Esthetic Restoration of an Enamel-Dentin Fractured Single Maxillary Central Incisor with an Indirect Composite Resin

A CASE REPORT

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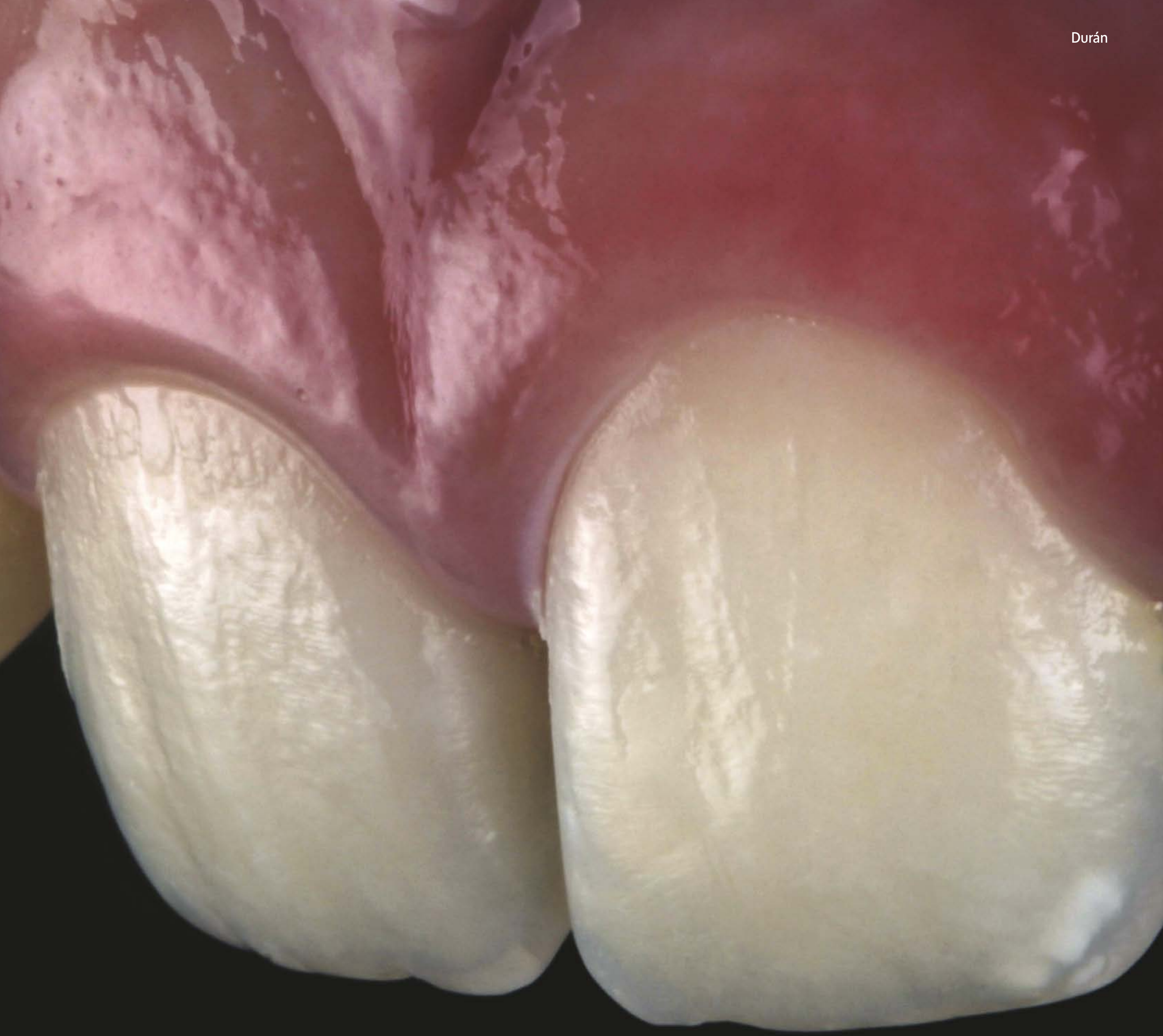
Abstract

Young patients frequently sustain dental trauma. Clinical guidelines are in place to ensure proper treatment protocol for such patients and cases. One simple restorative option—particularly for cases presenting with dentin-enamel fractures without pulp exposure—may be an indirect composite resin restoration. This alternative, which takes into account the difficulty of treating young, fearful, and uncooperative patients, offers a safe, predictable, and less anxiety-inducing experience for the patient and greater convenience, ease, time efficiency, and control of the esthetic and biological results for the clinician. This article describes a simple step-by-step protocol in which an indirect composite resin was performed to restore a dentin-enamel fracture of a maxillary central incisor in an uncooperative patient in order to achieve optimal esthetics and biological results.

Key Words: indirect composite resin, indirect restorations, dental trauma, tooth fracture, dentin-enamel fracture, preheating



“One viable alternative that offers a safe, predictable, and less anxiety-inducing treatment for the patient and greater convenience, ease, time efficiency, and control of the esthetic and biological results for the clinician is an indirect composite resin restoration.”

Introduction

Dental trauma is a frequent clinical complaint among patients, particularly children. Common causes include falls, contact sports, car accidents, or foreign bodies that crack or impact the tooth.[1] Because of their anterior location, the maxillary central incisors are the most frequently affected teeth, and crown fractures (i.e., infractions, enamel fractures, enamel-dentin fractures, or enamel-dentin-pulp fractures) are the most prevalent types of traumas.[2]

Enamel-dentin fractures are confined to enamel and dentin structures without pulp exposure. They exhibit no tenderness with percussion but usually test positive for pulp sensibility.

Radiographic images can show dental structure loss and foreign bodies within soft tissues, often corresponding with lacerations resulting from the impact of tooth fragments.[3]

According to current guidelines,[2] immediate treatment with tooth fragment reattachment is recommended whenever possible, either with definitive treatment (i.e., direct composite restorations) or provisional treatment (i.e., use of glass ionomer restorations with biomaterials for pulp protection). The decision-making process may be more difficult when it pertains to anterior tooth fractures. In many such cases, foreign bodies, soft tissue injuries, and blood are likely to be present, which can complicate the possible immediate treatment.[4,5] This is an issue especially when adhesive materials, which are more prone to fail in moist conditions (i.e., when water and blood are present) must be used.[6,7] Further complicating and influencing the choice of treatment is the patient's age, anxiety level, and level of cooperation.

When such cases present, one viable alternative that offers a safe, predictable, and less anxiety-inducing treatment for the patient and greater convenience, ease, time efficiency, and control of the esthetic and biological results for the clinician is an indirect composite resin restoration. The clinical case reported in this article details a complete step-by-step procedure in which an indirect composite resin was used for the restoration of a maxillary central incisor enamel-dentin fracture in a young patient.

Case Presentation

Initial Appointment

A 10-year-old boy presented approximately two weeks after a swimming pool accident with a chief complaint of tooth enamel-dentin fracture #9 without pulp exposure. After a complete clinical examination was performed and x-rays and photographs were taken, dental vitality was assured, confirming only dental hypersensitivity to dentin exposure **(Figs 1 & 2)**. The patient, afraid of treatment, was uncooperative and fidgety. His constant movement during the initial diagnostic appointment clearly indicated how difficult it would be to perform an immediate composite restoration. Instead, it was determined that an indirect Class IV composite resin restoration over a gypsum model would be a better therapeutic plan of action.

Accordingly, polyvinyl siloxane impressions were taken with two components (Vestige Putty Soft Fast and Vestige Light Normal, Trayart; Castelbaldo, Italy); one bite silicone register (Vestige Bite, Trayart) also was taken at this time. Cast working models were detailed in gypsum (Elite Rock, White, Zhermack; Eatontown, NJ). To avoid sensitivity, immediate dentin sealing (IDS) was performed at dentin exposure areas using a two-step self-etch bonding system (ClearFil SE Bond, Kuraray; New York, NY). A high-filler content flowable composite resin (ENA Flow A2, Micerium SpA; Avegno, Italy) also was used to ensure interphase stability bonding strength and to fill all possible irregularities. Enamel was left untreated.

Figure 1: Preoperative view of #9.

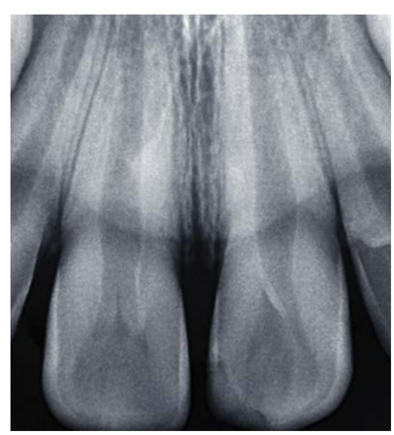


Figure 2: The initial radiograph revealed no additional fractures or apical lesions.

Figure 3: Employing the Bertholdo/Ricci/Barrote (BRB) matrix technique, carbon pencil lines were drawn over the silicone index to simulate the missing incisal edge.

Figure 4: Palatal view of the drawn silicone index.

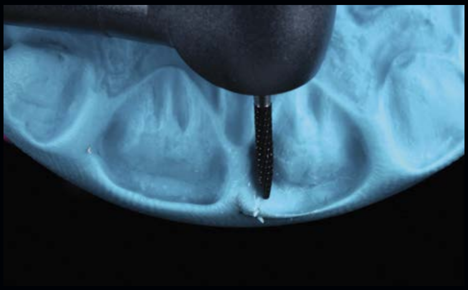


Figure 5: Following the previously drawn lines, part of the silicone index was removed with carbide burs to achieve the correct palatal shape.

Figure 6: View of finished silicone index showing available palatal space for composite resin layering.

Figure 7: A silicone index test was done to ensure correct adaptation and desired shape.

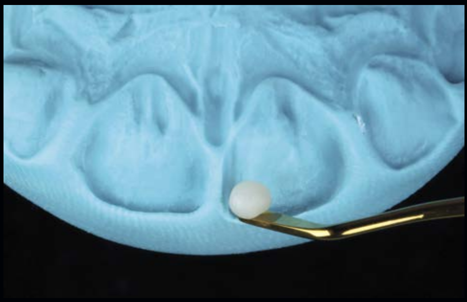


Figure 8: A small amount of enamel-like composite resin was applied at the palatal surface of the silicone index.

Figure 9: The palatal composite resin was adapted with a micro brush. Note that no wetting or 2-hydroxyethyl-methacrylate (HEMA)-free resins were used.

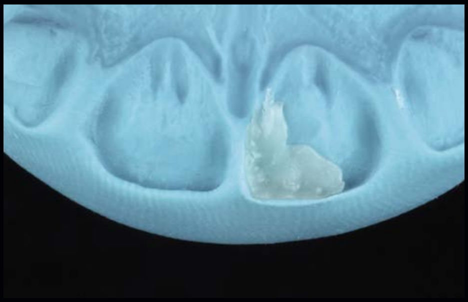


Figure 10: The palatal composite resin was adapted to the silicone index.

Indirect Composite Resin Restoration

Once the cast model was made, a laboratory silicone (Vestige Lab Putty 95, Trayart) was used to take an impression of the working model. The resulting silicone index was drawn with carbon pencil to simulate the amount of tooth structure lost due to the accident **(Fig 3)**. A carbide bur (H48LQ.314.012, Komet; Rockhill, SC) was used to remove the necessary amount of silicone until the correct palatal shape was obtained and reproduced in the silicone index, which was then verified with the cast working model **(Figs 4-7)**, according to the Bertholdo/Ricci/Barrote (BRB) matrix technique.[8]

Once the silicone index was finished, the cast model was sealed (Temp Seal, Micerium SpA) and isolated. A small amount of enamel-like composite resin (UE2, ENA HRi, Micerium SpA) was put into the index and adapted with composite instruments and micro brushes until a thin layer (approximately 0.5 mm) was obtained for the palatal resin increment **(Figs 8-10)**. This first layer inside the index was then positioned in the cast, adapted, and light-cured for 30 seconds **(Fig 11)**. Without removing the index, the proximal enamel (UE2) was applied and immediately light-cured for 30 seconds. After this, the silicone

Figure 11: The silicone index was positioned in the gypsum working model and light-cured. Clinicians should take care when removing the silicone index; a small amount of flowable composite resin at the interphase between the gypsum model and the palatal composite resin may make it difficult to remove.

Figure 12: View of proximal reconstruction in the mesial aspect with enamel-like composite resin.

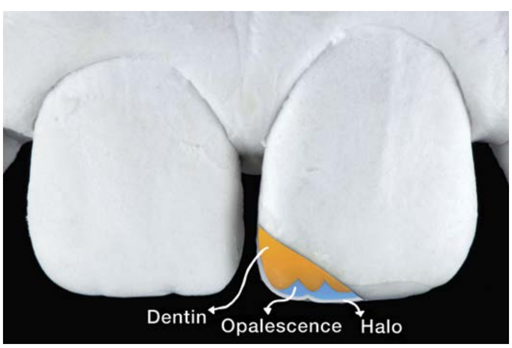


Figure 13: Schematic image showing the planning for composite resin layering.

Figure 14: Dentin-like composite resin was applied following the schematically planned internal mamelon shape.

index was removed, and the palatal and proximal contour formed a box into which dentin composite resin could be added **(Fig 12)**.

A schematic was drawn **(Fig 13)** to plan the correct shape of dentin mamelons with opalescence and the halo space. Chromatic dentin composite resin (UD4, ENA HRi)—carefully compacted with the palatal and proximal resin and sculpted following the dentin mamelon shapes—was applied **(Fig 14)**. To characterize the incisal third, an amber composite resin (OA, ENA HRi) was used to achieve the halo effect while a natural blue opalescent resin (OBN, ENA HRi) produced the opalescence **(Figs 15 & 16)**. The final layer of enamel (UE2) was applied until the correct tooth shape was reproduced **(Fig 17)**. Finally, a post-polymerization process was performed according to manufacturer instructions (Lampada Plus Curing Unit, Micerium SpA) to improve the degree of conversion of the indirect restoration's monomers **(Figs 18a-18c)**.

Bonding, Finishing, and Polishing

The restoration was first verified for fitting and adjustments **(Fig 19)**. Under rubber dam isolation, the tooth surface was prepared by sandblasting the resin coating of the IDS with 27-µm aluminum oxide particles (Zest Dental Solutions; San Diego, CA), then rinsing with water **(Fig 20)**. The enamel and sandblasted surfaces received an application of 35% phosphoric acid (Ultra-Etch; Ultradent, South Jordan, UT) for 30 seconds, were rinsed with water for another 30 seconds, and air-dried **(Fig 21)**. A layer of a two-step etch-and-rinse adhesive system (OptiBond S, KaVo Kerr; Brea, CA) was applied **(Fig 22)**, air-thinned, and light-cured for 20 seconds to reduce polymerization shrinkage. (For best results, keep the adhesive layer minimal so it does not interfere with the restoration seating.)

At this point, the indirect restoration's intaglio surface was sandblasted with 27-µm aluminum oxide before being cleaned with 37% phosphoric acid for 60 seconds, rinsed with water, and air-dried (this will lead to a rough surface to help ensure micromechanical retention). The surface was then covered by a thin layer of hydrophobic resin (Heliobond, Ivoclar Vivadent; Amherst, NY), light-cured for 20 seconds, and charged for cementation with a nanohybrid composite resin (EF2, Micerium SpA) preheated at 59° C with a composite warmer (ENA Heat) **(Figs 23-28)**.

The restoration was then carefully positioned onto the tooth surface with finger pressure **(Fig 29)**. Using a brush, excess composite resin was removed and any voids at the interphase were sealed. Light-curing was performed for 60 seconds from the buccal-palatal aspects.

Once the restoration was secured, correct morphology was achieved with extra-thin (40-µm) contouring and polishing aluminum oxide discs (Sof-Lex, 3M; St. Paul, MN) and 40-µm diamond finishing points (Enhance, Dentsply Sirona; Charlotte, NC) **(Figs 30 & 31)**. Finally, diamond spiral finishing and polishing wheels (Sof-Lex) were used to polish the restoration surface and obtain the final gloss **(Fig 32)**. Six-month follow-up photographs **(Figs 33 & 34)** and a postoperative radiograph **(Fig 35)** showed optimal esthetics and biological results.

Figure 15: Amber composite resin was applied at the incisal edge to reproduce the halo effect. Note that sufficient space must be left in order to achieve the opalescence.

Figure 16: Opalescent natural blue was applied between the space left between the halo and the dentin mamelons.

Figure 17: A final layer of enamel-like composite resin was applied to reproduce the entire tooth shape.

Figures 18a-18c: During post-polymerization, a glass Dappen dish with glycerin gel was used to eliminate the oxygen inhibition layer; this elimination increases the quality of the indirect composite resin restoration.

Figure 19: View of try-in.

Figure 20: The enamel surface was sandblasted with 27-μm aluminum oxide.

Figure 21: The enamel surface was etched with 37% phosphoric acid.

Figure 22: A two-step etch-and-rinse adhesive system was applied.

“The decision-making process may be more difficult when it pertains to anterior tooth fractures. In many such cases, foreign bodies, soft tissue injuries, and blood are likely to be present, which can complicate the possible immediate treatment.”

Figure 23: The inner surface of the indirect resin was sandblasted with 27-μm aluminum oxide.

Figure 24: A chemical cleaning with 37% phosphoric acid was performed for 60 seconds.

Figure 25: Hydrophobic resin was applied at the inner surface of the indirect composite resin.

Figure 26: The hydrophobic resin was light-cured.

Figure 27: Composite resin was preheated for cementation into the inner surface of the restoration.

Figure 28: Heating the composite resin at 59° C reduced the viscosity and density.

Figure 29: The restoration was placed. Preheated composite resin excess was eliminated with brushes.

Figure 30: Aluminum oxide discs were used to obtain the restored tooth's initial shape.

Figure 31: During the polishing procedure, diamond rubber points softened the surface to obtain the smoothest interphase.

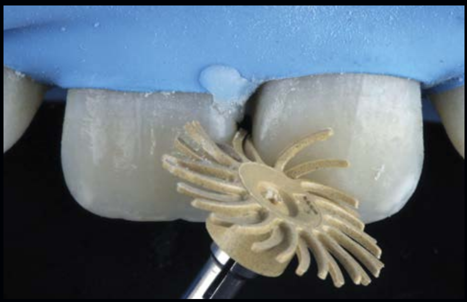


Figure 32: Diamond spiral wheels were used to obtain the final gloss. (The tooth must be moistened for this step.)

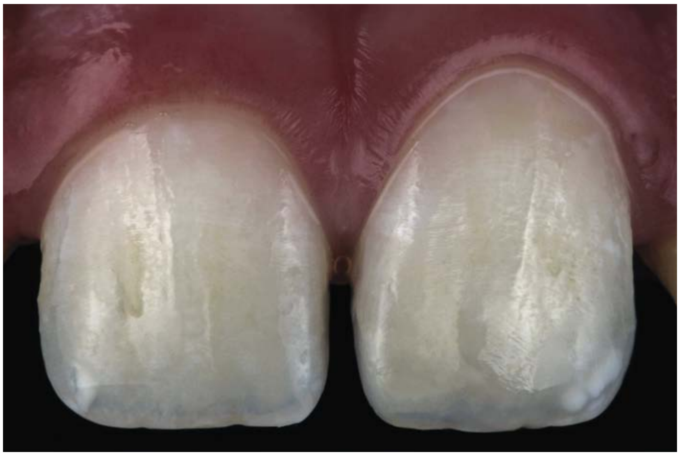


Figure 33: Frontal view of six-month control.

Figure 34: Lateral frontal view.

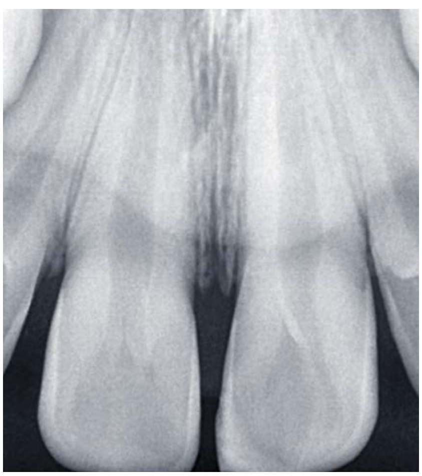


Figure 35: Postoperative radiograph.

Discussion

Treatment Alternatives

Various therapeutic alternatives are available to treat an enamel-dentin fracture without pulp exposure in a central incisor. They are presented here, with their respective advantages and disadvantages.

Tooth fragment reattachment: According to established guidelines for the management of traumatic dental injuries,[2] tooth fragment reattachment via adhesive procedures may be the most conservative approach. The fragment, however, must be intact and vital to ensure the correct fit and adaptation to the remaining tooth substrate. It is common to immediately observe a clear difference in value between the fragment and the tooth due to dehydration; in many cases, color will stabilize and achieve optical integration over time.[9] It is important to note that the tooth fragment must be preserved in hypertonic solutions to increase bond strength.[10]

Direct composite restoration using layering technique: Another option is to perform a direct composite restoration using the layering technique.[11] Advantages to this alternative may include tooth preservation, reparability, reversibility, fewer clinical appointments, and greater clinician control of the esthetic results.[12-14] This technique can be indicated for young patients whose tooth optical properties, shape, and texture are more accentuated (as long as the patient is cooperative since more clinical time will be necessary to perform the restoration). Additionally, the clinician must be highly trained in order to achieve the expected result in a shorter period of time.

This option was not selected in the case presented due to the extensive clinical time needed to obtain ideal esthetic results, given the fractured incisal portion's optical characterizations. The patient's uncooperative and restless behavior, which increased the likelihood of more chairside time to perform the technique and higher risk of incorrect characterizations and presence of bubbles and impurities, also factored into the decision-making process.

Partial veneers or ceramic fragments: These options can be accomplished through a refractory model with feldspathic ceramic by additive technique, as well as with other injectable glass ceramics, or with computer-aided design/computer-aided manufacturing (CAD/CAM) glass ceramics.[15,16] According to Rigo and colleagues,[17] this type of treatment allows for optimal esthetic outcomes and provides greater longevity than direct composite resin restorations. It is a conservative clinical alternative, requiring no preparation or, in some cases, only minimal correction such as rounding of the sharp angles to reduce ceramic fractures and to ensure a proper fit.[18] While this has the advantage of needing less clinical time than a direct composite restoration, it requires a highly trained ceramist and more clinical appointments, thereby increasing treatment costs.

TIPS FOR CLINICIANS

BEGINNER

- Fully smooth and round all sharp angles to ensure optimal restoration fit and reduce the risk of stress accumulation, which may cause the restoration to fracture during seating.
- During the bonding procedure, always use rubber dam isolation to prevent saliva, crevicular fluid, and mobile soft tissue from interfering with and contaminating the working field, thus adversely affecting the quality of bonding.
- Set the light-curing system at "high" intensity (i.e., 1000mW/cm2 or more) for cementation procedures where restoration thickness influences the pass of light.

INTERMEDIATE

- Use available adhesive systems according to manufacturer instructions for bonding indirect restorations. If available adhesive is not indicated for this clinical purpose, use the adhesive included in cementation kits. Verify step-by-step procedures to help ensure optimal quality bonding.
- Always repolish the restoration when cemented to secure a smooth restoration and good quality interphase surface.
- During yearly control appointments, use diamond polishing pastes, which are reported to produce smoother surfaces and better polishing results.

ADVANCED

- Polymerize every bonding layer. The use of ultra-thin adhesive layers won't interfere with seating the restorations when humidification is performed properly. When in doubt about the angles of the dental structure and possible undercuts, do not polymerize the bonding layer of the tooth surface or of the restoration, as this may interfere with seating.
- If dentin is exposed when doing indirect restorations, perform IDS with gold standard adhesive systems. Use three-step etch-and-rinse adhesives, two-step self-etch systems, and two-step etch-and-rinse systems to ensure quality adhesion.
- To improve bond strength values and to achieve hybrid layer stability, apply a final resin coating with a high-filler flowable composite resin with a film thickness not exceeding 0.5 mm. Always be sure to eliminate the oxygen-inhibited layer with glycerin.

Indirect composite resin restoration over a working cast model: This is a possible option in cases where patients are unable to finance the additional costs of an indirect ceramic restoration. It was selected for the case presented in this article because it offered the necessary accurate optical characterizations and increased the degree of conversion of the final restoration. Using the indirect method for this case—enamel and dentin-like composite resins for stratification layering—enabled the clinician to completely control the resin thickness, as well as handling of the morphology and the individual characterizations. Another advantage may be the better mechanical property performance, which allows the increased degree of monomer conversion after the post-curing process.[19] This claim is demonstrated in results such as those reported by Souza and colleagues,[20] in which a noticeable increase in the degree of conversion (between 75 ± 1 y 91 ± 5%) can be achieved by subjecting an indirect composite resin to a post-polymerization process, which also increases the flexural strength and Vickers microhardness. This indirect model approach also gives greater control over eliminating possible bubbles and impurities, which are likelier to occur during a direct method.

Additionally, the indirect technique requires less clinical time, since the first appointment is used for impression taking and color registration, and the second appointment for the cementation procedure. While some clinicians may consider cementation time consuming, in the hands of a highly trained practitioner, this technique actually may take less time than performing a direct composite restoration on an uncooperative patient. Working with a skilled dental assistant or hygienist on such patients also will make the process faster and more efficient.

Considerations for the Use of IDS

The use of IDS in the presented case report is based on a study by Magne and colleagues,[21] which showed the increase of bond strength to dentin with the development of an efficient resin-to-resin bond between an existing resin coating and the new luting composite resin. In this particular case, the initial bonding procedure used a two-step self-etch adhesive containing 10-Methacryloyloxydecyl dihydrogen phosphate (10-MDP) to reduce sensitivity by sealing dentinal tubules,[22] as well as a high-filler flowable composite as a resin coating to increase hybrid layer stability.[23] This same study also proved that after IDS, using airborne-particle abrasion or sandblasting to the existing resin surface and applying a fresh adhesive resin can reliably provide a secure bond.

In the presented case, Clearfil SE, a two-step self-etch bonding system, was used to apply that concept. As IDS was employed before impression taking, tooth preparations could be improved by filling undercuts and concave areas to obtain a more regular tooth preparation surface.[24] Thus the tooth preparation's geometric design could be optimized, limiting the restoration thickness and improving the restoration adaptation. A flowable composite resin was used, achieving rounded and smooth angles that improved restoration adaptation.

Considerations for the Use of Adhesive Strategies

The selection of an adhesive system should always be related to a specific clinical objective. For this reason, clinicians must be aware of the chemical composition, clinical techniques, and specific indications for the available adhesives systems in order to safeguard the procedures and provide long-lasting bonded restorations.

To perform IDS, different adhesive systems can be used (i.e., etch-and-rinse, self-etch, and universal or multimodal adhesives). For the case presented here, two adhesive strategies were employed. The first one corresponded to a two-step self-etch adhesive containing 10-MDP to stop the sensitivity through the IDS technique. As dentin was exposed and sensitive, the type of adhesive selected was justified as it is specific for dentin. (Because no surface treatment was needed for enamel, phosphoric acid and any type of etch-and-rinse adhesive, while they could have been used, were not strictly indicated.) The second adhesive used was a two-step etch-and-rinse system to bond to the tooth substrate during the bonding procedure. As the tooth surface was completely restricted to enamel and the resin area with IDS, the use of phosphoric acid—proven to be the best conditioning approach for enamel—was necessary. Also, this acid will chemically clean the resin surface after the airborne-particle abrasion. (Acidic primers from self-etch adhesives will not obtain ideal bond strength values to enamel, which was the justification for not using them in this step.)

Summary

In cases involving dentin-enamel fractures, clinicians must assess and accurately diagnose the case-specific conditions before deciding whether to perform immediate or provisional treatment. They must employ minimally invasive therapies, and an indirect composite resin restoration may be a suitable option with numerous advantages (i.e., reversibility, reparability, optimal esthetics, and more economical than ceramics) and may provide acceptable long-term success. While the author emphasizes that in such cases practitioners must be highly trained to obtain acceptable morphology and understand the optics and mechanical behavior of the composite resin available, with careful adherence to the simple step-by-step protocol detailed in this article it is possible to attain superior clinical performance and optimal results. This alternative, which takes into account the difficulty in treating young, fearful, and uncooperative patients, offers a safe, predictable, and less stressful experience for the patient and greater convenience, ease, time efficiency, and control of the esthetic and biological results for the clinician.

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