restorative Dentistry, São Paulo, Brazil

Lourenço Correr-Sobrinho, DDS, MSD, PhD, professor, Piracicaba Dental School, University of Campinas, Department of Restorative Dentistry, Dental Materials Area, São Paulo, Brazil

Adriana de Jesus Soares, DDS, MSD, PhD, professor, Piracicaba Dental School, University of Campinas, Department of Restorative Dentistry, Endondontics Area, São Paulo, Brazil

Flávio HB Aguiar, DDS, MSD, PhD, Piracicaba Dental School, University of Campinas, Department of Restorative Dentistry, São Paulo, Brazil

*Débora ANL Lima, DDS, MSD, PhD, assistant professor, Piracicaba Dental School, University of Campinas–UNICAMP, Department of Restorative Dentistry, Piracicaba Dental School, São Paulo, Brazil

*Corresponding author: P.O. Box 52, Piracicaba, São Paulo 13414-903, Brazil; e-mail: deboralima@fop.unicamp.br

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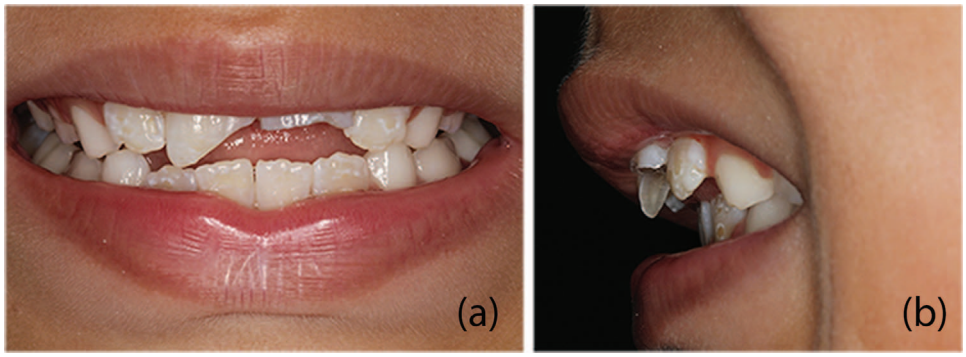

Figure 1. *Initial condition of patient with fracture of both central incisors. (a): Facial view. (b): Lateral view.*

function, and esthetics of traumatized teeth when using this multidisciplinary approach.

INTRODUCTION

Anterior tooth fracture, mainly involving enamel and dentin tissues, is the most frequent dental traumatic injury.[1] Male patients 7 to 15 years old are the most affected,[2-4] and the common etiological factors are falls, sports activities, and traffic accidents.[3] The maxillary incisors are the most commonly involved teeth,[2] especially in patients presenting malocclusion with marked overjet and anterior open bite.[1] In addition, crown fracture of permanent teeth is the most common type of traumatic dental injury.[5] Dental trauma often requires urgent treatment to relieve pain, decrease the exposure of the teeth involved, and restore function, thereby improving prognosis.[6,7]

Dental trauma is of interest to health professionals not only because of its high prevalence but also because of its negative effects on a patient's quality of life.[8] This situation can compromise the emotional state, provide difficulty with eating, negatively influence the appearance of the affected patient, and cause difficulty in speaking clearly.[9,10] Therefore, treating traumatized anterior teeth is integral to restoring normal day-to-day life.[7,11]

The correct diagnosis and evaluation of the case, which frequently involves a multidisciplinary approach, are important to the successful outcome of therapy.[6,7,9] After a traumatic episode, pulp tissue generally loses sensitivity, and a definitive diagnosis must be postponed to avoid unnecessary endodontic treatment. In addition, the diagnosis frequently is more difficult in young patients when considering the incomplete development of the Rachkow plexus, while the patient response may not be reliable because of an immature age. In these situations, a careful diagnosis and delay of endodontic treatment immediately after the trauma is recommended, until the pulp either recovers or presents a definitive sign of deterioration.[12]

The restorative treatment options for dental trauma include direct resin composite restorations, indirect restorations, or reattachment of the dental fragment.[6,13] The choice for treatment is determined by a diagnosis that assesses the extent of periodontal damage, the quality of the remaining tooth structure, and, when applicable, the conservation of the dental fragment.[6,14] The restoration of fractured teeth should reestablish functional and esthetic characteristics, including color, shape, and occlusal contacts.[15] Tooth fragment reattachment is the best option, since it maintains the original characteristics of the teeth.[6,14] In cases in which this treatment is not possible, esthetic materials, such as composite resins, provide excellent results in restoring damaged teeth with minimal sacrifice of additional tooth structure.[1]

Depending on the extension of crown fracture and pulpal damage, endodontic treatment may be necessary. Recently, immature teeth have been treated with pulp revascularization, which has emerged as a promising alternative with more advantages than the traditional treatment of apexification.[16,17] Studies have demonstrated that revascularization promotes root end development and radicular reinforcement, preventing root fractures.[18-20] In addition, this treatment may be performed in one or two sessions without the use of mechanical instrumentation, which could further weaken an immature tooth. This article reports a clinical case in which a multidisciplinary approach, involving endodontics and restorative dentistry, was used to establish a correct diagnosis and to restore maxillary fractured incisors, thereby reestablishing biological, functional, and esthetic factors in a young patient.

CASE REPORT

A seven-year-old male patient presented to the clinic at the Piracicaba Dental School, State University of Campinas–São Paulo, with a visible fracture (Figure

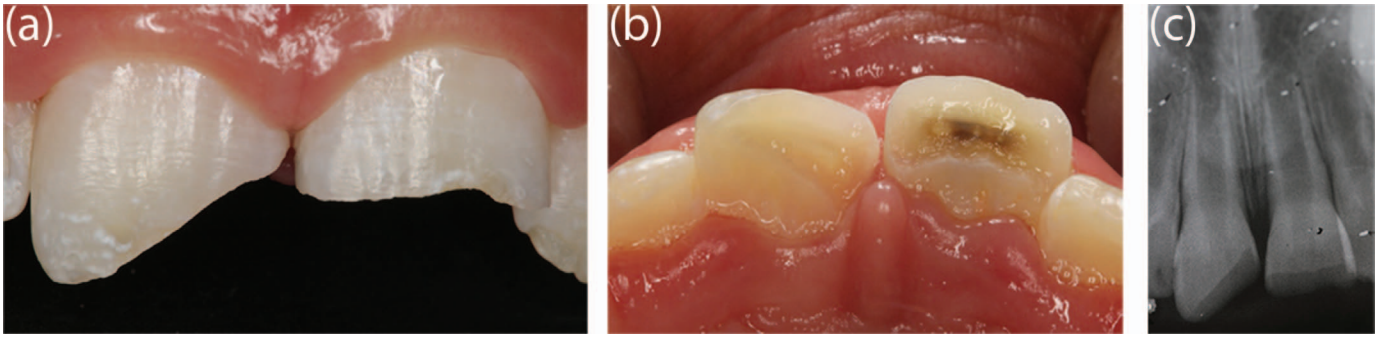

Figure 2. *Clinical (a) and radiographic (b) evaluation of the fractured teeth.*

1) in both maxillary central incisors due to a bicycle accident that happened approximately seven days prior. The patient did not initially complain of pain. After clinical and radiographic examination (Figure 2), the clinician diagnosed a crown fracture including enamel and dentin in both maxillary central incisors without clinical mobility. The patient and his guardian did not save the dental fragments. Clinical examination of the affected teeth determined both to be vital, according to a sensitivity test, and negative for percussion and palpation tests. The radiographic examination showed extensive fracture of the maxillary central incisors, with immature root formation and an open apex, but with normal periapical and periodontal tissues. These results indicated vitality of the damaged teeth, eliminating the need for endodontic treatment at the initial examination. Thus, since there was no pulp exposure, indirect pulp capping of the pulp-dentin complex was suggested for the left central incisor, as this was the least invasive approach.

In the absence of the dental fragments and with partial coronary fracture of the upper central incisors, the restorative treatment was performed using composite resin immediately after the diagnosis. One of the first steps of the direct restoration technique is color selection. This was performed by determining the colors and characteristics of the teeth to be reproduced by the composite resins. In this case, the patient presented with amelogenesis imperfecta, revealing enamel pits and white spots in all of the maxillary anterior teeth, mainly in the incisal third. It was likely that the central incisors were affected too, since the remaining distal incisal angle demonstrated the presence of white stains. These characteristics should be replicated in the restorations to make them as natural as possible and to mimic the restorative material as dental structure. The color was properly selected by inserting a small increment of composite resin on the buccal surface of the tooth, near the region that was to be replaced (Figure 3). The colors selected were A2 and A1 for the medium and incisal thirds of dentin, respectively; Opaque White to reproduce the amelogenisis imperfecta; Translucent White for the incisal third; and Enamel Neutral to reproduce enamel (Amelogen, Ultradent Products Inc, South Jordan, UT, USA).

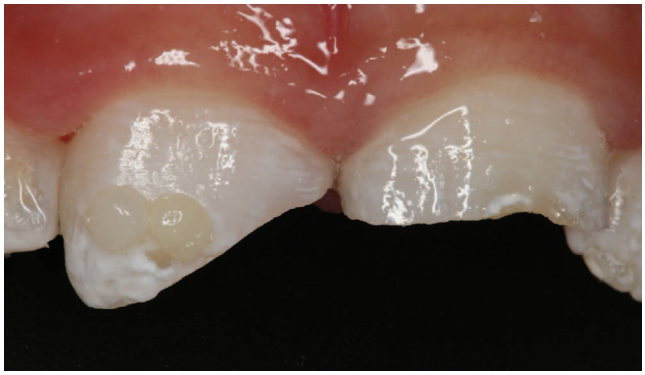

Figure 3. *Shade testing using uncured composite.*

The operatory field was isolated using a rubber dam and stabilized with clamps on the deciduous molars and dental floss in the anterior teeth. The region of fracture was smoothed using a round diamond (1190F, KG Sorensen, Cotia, SP, Brazil) to remove unsupported enamel rods and to enable better adhesion between the restorative material and the tooth structure (Figure 4). As the fracture in the left maxillary central incisor was considered deep, near the dentin-pulp complex, it was protected using a liner. For this procedure, a light-cured calcium hydroxide cement (Ultra-blend, Dentin Shade, Ultradent Products Inc) was applied on the exposed dentin (Figure 5) and light cured for 10 seconds using an LED device (Valo, Ultradent Products Inc). Prior to the restorative procedures, the adjacent lateral incisors were protected using Teflon to limit surface treatments to the central

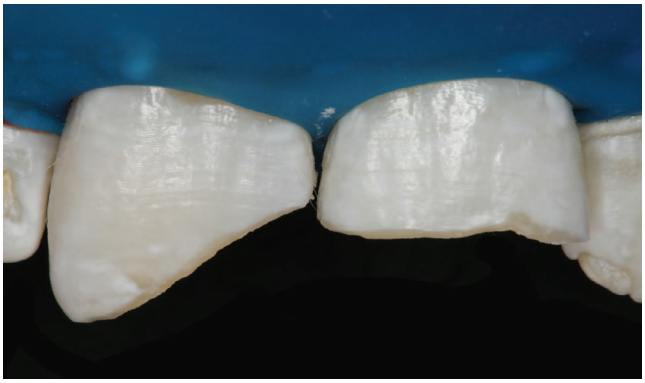

Figure 4. *Isolated operatory field and smoothed enamel margins with a ½ mm bevel.*

incisors. The teeth were etched using 35% phosphoric acid (Ultra-Etch, Ultradent Products Inc) for 15 seconds on dentin and 30 seconds on enamel (Figure 6). Next, the teeth were washed with air/water spray for 30 seconds. After this, the enamel was completely dried with air spray and dentin was covered with sterile cotton to leave a moist substrate to ensure adequate bond to both tissues. Two layers of an etch-and-rinse adhesive system (Single Bond 2, 3M ESPE, St Paul, MN, USA) were applied (Figure 7) and air-dried for 10 seconds, followed by 20 seconds of light curing.

The chosen technique was the stratification technique, which enabled the creation of light and dark variation effects similar to that of the natural dentition. The clinician began the technique on the palatal surface using a polyester matrix (TDV Dental, Pomerode, SC, Brazil) that was stabilized behind the tooth using the clinican's index finger.

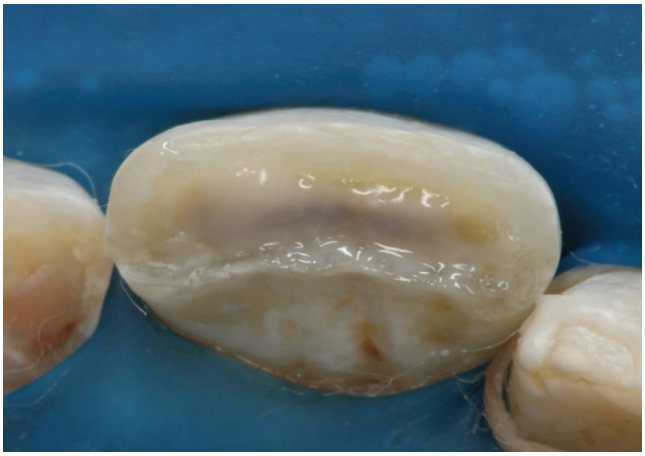

Figure 5. *Left central incisor after pulp-dentin protection covering only the specific pulp horn areas, maintaining enamel margins free of this material to offer less interference with the color matching and potential bond strength.*

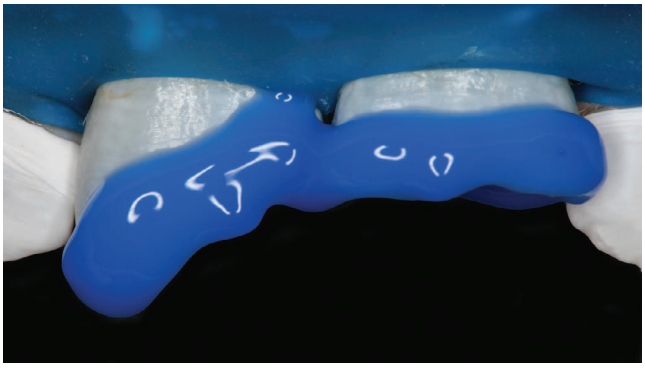

Figure 6. *Conditioning the teeth with 35% phosphoric acid extending beyond the anticipated margin to prevent unattached composite resin.*

With this matrix in position, the first enamel composite resin increment (Enamel Neutral) was inserted on the palatal aspect of the fracture and on the polyester matrix. Light curing was performed with the polyester matrix, clinician's finger, and composite resin in position. The palatal surface of the restoration was then finished (Figure 8). This surface, in both maxillary incisors, was used as the support for the following resin increments. Sequentially, the composite resin selected to reproduce dentin was inserted as indicated earlier, A2 in the middle and beginning of the incisal third (Figure 9a), followed by A1 in the rest of the incisal third (Figure 9b) and into the incisal halo (Figure 9c). Between the dentin and the incisal halo, a more translucent resin was inserted (Translucent White) to reproduce the transparency characteristic of the mamelons (Figure 9c). Small increments of a white opaque resin composite were inserted (Opaque White) to reproduce the amelogenesis imperfecta stains (Figure 10a). Finally, the restoration was finished using a thin layer of enamel composite resin (Enamel Neutral; Figure 10b). All composite resin increments

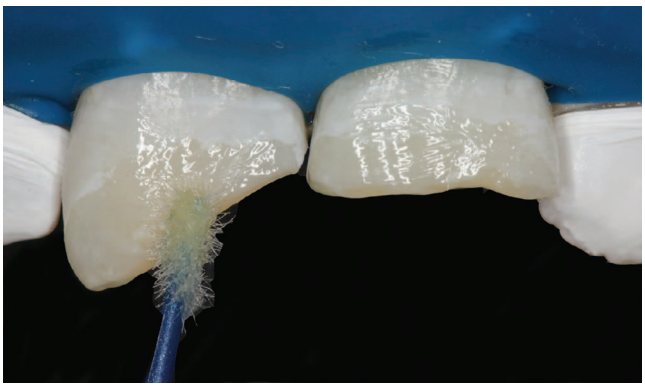

Figure 7. *Applying the adhesive using a microbrush extending beyond the anticipated enamel margins.*

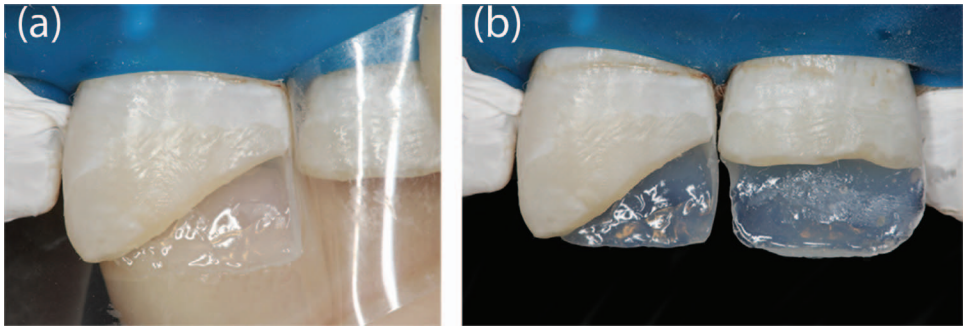

Figure 8. *(a): Construction of palatal surface using the freehand technique. (b): Palatal surfaces of right and left central incisors.*

were light cured with the same LED device for 20 seconds.

After the final light curing, the retainers and rubber dam were removed and the occlusal contacts were checked using carbon paper. As the patient presented overjet, no premature contacts were identified. The patient returned at a later date to have the restorations finished and polished using silicone rubber discs of decreasing grit size (green → yellow → white; Jiffy Polishers, Ultradent Products Inc) followed by a silicon carbide brush (Jiffy Brush, Ultradent Products Inc; Figure 11). After these procedures, the final appearance of the restorations demonstrated the ability of the resin composite materials to reestablish the function and esthetics of the lost dental tissues (Figure 12). In Figure 12a, a slight difference in shade can be noted between the composite resin and the adjacent enamel. Maybe, with the execution of a longer bevel at the enamel margin, this discrepancy could be avoided. However, because of the patient's age and possible future intervention, a more conservative approach was performed with a small bevel of ½ mm.

One month after placing the restorations, the patient presented with pain in the traumatized teeth. A negative result on the sensitivity pulp test associated with pain on percussion revealed an irreversible pulpitis in the left central incisor. Based on the diagnosis, pulp revascularization using triple antibiotic paste (250 mg ciprofloxacin, 400 mg metronidazole, and 50 mg minocycline) was performed.[21] After complete explanation of the procedure, risks, and benefits, informed consent was obtained from the patient's legal guardians to perform pulp revascularization. The cavity access was prepared using a diamond bur (KG Sorensen, Cotia, SP, Brazil), and the root canal was carefully decontaminated with irrigant solutions (6% NaOCl, physiological solution, and 2% chlorhexidine gel). Subsequently, triple antibiotic paste was inserted and left for 21 days. At the second visit, the medication was removed and a manual K-file (Dentsply-Maillefer, Ballaigues, Swiss) was introduced 2 mm beyond the working length to induce bleeding into the canal. A barrier of white MTA (Angelus, Londrina, PR, Brazil) was placed on the blood clot, and the access opening was double sealed with Coltosol (Coltene-Whaledent, Langenau, Germany) followed by composite resin (Amelogen, Ultradent Products Inc). The final restoration with composite resin was performed using the same restorative materials and procedures described earlier.

The pulp revascularization therapy was followed up for 18 months with clinical and radiographic records. The treated tooth did not recover pulp sensitivity, although the patient did not complain of pain on percussion or palpation. Radiographic examination showed apical closure, a slight increase in root length, and the formation of a mineralized

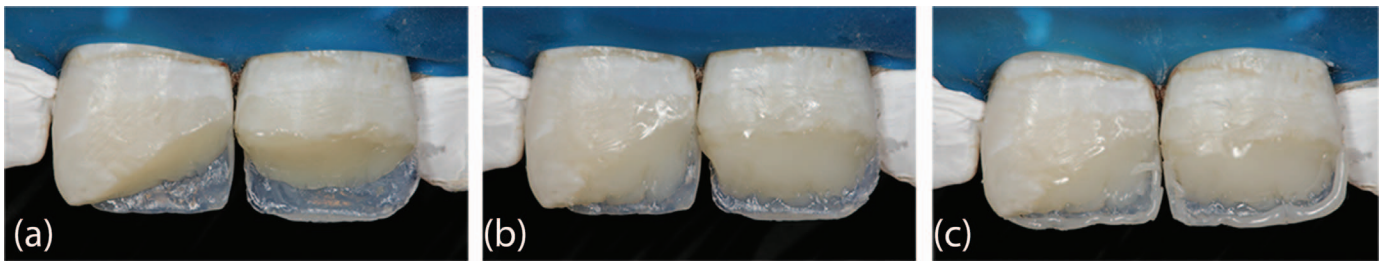

Figure 9. *Dentin stratification of the restoration using composite resin (a): middle third, (b): incisal third, and (c): opaque halo.*

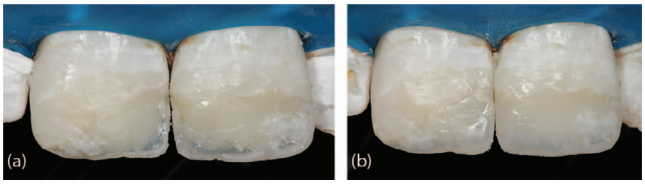

Figure 10. *Enamel stratification of the restoration using composite resin. (a): Translucent and opaque resin in the incisal third and (b): enamel layer.*

barrier between the root canal and the sealing material (Figure 13).

DISCUSSION

In traumatic injuries, treatment options depend on various factors, including injury type, affected teeth, and time elapsed after trauma.[9] Also, children and adolescents with dental injuries experience a greater impact on daily living than those without injuries.[8] When considering these aspects, it is important to begin treatment of injured teeth as soon as possible.

Crown fractures that involve enamel and dentin are the most common type of dental trauma.[22] Depending on the size of the pulp exposure, the time of contact with saliva, and the macroscopic appearance of pulp tissue, a conservative therapy may be indicated. In these situations, the correct diagnosis is a challenge because of the temporary loss of pulpal sensitivity after trauma.[23,24] The lack of certainty generally leads to conservative treatment and careful follow-up because, although an immediate negative response to pulp testing indicates pulpal damage, this response might not predict pulp necrosis because sensitivity tests assess nerve activity rather than vascular supply, which is ultimately responsible for pulp survival.[25]

Without pulp exposure, indirect pulp capping in cases of dental trauma in younger patients should be encouraged, since it may allow for a more conservative treatment. It is likely that dentin protection aids the pulp-healing process by excluding the exogenous chemophysical factors that may otherwise induce pulp necrosis.[5] In a retrospective study, Wang and others[5] reported that the use of a dentin protector before placing a composite restoration led to a pulp survival of 72% after 36 months of evaluation. In addition, these authors indicate that a delay in treatment up to 10 days, as in this case report, was not a significant factor related to pulp necrosis.

In the present case, considering that the pulp was not directly exposed for both incisors, an indirect pulp cap was performed only for the left maxillary central incisor because its fracture was closer to the pulp chamber based on clinical and radiographic evaluations. Despite this conservative attempt, after one month of follow-up, the pulp tissue was unable to heal itself, possibly because of the intensity of the trauma, and endodontic treatment was necessary. According to Elbay and others,[9] pulp necrosis is the most common posttraumatic complication. Another possible cause for pulpal necrosis is injury to the periodontal supporting tissues,[9] which may have compromised the vascular bundle. In addition, because of the exposure of the dentinal tubules to the oral environment, pathways to the pulp are available for a variety of noxious agents from the oral environment, including bacteria and toxins, which can contribute to pulpal contamination.[5] Moreover, the patient in the current case presented with immature permanent teeth that had thin root walls and open apices. Ideally, these situations require treatment that allows for complete root development.

In this case report, where the tooth fragments were not retrieved, the fractured teeth were restored with composite resin instead of cementing the tooth fragments. The development of adhesive dentistry has introduced a more conservative technique when restoring dental trauma, using the patient's own fragment or using suitable materials, such as composite resins, to restore the fractured tooth. A composite resin restoration should replace the lost dental structures so that they blend with the surrounding structures.[26] In this case, an Amelogen microhybrid resin composite was chosen, since it has adequate properties for esthetic restorations. Da

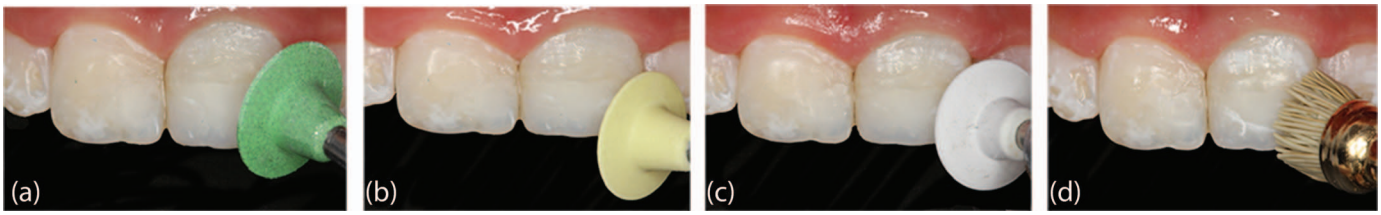

Figure 11. *Finishing and polishing of the restorations using silicone rubber discs (a-c) and a silicon carbide brush (d).*

Figure 12. *Final result of restorations. (a): Front view. (b): Lateral view.*

Silva and others[26] reported that this resin composite presents fluorescence values closer to those provided by dentin/enamel, making this material reliable for esthetic restorations. This resin composite also presents with an adequate degree of conversion (around 60%).[27] This parameter is important when restoring teeth, because a low degree of conversion during polymerization may result in a material with unsuitable mechanical and physical properties, such as greater discoloration, degradation,[28] poor wear resistance, and poor color permanence.[29]

The clinical and radiographic follow-ups demonstrated a successful treatment for reestablishing the health of the patient in relation to the biological, functional, and esthetic aspects. Considering pulp revascularization, positive results were demonstrated, since the patient did not complain of pain, and radiographic examination showed apical closure and a slight increase in root length after 18 months (Figure 13). The regenerative treatment has been widely studied and has demonstrated promising outcomes for root end development and radicular reinforcement, which can help prevent root fractures.[30,31] In addition, this treatment provides more advantages when compared with apexification, including shorter treatment time,[32] esthetic rehabilitation, and survival of traumatized teeth. In the present report, no great increase in the thickness of the root walls nor a remarkable increase in root length were observed. Thus, it may be suggested that revascularization is still in progress, and longer periods of follow-up could demonstrate more advanced root development for the current case.

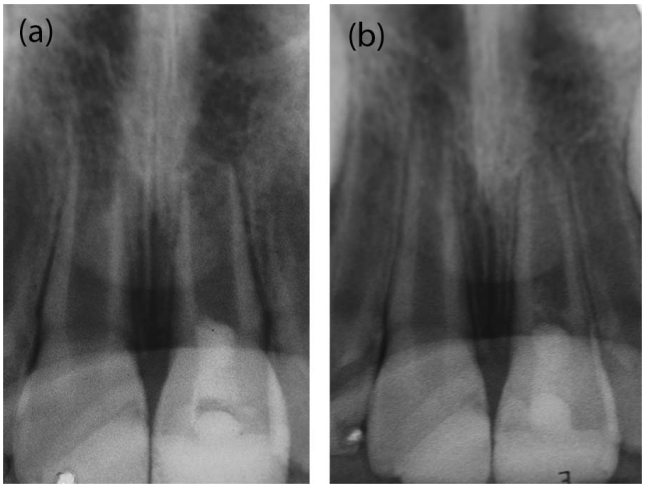

Figure 13. *Radiographs after pulp revascularization (a) and after 18 months (b).*

CONCLUSION

In the reported case, the patient was completely satisfied with the final results. The treatment achieved its objective of restoring function and esthetics of the fractured anterior teeth in a younger patient.

Human Subjects Statement

This study was conducted at the Piracicaba Dental School, University of Campinas, Brazil.

Conflict of Interest

The authors of this article certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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