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Immediate dentin sealing in indirect restorations of dental fractures in paediatric dentistry

ABSTRACT

Aim At present, two different clinical procedures to ensure the adherence of indirect tooth restorations to the dental tissues are available: a traditional method based on a delayed dentin sealing (DDS) and an innovative approach that contemplates an immediate dentin sealing (IDS). In this study the authors highlight the advantages of the latter method (IDS), describing the operating phases of this procedure used in paediatric dentistry to perform indirect restorations of dental fractures.

Materials and methods The operating phases of indirect composite restorations of dental fractures in paediatric patients are described, introducing an innovative procedure that recommends the immediate application of the dental adhesive (IDS) on the exposed dentin before the subsequent operating phases of tooth preparation, dental impression and adhesive cementation of the restoration.

Results The immediate application of the dental adhesive (IDS) on the freshly cut exposed dentin, before taking the dental impression, protects the dental pulp from bacterial contamination and prevents post-operative sensitivity. At the same time, this procedure provides an ideal substrate for formation of a hybrid layer with excellent adhesion properties.

Conclusion Both methods (DDS and IDS) allow the formation of an adequate hybrid layer to seal the dentin in the interdiffusion area, although SEM images of samples treated with the two methods reveal clear ultrastructural differences between the different interfaces.

Keywords Adhesion; Dental fractures; Dentin sealing; Indirect restorations.

Introduction

In paediatric dentistry, reconstruction of extensively damaged teeth, especially in aesthetically complex cases, is preferably performed with an indirect technique to obtain a highly predictable aesthetic result and avoid multiple stressful sessions to the child. Moreover, fabrication of restoration in the laboratory allow control over the extraoral phenomena related to volumetric polymerisation of the composite material, thus improving its biomechanical and physical properties and its functional and aesthetic longevity [Asmussen and Peutzfeldt, 1990, Silva et al., 2007; Loza-Herrero et al., 1998; Santana et al., 2009]. Predictable aesthetics and functional longevity of the restoration cannot, however, be achieved without an adequate dental pulp protection that can be obtained by applying an adhesive technique. This technique allows both immediate sealing of the pulp–dentin organ, preventing bacterial infiltration and the postoperative sensitivity, and adhesion of the restorative elements to the dental tissues. At present, two different procedures to ensure the adherence of indirect tooth restorations to the dental tissues are available: a traditional method based on a delayed dentin sealing (DDS) and an innovative approach that provides an immediate dentin sealing (IDS).

In this study the authors highlight the advantages of the latter method (IDS), describing the operating phases of this procedure used in paediatric dentistry to perform indirect restorations in case of dental fractures.

Materials and methods

A nine year-old child was referred to our observation at the Department of Paediatric Dentistry of University Hospital "Tor Vergata" of Rome, after a trauma occurred during recreational activity. Objective clinical examination showed absence of lesions of the cutaneous and mucous tissues. An extensive class IV fracture on tooth 11 without dental pulp exposure was present, together with a smaller enamel-dentin fracture on tooth 21 (Fig. 1). Teeth showed absence of mobility and positive response to the vitality test. Palpation and percussion tests were negative. A completed diagnosis was made with a periapical x-ray, showing the correlation between the fracture lines and the respective pulp chambers with the anatomical integrity of the two roots. The child's parents also reported the impossibility to rescue the tooth fragments, the use of which would have certainly represented the first choice reattachment procedure. Under 4x magnification, the fractured dental crowns exhibited a non homogeneous chromatic map and hypoplastic spots. In such conditions, in order to obtain a valid aesthetic result, we opted for an indirect reconstructive composite technique on tooth 11 and a direct reconstruction with composite material on tooth 21.



FIG. 1 The initial case: tooth 11 with a class IV fracture and tooth 21 with minimal fracture.

First operating phase: immediate dentin sealing (IDS)

Given the remarkable dentin exposure on tooth 11, after isolation of the operative field we opted for sealing of the dental pulp to protect it from bacteria and toxin contamination and prevent sensitivity. At the same time, a stable adhesive interface, ensuring the subsequent adhesion of the composite cement and prosthetic element, was obtained. Therefore, an innovative procedure was used, based on the immediate application of the dental adhesive IDS (Immediate Dentin Sealing) on the exposed dentin [Magne, 2005; Swift, 2009]. Since the freshly cut exposed dentin represents the ideal substrate to form a hybrid layer with a higher adhesive potentiality, a round bur at low speed and minimum pressure was used, with the aim of exposing only the fresh dentin [Paul and Scharer, 1997]. Although the two-step "self-etching" adhesives are well apt to perform the IDS technique [Magne et al., 2007; Stavridakis et al., 2005], we opted for the use of a three-step "etch-and-rinse" enamel-dentin adhesive which, if properly applied as in the case of Optibond FL (Kerr), allows to obtain an excellent dentin hybridisation. This adhesive is for 48% filled by weight which showed, over many years, to possess an optimal elastic modulus able to damp mechanical stress [Dietschi et al., 2002] and form an ideal compatible layer for the ultimate restorative cementation [Magne and Douglas, 1999]. After local application of 37% orthophosphoric acid for 15 s, the dentin surface was extensively rinsed with water for additional 40 s. After air drying, the surface was treated with chlorhexidine (0.2% non-alcoholic solution) for one minute, in order to ensure inhibition of metalloproteases which are probably activated by the demineralisation of the dentin treated with orthophosphoric acid [Breschi et al., 2008]. Several *in vitro* studies have shown that these collagenolytic enzymes may damage the adhesive interface in the long term [Breschi et al., 2009]. After chlorhexidine application, no water rinse is executed but the excess solution is removed with an aspirator. This allows obtaining a dentinal surface with an ideal humidity where the primer is applied with a micro brush. After the first soaking, a second one follows, for



FIG. 2 Immediate dentin sealing of tooth 11.



FIG. 3 Tooth preparation is completed.

a total time ≥ 40 secs. After insuring the evaporation of the solvent and water molecules with a mild air blow, bonding application, which allows the resin monomers to efficiently impregnate the collagen network, is performed trying to avoid air bubble trapping (Fig. 2). Afterward, light curing and the "air blocking" procedure will follow [Magne, 2005; Magne and Douglas, 1999; Magne et al., 2005; Magne et al., 2007; Stavridakis et al., 2005]. A glycerine gel is used to cover the layer of polymerised adhesive, followed by an additional 10 s light cure to ensure complete polymerisation of the superficial layer.

Second operating phase: Tooth preparation and impression

Then the preparation of the margin in the enamel thickness is executed. A small chamfer is frontally made with a round fine-grained bur, which aims at preserving the remaining enamel and prevents marginal infiltration. Palatally, a 90° shoulder finish line ensures an adequate thickness to the margin of the composite restoration. All the prepared enamel is then polished with a rubber cup. Figure 3 shows the perimeter of the preparation and the sealed and hybridised dentin. After removal of the rubber dam, the dental impression is taken using a polyvinyl siloxane with different viscosity: high viscosity in the tray and low viscosity on the preparation. On the master model the stratification, performed restoring the lost anatomy and dosing appropriately the different masses and pigments available, produces the greatest integration of the dental restoration with the natural tooth. Before the final polishing and post-polymerisation in the laboratory, the restoration is checked in the test session, to ascertain its marginal adaptation and evaluate the aesthetic result obtained. The procedure of post-polymerization applied to the hybrid composites, together with the mechanical polishing of the surface, significantly improves the biomechanical characteristics of the material. For example, wear resistance, when tested with sliding *in vitro* tests, reaches up to 200,000 cycles, a result comparable to five years of masticatory activity [Suese and Kawazoe, 2002]. Figure 4 shows the final restoration before cementation.



FIG. 4 Indirect restoration composite after finalisation in the laboratory.

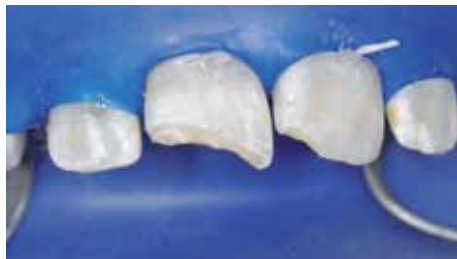


FIG. 5 Isolation of the operative field with a rubber dam before the adhesive cementation of indirect composite restoration.



FIG. 6 Restoration completed and final aesthetic result.

Third operating phase: Adhesive cementation

As in all adhesive techniques, the cementation phase must be preceded by isolation of the operating field (Fig. 5). The whole surface is gently cleaned with a brush using a mixture of pumice and water. During the phase of final cementation the IDS technique protocol recommends that a filled adhesive such as Optibond FL (when used) can be "reactivated" with a thorough cleaning and surface roughening [Paul and Scharer, 1997] performed by a light micro-abrasive blasting with 30 micron silicon oxide. This allows intermolecular van der Waals force interactions with the remaining free radicals and the development of micromechanical interlocking between the pre-polymerised and the new adhesive layer where the dental cement will be positioned [Magne et al., 2005]. The restoration is also gently treated on its bonding surface with a micro-abrasive blasting to enhance the retentive properties. It is then cleaned with pure alcohol and perfectly dried, to obtain greater adhesion through the development of mechanical interconnections [D'Arcangelo and Vanini, 2007]. The adjacent teeth are protected with Teflon and the surface is exposed to orthophosphoric acid for 30 seconds, to ensure cleansing and peripheral enamel conditioning. Then, a thorough rinse with water (without blowing) and a perfect drying are performed. The adhesive resin is gently applied on the preparation with a brush, to not alter the prisms of demineralised enamel, and on the restoration successively protected from light. A micro-hybrid light cured composite containing a high percentage of BIS-GMA was used for the attachment. This composite is pre-heated to increase its fluidity. A small amount of composite is placed in the restoration which is gently pushed into the correct position. The composite in excess is gradually removed, before with a dental probe and then, at the end, with a brush. After that, in this case we proceed to polymerisation with two lamps positioned on the buccal and palatal side. An additional polymerisation of the marginal composite exposed in the absence of oxygen is carried out by covering the margin surface with a glycerine gel for 30 seconds. The excess composite is then gently removed from

the surface with a sharp instrument. The polishing is carried out with a silicone rubber cup under air blowing to avoid overheating of the material, and finally with a silicon carbide impregnated brush. Alternatively, the polishing phase can be performed with brush and 3-5 µm diamond paste and lastly with felt and aluminum oxide. Tooth 21 was reconstructed in a successive phase. Figure 6 shows the final aesthetic result and the chromatic integration obtained.

Discussion

At the present time, two different clinical procedures to ensure the adherence of indirect tooth restorations to the dental tissues are available: a traditional method based on a delayed dentin sealing (DDS) and an innovative approach that recommends an immediate dentin sealing (IDS). Both methods of adhesion allow the formation of an adequate hybrid layer to seal the dentin in the interdiffusion area, although SEM images of laboratory samples treated with IDS [Magne and Douglas, 1999] show clear ultrastructural differences between the different interfaces. In DDS (Delayed Dentin Sealing) the operator can leave the dentinal tissue exposed at the end of the preparation, delaying the adhesive procedures of hybridisation to the time of positioning and fixation of the prosthetic restoration. In the DDS procedure, the adhesive is polymerised during the restoration simultaneously to the process of cementation, leaving exposed the dentinal tubules to bacterial contamination, impression material and various polluting compounds that can alter the dentinal surface and compromise the subsequent adhesive processes [Bertschinger et al., 1996]. A partial gap between the hybrid layer and the composite cement has been frequently observed, while the continuity between the hybrid layer and the dentine remains constant. This may be due to the partial collapse and compression of the demineralised collagen fibrils impregnated with the unpolymerised resin, caused by the increased pressure generated by dental cement insertion during the positioning of the restoration. In fact, the dental cement, by filling all the available

space with its more viscous composition, reduces the thickness of the layer of adhesive resin. In this case, less adhesive resin between the fibrils of the hybrid state is available. As a consequence, the hybrid layer becomes weak with the risk of negative effects on the adhesive interface [Dietschi and Herzfeld, 1998; Dietschi et al., 1995; Magne and Douglas, 1999]. On the other hand, in the IDS procedure during dentin conditioning and hybridisation, the dentin surface exposed is immediately sealed by the dentin adhesive polymerised before the final impression. In this case, the scanning microscope examination shows that the hybrid layer does not present gaps between pre-polymerised adhesive and dentin, and is characterised by longer resin extension and continuity within the interspace between the composite cement and the pre-polymerised adhesive [Magne and Douglas, 1999; Magne et al., 2005]. Moreover, protection of the dentin from bacterial penetration is also guaranteed, with preservation of the dental pulp organ over the period lasting from taking the impression and the cementation of the prosthetic restoration. In addition, dentinal sensitivity is reduced [Bergenholtz, 1997; Brannstrom, 1996]. The immediate sealing of dentinal tubules is thus particularly recommended in all cases where a temporary isolation from fluid pollution of the oral cavity is not practicable. In such cases, during the time of prosthetic construction before the cementation, it is possible that the polymerised adhesive can be exposed to oral fluid microinfiltration, with consequent deterioration of its adhesive properties. Nevertheless, a recent *in vitro* study has shown that the microtensile bond strength (MTBS) test, performed in human teeth immediately treated with three steps etch-and-rinse (Kerr Optibond FL) or two steps self-etching (SE Bond Kuraray) adhesives (prior to impression making) and covered with temporary filling materials (Tempfil inlay / onlay Kerr), does not show significant changes between samples immediately restored and samples with up to 12 weeks of elapsed time prior to placement of the definitive restoration [Magne et al., 2007]. Structurally, longer resin tags are observed in IDS, without interruption or discontinuity among the different interfaces: dentin, resin, pre-polymerised adhesive and composite cement. *In vitro* tests performed on laboratory samples treated with this technique show an increased adhesion force as compared to those obtained with the DDS [Bertschinger et al., 1996; Paul and Scharer, 1997].

Conclusion

The immediate application of the dental adhesive (IDS) on the freshly cut exposed dentin, prior to impression making, has become in recent years a reliable and well-established clinical procedure. This procedure makes it possible to protect the dentinal pulp organ from external contamination, thus preventing post-

operative sensitivity. At the same time, this technique provides an ideal substrate for formation of a hybrid layer with increased adhesion strength as compared to that obtained with the delayed dentin sealing (DDS) procedure.

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