Treatment of extended anterior crown fractures using type III bonded porcelain restorations (part two)

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Bonding strategy

Type IIIA bonded porcelain restorations can be placed according to the exact same protocol used for traditional porcelain veneers (Magne and Belser 2002). Conditioning of the tooth surface is generally limited to a 30-second etching procedure with 37% phosphoric acid if the prepared surface is essentially located within the thickness of enamel.

However, if a considerable area of dentin has been exposed during tooth preparation, it is suggested a dentin adhesive be applied strictly according to the manufacturer's instructions. The clinical significance of successful dentin bonding is particularly strong in the case of indirect bonded porcelain restorations, eg inlays, onlays and veneers, because the final strength of the tooth restoration complex is highly dependent on adhesive procedures. Long-term clinical trials by Dumfahrt and Friedman showed that porcelain veneers partially bonded to dentin have an increased risk of failure (Dumfahrt 2000, Friedman 1998). Recent advances in the knowledge database for dentin bonding agent application suggest these failures can likely be prevented by changing the application procedure of the dentin bonding agent. In fact, there are basic principles to be respected during the clinical procedure of dentin-resin hybridisation, the most important of which are related to problems of dentin contamination and susceptibility of the hybrid layer to collapse until it is polymerised. These essential elements when considered within the frame of indirect bonded restorations, especially bonded porcelain restorations, lead to the conclusion that dentin should be sealed immediately after tooth preparation, the so-called immediate dentin sealing (see Figure 4), prior to impression taking (Magne and Belser 2002). Among the most reliable contemporary systems, OptiBond FL (Kerr Hawe, +44(0)1733 892292) is particularly indicated for

immediate dentin sealing because of its ability to form a consistent and uniform layer and its cohesiveness with the final luting composite (Magne and Douglas 1999e). Although there is a tendency to simplify bonding procedures, recent data confirm that conventional three-step etch and rinse adhesives still perform most favourably and are most reliable in the long term (Van Meerbeek et al 2003, de Munck et al 2003). Just prior to luting procedures (when placing the final restoration), the surface of the adhesive will be meticulously cleansed with pumice or microsandblasting. The entire tooth preparation surface then can be considered and conditioned as it would be done in the absence of dentin exposure: H_3PO_4 etch (30 seconds), rinse, dry and coat with adhesive resin.

There are several rational motives and other practical and technical reasons supporting immediate dentin sealing. Freshly cut dentin is the ideal substrate for dentin bonding (Bertschinger et al 1996, Paul and Schaerer 1997a, Paul and Schaerer 1997b). Significant reductions in bond strength can occur when simulating dentin contamination
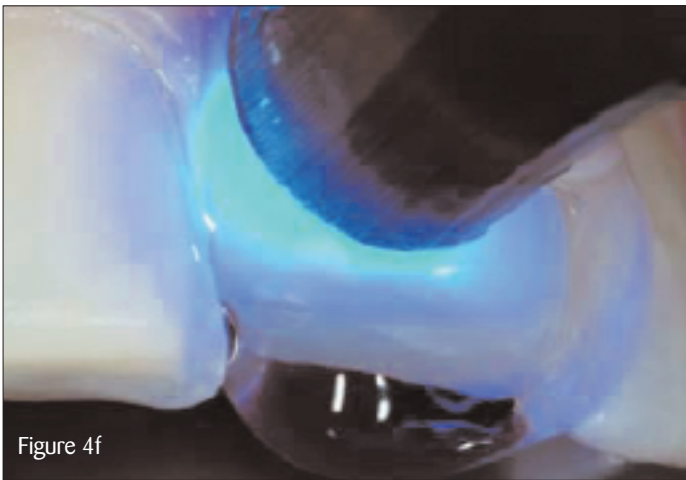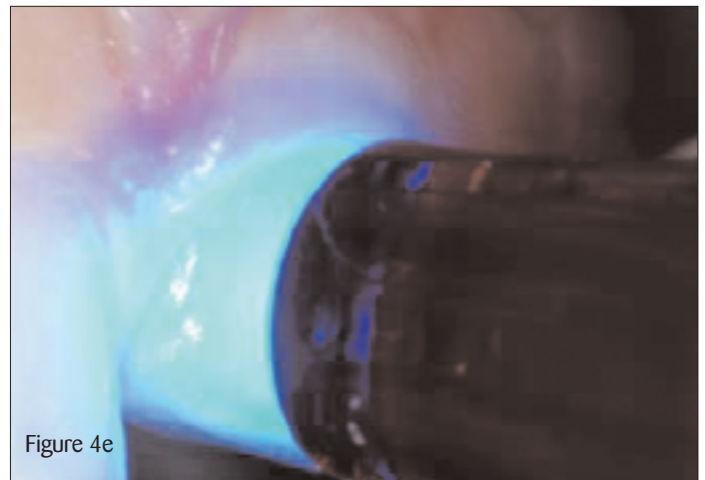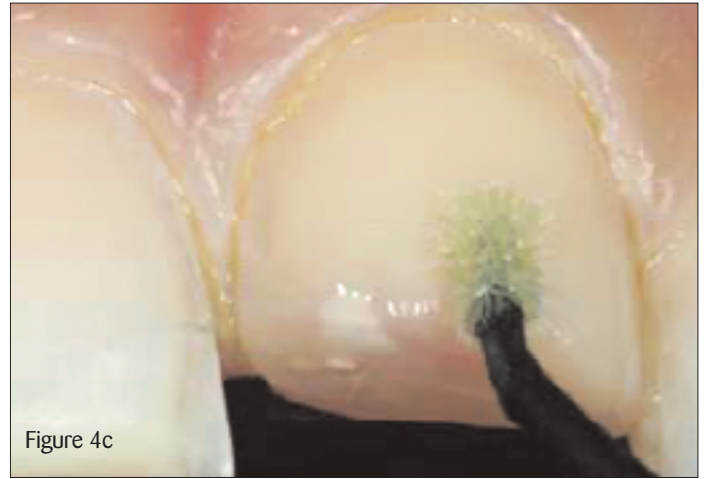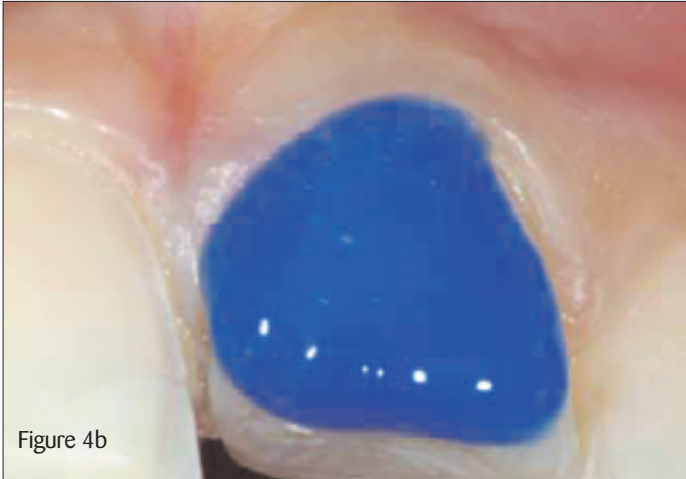

Figure 4a

Figure 4b

Figure 4c

Figure 4d

Figure 4e

Figure 4f

Figure 4g

Figure 4: Clinical situation after preparation of teeth 1 and 1. Extreme prominence of 1 led to a significant exposure of dentin at the facial axial level of the preparation. Margins are still located in enamel. The exposed dentin surface is decontaminated by roughening with a diamond bur **(Figure 4a)**, then immediately etched for five to 15 seconds, depending on the adhesive system used. It is recommended to extend etching 1 to 2mm over remaining enamel to assure further adhesion of eventual excess resin **(Figure 4b)**. Following abundant rinsing, excess water is suctioned and the priming agent (hydrophilic monomer, eg Bottle 1 in Optibond FL, Kerr Hawe, +44(0)1733 892292) is applied to dentin with a gentle brushing motion for 30 seconds **(Figure 4c)**. Several applications of fresh primer are recommended. The dentin surface is suctioned again to eliminate the solvent (eg alcohol in the case of Optibond FL primer) from the priming solution. One coat of adhesive (Bottle 2 in Optibond FL) is then applied, left to diffuse for 20 seconds **(Figure 4d)** and cured, first for 20 seconds **(4e)**. A thick layer of glycerin jelly is applied to the sealed surface and beyond, and another 10 seconds of light curing is applied to polymerise the air-inhibited layer of the resin **(Figure 4f)**. Glycerin can be easily removed by rinsing **(Figure 4g)** and impression can be carried out. Note the reattached fragment on 1, which will be supplemented by the veneer restoration.

Figure 5a

Figure 5b

Figure 5c

Figure 5d

Figure 5: Comprehensive case of bonded porcelain restorations including a type IIIA on ⌐1. All of the layering will be performed on a so-called soft tissue cast. Refractory dies have already been dehydrated, coated with the connecting porcelain, and fired **(Figure 5a)**. The first bake will generate an opaque dentin core on the fractured tooth **(Figure 5b)**. It is followed by the application of a core of regular dentins and more translucent incisal enamels. An inner translucent enamel skin covers this buildup **(Figure 5c)**, and then the second bake can be carried out. A slight cutback should allow the application of superficial enamel stains followed by a low-temperature fixation bake. The final volume of the restoration can be accurately obtained through the application of a thin enamel skin **(Figure 5d)** and its subsequent firing. Glazing and mechanical polishing are then combined to obtain the final surface texture and gloss. The refractory material is removed by microsandblasting only after completion of surface finishing procedures.

with various provisional cements compared to freshly cut dentin. In practice, freshly cut dentin is present only at the time of tooth preparation (before impression).

Precuring of the dentin bonding agent leads to improved bond strength (McCabe and Rusby 1994, Frankenberger et al 1999). Applying and curing the dentin bonding agent immediately before the insertion of an indirect composite or porcelain restoration could interfere with the complete seating of the restoration. Eventual dentin exposures are therefore sealed immediately, the dentin bonding agent is applied and cured directly after the completion of tooth preparations, before the final impression itself, which was confirmed to generate superior bond strength and less gap formation (Ozturk and Aykent 2003, Jayasooriya et al 2003a, Magne and Douglas 1999e, Jayasooriya et al 2003b).

Immediate dentin sealing allows stress-free dentin bond

development: dentin bond strength develops progressively over time. In directly placed adhesive restorations, the weaker early dentin bonding is immediately challenged by the overlaying composite shrinkage and subsequent occlusal forces. On the other hand, when using immediate dentin sealing and indirect bonded restorations, because of the delayed placement of the restoration (intrinsic to indirect techniques) and postponed occlusal loading, the dentin bond can develop without stress, resulting in significantly improved restoration adaptation (Dietschi et al 2002).

Immediate dentin sealing protects dentin against bacterial leakage and sensitivity during provisionalisation (Pashley et al 1992, Cagidiaco et al 1996).

Tooth preparations must be rigorously isolated with a separating medium (eg a thick layer of petroleum jelly) during fabrication of the provisional restoration. It is

strongly suggested to avoid resin-based provisional cements, but provide mechanical retention and stabilisation instead (eg locking the restoration through additions of liquid resin in palatal embrasures).

Laboratory recommendations

From the dental laboratory perspective, it is recommended to fabricate type IIIA bonded porcelain restorations on refractory dies technique or using a foil technique. Ceramic fired over refractory die is the oldest and most widespread method for fabricating a porcelain piece (Bruce 1981). Model making can be tedious because multiple dies are required (single dies, refractory dies, soft tissue model). The main advantages of this technique, however, lie in the fact that (1) no special equipment is required, (2) extremely sophisticated effects of colour and translucency can be obtained through a full-thickness layering technique, and (3) traditional feldspathic porcelains can be used; and when combined with hydrofluoric acid etching and silanisation, these porcelains demonstrate extremely reliable bonding to resins (see next section) (Roulet et al 1995).

From an aesthetic standpoint, the refractory die technique will enable the use of modified opaque dentin as a core buildup during initial layering (see Figures 2c (part one, April *Private Dentistry*) and 5). Type IIIA bonded porcelain restorations are characterised by lack of sufficient supporting natural dentin, which must be compensated by a special buildup of opaque dentin that reproduces a similar outline for all preparations (see Figure 5b). The absence of opaque dentin would result in increased light absorption at the level of the missing natural dentin. Once the core dentin is fired, the elaboration will continue with two consecutive firings: the dentinoenamel core firing (see Figure 5c) and the enamel skin firing (see Figure 5d). The final steps will be a glazing bake followed by mechanical polishing and deinvesting by microsandblasting with glass beads.

It is strongly recommended to avoid etching the restorations in the laboratory before the try-in. Etched porcelain is extremely sensitive to contamination. Clinical try-in procedures generally include verification of the marginal fit of the restoration and seating on the original stone dies as well as proximal contacts on a solid model. These procedures can generate significant die stone contamination and subsequent bond strength reduction (Swift et al 1995). Unlike saliva contamination, die stone contamination is not easily cleansable. In any case, one must avoid contact between the etched/silanated porcelain veneers and stone models or tooth surfaces. Both porcelain and tooth surface conditioning should therefore be systematically carried out after try-in, not before (Roulet et al 1995).

Bonding to porcelain

Bonding to feldspathic porcelain can be achieved through etching (10% hydrofluoric acid gel during 90 seconds, followed by abundant rinsing) and cleaning. Cleaning the

Figure 6a

Figure 6b

Figure 6c

Figure 6d

Figure 6: Internal view of bonded porcelain restorations after the ceramic has been etched with 10% hydrofluoric acid for 90 seconds and rinsed. Even abundant rinsing proves insufficient to clean the porcelain, which is often contaminated by a white residue or deposit **(Figure 6a)**. The latter can be selectively removed with a brush and phosphoric acid **(Figure 6b)**, followed by placing the restorations in an ultrasonic bath in distilled water for a few minutes **(Figure 6c)**. The etched surface is now clean and ready for the application of the silane and subsequent heat treatment **(Figure 6d).**

etched porcelain is a critical factor. During the etching process, dissolution of the glassy matrix ultimately leaves retentive holes and tunnels between the acid-resistant crystals. During rinsing, this extremely rough surface is immediately contaminated by ceramic residues and remineralised salts, leaving a typical whitish residue (Jones et al 1989) (see Figure 6a). The whitish area is often misinterpreted as a positive etching outcome. Ultrasonic cleaning, which can be preceded by phosphoric acid precleaning (Figure 6b), is essential to remove the residues, enlarging and enhancing access to the microretentive features (Peumans et al 1999). Energy dispersive spectroscopy analyses have shown that the crystalline precipitates on the etched surfaces, which are not readily soluble in water, are the reaction products of sodium, potassium, calcium, and aluminum. The precipitates remain on the surface after HF acid application; they can be removed only by ultrasonic cleaning (see Figures 6c and 6d), not by rinsing alone (Canay et al 2001).

The micromechanical bond generated through etching and cleaning can be enhanced by chemical coupling, ie silanisation. Silane solutions contain a significant amount of solvent and must be evaporated for at least five minutes at room temperature (or one minute in a dry furnace at 100°C). This procedure allows the elimination of solvents and other contaminants and enhances the condensation of the silane on the ceramic surface (Roulet et al 1995). That specific thermal treatment can also be carried out using a hair dryer.

Practitioners must be extremely prudent when conditioning other types of ceramics. They must be aware that the tensile fracture resistance of the composite-ceramic adhesion zones is controlled primarily by ceramic microstructure and ceramic surface treatment. Procedures that apply to traditional feldspathic porcelain might not apply to other materials, eg some pressed ceramics or alumina ceramics (Sadoun and Asmussen 1994, Della Bona et al 2000).

Final considerations about function

A concern might be raised through the combination of

large incisal edge of porcelain and anterior guidance requirements. There seems to be an association between the absence of anterior guidance (ie open bite) and temporomandibular disorders (Okeson 1996). A key element in the development of harmonious occlusion is therefore by the incisal guidance the steepness of which is not important for neuromuscular harmony (Ramjford and Ash 1983, Dawson 1989). To minimise stresses during protrusive movements, some clinicians reduce the length of an aesthetically correct tooth. This disastrous approach results in a reverse smile line and ages the patient many years (Dawson 1989). As proven by clinical results, there should be no fear to rejuvenate the patient's smile by increasing the central incisors' prominence and length because ideal occlusion refers both to an aesthetic and physiologic ideal (Magne et al 2000, Ramjford and Ash 1983, Beyron 1969). Another reason to avoid distributing the anterior guidance over a maximum number of teeth, is the favourable mechanical behaviour of bonded porcelain restorations discussed previously. In conclusion, the functional features of teeth restored by bonded porcelain restorations type IIIA can be identical to those of intact natural teeth. Particular emphasis must be addressed to the maintenance or re-establishment of an adequate and functional anterior guidance regardless of whether this guidance involves the new restorations.

Conclusions

Considerable advantages, such as the economical and noninvasive treatment of crown-fractured anterior teeth, are inborn to type IIIA bonded porcelain restorations, reducing the need for preprosthetic interventions (eg root canal therapy and crown lengthening), and the use of intraradicular dowels. The success of the concept lies in the combination of sound adhesive principles, adequate design of the restoration and favourable load configuration, geometry, and tissue arrangement inherent to incisors. Immediate dentin sealing is recommended in case of significant dentin exposure. In the laboratory, the refractory die technique allows the development of a progressive translucency that enhances the blending of the incisal part of the restoration with the remaining cervical aspect of the fractured tooth. Adhesion strength to the feldspathic porcelain can be optimised through specific post-etching cleaning and silanisation. Given the aforementioned adhesion principles and biomechanical

facts, the functional features of teeth restored by bonded porcelain restorations type IIIA can be identical to those of intact natural teeth. PD

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