Posterior Composite Resins-
Reducing Post Operative
Sensitivity (Part One)

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The application of composite resin as a restorative material for posterior teeth, has provided clinicians with an opportunity to offer their patients aesthetic and often more conservative approaches to restorative dentistry, whilst also addressing the issues that some practitioners have in working with metal-based restorative materials. Composite resin is, however, a technique sensitive material to use and many clinicians have reported a high incidence of post-operative sensitivity in their patients, after posterior composite placement. Whilst the causes of post-operative sensitivity are many and varied, this article will discuss how application of a lining material may assist in overcoming this problem.

Brännström (1963) described the hydrodynamic theory as the mechanism for dentinal pain. Conventional metallic restorative materials benefited from cavity varnishes, or liners applied at the time of restoration placement, which provided initial protection of the freshly exposed dentinal tubules, within the prepared cavity. Over time, the varnishes or liners often dissolved away, however the corrosion products of the alloy restoration would effectively seal the dentine-restoration interface, the result being that little dentine hypersensitivity was ever experienced.

Composite resins are now placed utilising excellent fourth or fifth generation dentine bonding agents (DBAs). Research has shown that these dentine bonding agents are effective, predominantly due to a micromechanical retention with the dentinal tubules and exposed collagen fibrils of the peritubular dentine. This results in the formation of a resin-organic zone called the “Hybrid Layer” (Nakabayashi, 1985). Composite resins do not corrode, or form degradation products that fill the dentine-restoration interface, so in order to be successful, they must rely on the integrity and completeness of the bond between the DBA and the surface of the dentine, to effect a complete seal of the cavity preparation. Unfortunately, there are numerous obstacles in the way of achieving a perfect seal, and the resultant “imperfection” leads to the formation of micro or nano-gaps between the dentine and the restorative, leading to the subsequent possibility of fluid movement and ultimately dentinal pain. Accordingly, the careful selection and application of materials during posterior composite placement may lead to improved dentine-restorative sealing and therefore decreased postoperative sensitivity.

Glass Ionomer Cement Cavity Liners

In recent times, there has been a shift away from using cavity liners beneath permanent restoratives. Traditionally, many liners contained a Eugenol base and there has been some concern regarding the potential of Eugenol to inhibit the polymerisation reaction of the composite restorative material (Millstein and Nathanson, 1983). With regard to calcium hydroxide based liners, there has also been concern that the liner itself was soluble and therefore not suited to long-term application under a composite restoration (Hwas and Sandrik, 1984).

More recently, with improvements in the properties of dentine bonding agents, the adhesive resin technique has evolved into one where exceptional reliance has been placed on the bond strength between the DBA and the dentine surface, for both retention of the restoration, and the effecting of a hermetic seal. This teaching has evolved due to observation of the high bond strengths that can be achieved in in-vitro studies and the excellent penetration of the hydrophilic DBA monomers into the dentinal tubules and peritubular collagen fibrils (Hybrid Layer). Unfortunately, these in-vitro studies do not adequately address the question of the short and long term durability of the DBA to dentine bond.

Most clinicians are familiar with the term “total etch and total seal,” when placing composite restorations and there has been a marked shift away from the use of cavity liners, in favour of using a DBA to adhere to the entire exposed dentine surface. However, the procedure for correct preparation of the dentine surface and incremental placement and polymerisation of the composite resin requires a high level of skill and understanding of the materials involved in the procedure. As a result, there are many opportunities for possible sources of incomplete adaptation and bonding
between the DBA and the dentine surface to occur (Peutzfeldt and Asmussen, 2002). It is not surprising to expect that the bond will not be complete in some areas of the cavity preparation and that these areas of incomplete bonding will most likely be areas that allow the micro-movement of fluids, leading to postoperative sensitivity.

A simple approach to prevent such an occurrence is to use an appropriate cavity liner prior to the application of a DBA (Akpata and Sadiq, 2001). To fully benefit from this technique, a change in philosophy on the concept of dentine bonding is needed. The clinician should not consider the DBA as a "bonding" agent that will adhere the restoration into the cavity and retain it against dislodgement. Rather, it is useful to consider that the cavity preparation still requires some resistance and retention form (via mechanical undercuts), and that the DBA is a "sealing" agent with the capacity to hermetically seal the restoration at the enamel margin and peripheral dentine. Therefore, deeper in the cavity, where dentine bond strengths may be compromised due to greater numbers and diameters of dentinal tubules and greater dentine moisture content, a self-adhesive liner is used to effect a seal on the dentine. The DBA then seals the peripheral dentine and helps to adhere the liner to the composite restorative (see illustrations 1 & 2).

The ideal lining material should be self-adhesive to tooth structure and provide a hermetic seal; be easy to apply, preferably light activated; be able to provide a bond to the DBA and/or composite restorative, and also afford some antimicrobial activity and/or fluoride release activity for possible benefit in deeper cavity preparations. Glass ionomer cements are an ideal material for application as a liner beneath composite restorations, and Vitrebond (3M ESPE) is an exceptional material for such an application (Illustration 3).

Vitrebond contains a proprietary modification of a polyalkenoic acid (Vitrebond copolymer) which allows Vitrebond to undergo an initial polymerisation set after light activation, followed by a significant proportion of the material setting by conventional GIC (acid-base) reaction. Vitrebond is therefore able to make chemical linkages to the methacrylates in the DBA and composite restoratives, yet still has significant GIC chemistry, so that it is able to chelate to mineralised tooth structure and also release some fluoride into the surrounding dentine. In-vitro studies on dye penetration show that Vitrebond has very high resistance to microleakage, and this makes it an excellent choice for a liner (Martin and O’Rourke, 1993; Youngson and Holguin, 1992).

This article to be continued in Part Two of the 3M ESPE “Solutions for Dentistry” Series.

References:

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Figure 1. A defective class II restoration in the second premolar is to be replaced with a posterior composite resin.

Figure 2. The old restoration has been removed, and the cavity preparation is conservative yet has retentive features. A glass ionomer cement base (Vitrebond, 3M ESPE) has been applied covering all but the most peripheral dentine to effect a seal on the exposed tubules.

Figure 3. 3M ESPE Vitrebond Liner
Posterior Composite Resins- Reducing Post Operative Sensitivity (Part Two)

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Advances in dentine bonding chemistry has transformed the way in which composite resins can be used in modern practice. Most clinicians use 4th Generation (two bottle) or 5th Generation (one bottle) Dentine Bonding Agents (DBAs), to effect a bond to dentine by penetration of a hydrophilic, polymerisable monomer into exposed dentinal tubules and in between individual exposed collagen bundles and fibrils in demineralised, peritubular dentine. In-vitro studies have shown that a micromechanical bond results after the formation of a Hybrid Layer between the DBA and the dentine and there is now a mass of clinical data to support the successful use of DBAs, at least in the shorter term.

However, the use of these DBAs is very technique sensitive and open to unintentional abuse. The concept of a "total etch, total seal" technique of dentine bonding (discussed previously in Issue 1) has considerably simplified the process of dentine bonding. Both enamel and dentine are etched by the same acid preparation in a single step, to create the micro-mechanical retention pattern in the enamel prisms, as well as removal of the smear layer which exposes dentinal tubules and peritubular collagen fibrils in the dentine. The residual acid must be washed away and the resultant dentine left in a "moist" state, so that, the collagen fibrils are sufficiently hydrated and remain in a three dimensionally "suspended" state (figures 1 and 2). This will facilitate the flow and penetration of the hydrophilic monomer in and around the fibrils to form an interlocking network of resin and collagen called the Hybrid Layer (figure 3).

Potential problems can arise if the etching agent is not completely washed away, if the dentine is not left sufficiently moist for suspension of the collagen fibrils, and if the hydrophilic bonding resin does not flow completely into all of the demineralised and exposed areas between the collagen fibrils, resulting in nano-gaps. The potential consequences of such procedural problems are poor micro-mechanical bonding of the DBA to dentine surface and the formation of spaces within the DBA and dentine interface (figures 4 and 5).

Therefore, lack of effective bond may lead to post-operative sensitivity and early failure.
A solution to these potential problems might come from the use of a 6th Generation (two bottle) or 7th Generation (one bottle) dentine bonding agent. These new DBAs are referred to as the "self-etching" dentine bonding systems. Rather than first etch the enamel and dentine surface with a strong acid, the self-etching systems use a hydrophilic bonding monomer, which has phosphate modified side-chains making the molecule very acidic in an aqueous environment. These new bonding monomers have a pH sufficiently low that they will efficiently etch enamel and dentine to produce micro-mechanical retention patterns similar to regular 37% phosphoric acid. The significant advantage of these self-etching systems is that they only etch where they are applied. Where they are applied, there will also be polymerisable monomer to crosslink and form a set film. In other words, when a self-etching monomer is used, primer will penetrate into every single nano-space that is created during the etching process, because the etchant and the primer are the same molecule (figure 6). There is no rinse stage, there is no need to try to create a "moist" tooth surface, and there is no need to hope that the monomer being applied will actually flow into every little nano-gap opened up during the demineralisation phase. The "self-etching" chemistry is really the ultimate in "total etch, total seal" and the use of "self-etching" DBAs dramatically simplifies the procedure of dentine bonding by removing some crucial technique-sensitive steps. Early clinical results and the experiences of this author attest to the significant decrease in post-operative sensitivity reported by patients after "self-etching" DBAs have been used (Gordan and Mjor, 2002).

One of the new self-etching dentine bonding agents is Adper Prompt Self Etch (3M ESPE). The DBA is available in two-bottle form, and also in a unique, uni-dose L-pop applicator for convenient, accurate and hygienic dispensing. Adper Prompt SE also contains 3M ESPE's proprietary Vitrebond for convenient, accurate and hygienic dispensing. Adper Prompt SE is also very compatible in forming cross-linkages (and thus a seal) with a glass ionomer lining material (discussed in Part One of this series).

The recommendations for use of 3M ESPE Vitrebond liner and 3M ESPE Adper Prompt SE in a posterior composite restoration are:

1. Preparation of the cavity and removal of carious dentine.
2. Placement of mechanical retention features into the cavity.
3. Placement of Vitrebond cavity liner on exposed dentine and any visible microcracks in the dentine (1st Layer of seal). Some dentine may be left uncovered peripherally to allow the DBA to make some peripheral seal against the dentine (2nd Layer of seal).
4. Application of Adper Prompt SE (3rd Layer of seal) to non-desiccated dentine and enamel. The DBA should be applied and rubbed onto the tooth surface for 15 seconds and then air-dried.
5. A second layer of Adper Prompt SE should be applied to the tooth, dried and then light cured for 10 seconds.
6. Placement of the composite restorative in increments (figure 7 and 8).

Figure 6. The application of a self-etching primer results in a demineralisation pattern which is perfectly permeated by the polymerisable monomer as the etchant and monomer are the same molecule. No nano-gaps are formed.

Figure 7. After application of the self-etching DBA, 3 or more increments of restorative composite are placed to help dissipate polymerisation stresses.

Figure 8. The final restoration after contouring and polishing. This patient did not report post operative sensitivity.

The final restoration therefore, consists of 3 layers of seal, each at its most appropriate place and depth for maximum effectiveness. The resultant restoration should be less likely to result in post-operative sensitivity due to fluid movement, as a result of unsealed dentine.

References:

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