TIPS FOR SUCCESSFUL POSTERIOR RESIN COMPOSITE RESTORATIONS

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Because of the development of material science and cariology, it became very easy to obtain successful results with posterior restorations using adhesive resin composites. The successful results include esthetics, long lasting function, and of course, no post operative sensitivity of the tooth. At the same time, the procedures and manipulation of the materials should be simple and easy to reduce the operator's technique sensitivity.

1. Cavity preparation

Cavity preparation for the adhesive restoration is extremely simple and easy. The most significant reason for the post operative sensitivity is over-cutting of dentin during the cavity preparation. When the outer carious dentin, which is infected by bacteria and easily stained with caries detecting dye solution, is removed, the cavity floor dentin is not sensitive, even if it is very close to the pulp. Once the intact dentin is exposed in the cavity, it must be very sensitive because the dentinal tubules are open and transfer the stimuli to the pulp. Bonding with perfect sealing of the tubules is essential for decreasing sensitivity. Furthermore, cutting of sound dentin may cause pulpal inflammation or hyperemia. In most cases, these pulpal changes recover with time, however, some cases requiring endodontic treatment may occur because of irreversible pulpal changes.

Bon -ding with perfect sealing of the tubules is essential for decreasing sensitivity.

The procedure of this technique established by Dr. Fusayama [New Concepts in Operative Dentistry, Quintessence Publishing, 1980] is as follows; 1. opening the cavity with high speed cutting (Figures 1&2), 2. excavation of the outer carious dentin according to the guide of caries detector and natural discoloration using slow speed steel burr or hand instruments (figures 3-5), 3. repeating the staining of the lesion and its removal until staining becomes light pink or less (figure 6). In addition, the wetness of the cutting debris and the sensitivity of the tooth are very valuable information for diagnosing the amount of dentin to be removed. Then the bonding and filling materials are applied without lining materials even when the cavity is very deep (Figure 7&8).

When the outer carious lesion is removed according to the guide of staining with caries detector and natural discoloration, patients don't feel severe pain during the caries excavation (Figure 9). Clinical evaluation of the VAS (Visual Analogue Scale) value of the pain during the treatment of caries revealed that the younger patients tended to feel stronger pain than older patients. However, the pain was much less than the pain during a shot of local anesthesia [Terano et al., JDR 79 abst.#1162, 2000]. Though various methods for diagnosing dentin caries removal have been proposed, this technique is the most practical for achieving "minimum invasive" caries treatment.

After removal of the outer carious dentin, the cavity floor consists of the so called inner carious dentin, which is also named as caries affected dentin. It is clearly shown that the caries affected dentin is not permeable (Figures 10-13). It means that the cavity floor dentin is not sensitive. The SEM picture exhibits the occluded dentinal tubules with mineral deposits even after the phosphoric acid etching (Figure 14). That's why the lining is not necessary when this technique is applied. The lining is recommended when the intact dentin was cut or when the patients felt significant pain during the cavity preparation.

When this minimal invasive technique for caries removal and cavity preparation is used, post operative tooth sensitivity seldom occurs. Even when the cavities are left as it is without any filling, the tooth is not sensitive because the cavity floor dentin consists of the caries affected dentin with the occluded tubules.

2. Selection of the Adhesive Resin:

High quality adhesive provides good sealing and reinforcement of the tooth substance and filling material. Adhesive resin which xhibits strong bonding, low technique

Figure-1.
Before Treatment

Figure-2. Cavity is opened with High Speed Diamond Point

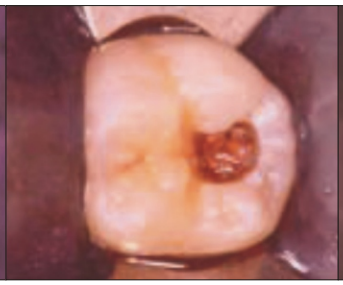

Figure-3.
Discoloration is seen

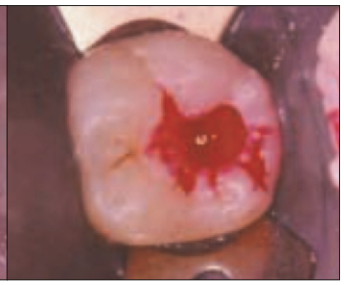

Figure-4.
Caries detector is applied

Fig.5. Lesion to be removed is clearly indicated

Fig. 6. Removal of the outer lesion, and the prepared cavity

Fig. 7. Bonding procedure is applied

Fig. 8. After filling and polishing

Fig. 9. VAS value of pain during the caries removal and cavity preparation LA : VAS value during the shot of local anesthesia

Fig. 10. Extracted molar with cavitated lesion

sensitivity and durable bond to both enamel and dentin should be selected.

SE Bond is very well known as extremely excellent adhesive resin for both enamel and dentin. SE Bond consists of two steps, which is selfetching primer application and bonding resin application. It does not require the wet bonding technique since the water rinsing is not necessary. Wet bonding technique is well known as a technique sensitive bonding procedure, since both the over-wet and over-dry condition result in decrease of the bond. Especially in the cases of posterior restorations, the wet bonding technique is very difficult to apply, because configuration of posterior cavities is very complicated.

Operator technique sensitivity with SE Bond is much lower than with the all-in-one type adhesive, which consists of only the selfetching adhesive. Because of the extremely simplified bonding procedure of the all-in-one type adhesives, both performance of bonding and technique sensitivity are generally sacrificed.

3. Selection of the resin composite

Clearfil AP-X, which is a heavy filled semi hybrid type resin composite, was developed for both anterior and posterior restorations.

The consistency of Clearfil AP-X must be felt relatively thin compared to most posterior resin composites. However, Clearfil AP-X is not sticky to the instruments. This unique property was achieved by an original technology, named "interfacial boundary control" between filler particle and matrix resin. It is very easily recognized when you compare with any of the composite resins which are used in your clinic. This is one of the most unique characteristics of Clearfil AP-X.

Stickiness of the resin pastes to filling instruments is reduced by increasing the consistency of the paste in the resin materials so called packable or condensable resin. However, the high consistency resin composites may have disadvantages such as the difficulty of spreading, especially in a very small and complicated cavity, and poor adaptation to both cavity walls and the incremental interface.

When the cavity wall adaptation and voids in Class I resin composite restorations were investigated, it was revealed that thick-consistency composite had more problems related to voids and wall adaptation than the medium and thin consistency composites [Opdam et al., Dental Materials 12:230-235, 1996].

Thus, Clearfil AP-X, which can be classified as a mediumconsistency resin composite, can be said to be very easy to fill into cavities of posterior teeth and to obtain excellent wall adaptation without voids. This property is also advantageous when the incremental filling technique is applied to deep cavity restorations, obtaining good adaptation between incremental layers.

Even the consistency is very thin before polymerization, flexural strength, Vickers hardness, and tooth brush wear resistance of Clearfil AP-X are very high. This is mainly because of the high filler content of 85.5 weight % (Figure 15). Barium glass is used as the filler particles and this glass is relatively soft compared to silica filler particles. Because of this relatively soft filler, polishing of this resin is very easy.

4. Long term clinical performance

In most of the papers reporting the longevity of posterior resin restorations, the wear of the composite resin was not a significant reason for the replacement of that restoration. The main cause of failure for composite restoration is usually secondary caries around the restorations. To increase the longevity of the restorations, the refurbishing of the restorations is believed to be very effective [Mjor, Adhesive Dentistry 19:236, 2002].

The survival rate of the composite restoration in posterior teeth was reported to be higher than that of cast restoration [Kubo et al., Japan J Conserv Dent.44:802-809, 2001]. The calculation was based on the results of 19 years clinical

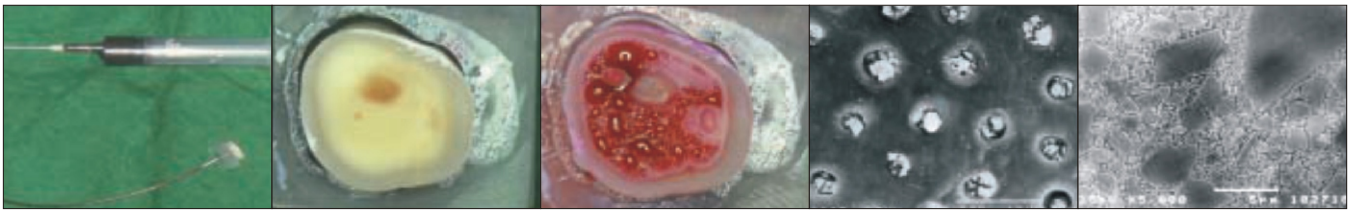

Fig. 11. The oculusal surface was ground and the root was also removed. The crown segment was bonded to a plastic plate and connected to a syringe to be able to apply a pressure from pulpal side. The pulp chamber was filled with a red dye solution.

Fig. 12. Occlusal view after preparing the flat surface. Lesion with the discoloration is removed according to the clinical procedures.

Fig. 13. After the etching, the red dye solution infiltrated from the pulp. The dye was seen only at the area of the intact dentin, indicating the cavity floor dentin is not sensitive.

Fig. 14. The dentinal tubules at the caries affected dentin were occluded with mineral deposits even after the phosphoric acid etching.

Fig.15. SEM of the AP-X, showing the heavily filled with various sizes of fillers.

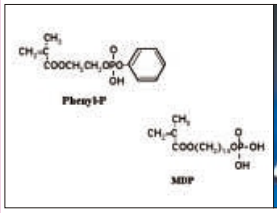

Fig. 1. Adhesive resin monomers developed by Kuraray Medical Inc., MDP and Phenyl-P, which include the phosphate bases. Because of the acidic part, they are named to be acidic monomer, which enables to reduce the pH of the primer solution.

Fig. 2. Clearfil SE Bond consists of one bottle self-etching primer and one bottle light cured adhesive.

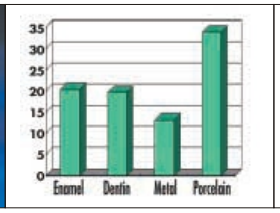

Fig. 3. Bond strengths (MPa) of the SE Bond to enamel, dentin, metal and porcelain. Alloy Primer (Kuraray Medical) and Activator (Kuraray Medical) were used for the bonding to metal and porcelain respectively.

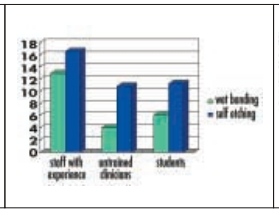

Fig. 4. Dentin bond strengths (MPa) of adhesives with a self-etching primer and phosphoric acid, obtained by the well experienced operators, untrained clinicians attended a continuing education program, and the dental students.

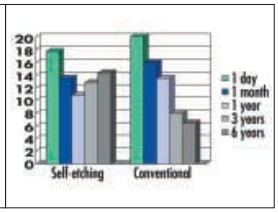

Fig.5. Long term dentin bond strengths (MPa) of a conventional adhesive with acidic conditioner and adhesive, and a product with the self-etching primer

assessment. This result is enough to assure the propriety of the Fusayama's technique. The recent materials can be expected to exhibit much better results than the reported survival rate at 19 years, approximately 80 %, because of the improvements of the materials.

What is Clearfil SE Bond?

Concept of SE Bond

The technology of self etching primers was developed by Kuraray Medical Inc. This was achieved by the development of the so called adhesive resin monomers, named MDP or Phenyl-P (Fig. 1). The adhesive resin monomers includes the acidic part, that is phosphate. Because of this acidic part, the primer solution containing the MDP becomes acidic, and can etch the enamel and dentin surface.

The wet bonding technique is required only when the acid is applied and rinsed with water. In the case of the bonding procedures using the self etching primer, the uncertain method of et bonding technique is not required since the collagen fibers are already incorporated with the resin monomers in the primer solution. The bonding procedure of Clearfil SE Bond (Figure 2) is, application of self etching primer for 20 seconds, drying the surface with air blast removing the excess primer solutions from the surface, application of the bonding resin, and light curing. With this extremely simple bonding procedure, very strong bonding to both enamel and dentin, as well as to various dental materials can be obtained (Figure. 3) [Harada et al., Dentistry in Japan 36: 47-53, 2000]. SE Bond is used in the clinic for not only restorative procedures but also intraoral repairs of fractured restorations, secondary caries and so on.

Technique sensitivity

Miyazaki et al. [American Journal of Dentistry 13:101-104, 2000] also reported the larger variation in bond strength of an adhesive with total etching and wet bonding technique than a self etching adhesives (Figure 4). In the case of the wet bonding technique, both over wet and over dry conditions result in the decrease of the bond.

A new type of bonding material, an all-in-one type adhesive, consists of a real one-step bonding procedure. The self-etching adhesive is applied and cured. The adhesive has to include some amount of water to be acidic, and it has to be polymerized with dissolved smear layer.

Although the bonding procedure is simplified, the technique sensitivity and bonding erformance seem to be sacrificed. In fact, these all-in-one adhesive resins demonstrated lower bonding than adhesives with a twostep self-etching primer [Nakaoki et al., 79th IADR, Abst.#1815, 2001]. Another recent study revealed that SE Bond showed the most stable and strong bond when compared with an adhesive with phosphoric acid etching (Single Bond) and an adhesive of all in one system (Touch & Bond) [Nikaido et al.,31st AADR, 2003]. Even when students without the experience of using adhesive resins prepared the specimens, the best results were obtained with SE Bond. Also, SE Bond exhibited less technique sensitivity than the other bonding materials.

The only problem with this adhesive system is the consistency of the self etching primer, which is very thin. The primer flows very easily down the cavity walls, however, this problem is easily solved by applying the

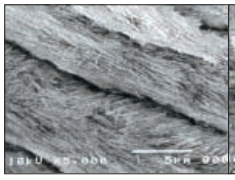

Fig. 6. Phosphoric acid etching provided the typical etching pattern of the longitudinally cut enamel prisms

Fig. 7. Self-etching primer of SE Bond provided relatively weak etching effect compared to phosphoric acid.

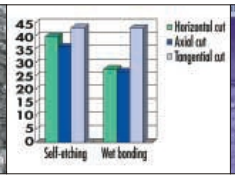

Fig. 8. Enamel bond strengths (MPa) of SE Bond and Single Bond to horizontal and axial sectioned surfaces with the longitudinally cut enamel prisms, and to tangentially sectioned surface with cross-cut prisms.

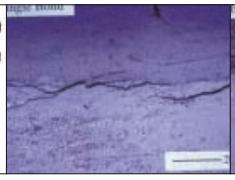

Fig. 9. Laser scanning microscopic image of the bonding interface between enamel and single bond showing the crack propagation along the prisms under the interface.

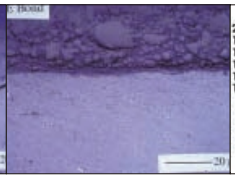

Fig. 10. Laser scanning microscopic image of the bonding interface between enamel and SE Bond showing the tight bonding without crack propagation.

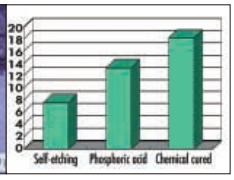

Fig. 11. Incidence (%) of post-operative tooth sensitivity after composite resin restorations using the adhesives with self-etching primer, phosphoric acid etching with light cured adhesives or chemical cured adhesives.

primer 2 or 3 times during the application time [Ogata et al., Operative Dentistry 24:81-88, 1999].

Long term bond durability

The bonding durability of the adhesive with a self etching primer has been reported to be superior than the adhesive with total etching technique even after 6 years (Figure 5) [Burrow et al., Adhesive Dentistry 19:254, 2002]. It is because of the very stable hybrid layer formation, though it is very thin. Effects of incomplete removal of water from the hybrid layer and insufficient penetration of the resinous material into the collagen layer are considered to be main causes of the degradation of the hybrid layer. As the result, the quality of the hybrid layer should be inferior in the case of total etching technique and/or wet bonding technique.

There might be a concern if it is safe to leave the acidic primer on the tooth surface, since water rinsing is not applied after the application of the self etching primer. Fortunately, a seven-year clinical evaluation of an adhesive using the self-etching primer, Clearfil Liner Bond 2, revealed excellent results without any de-bonding, nor pulpal response [Akimoto et al., Japanese Journal of Conservative Dentistry 2001]. Enamel and dentin are very strong buffers against the acid. After application of the primer for 20 seconds, the acidity of the primer must be decreased dramatically. The excess of the primer solution is also removed by air blasting. If it is harmful to the dentin/pulp complex, the excellent clinical performance without post operative sensitivity cannot be obtained.

The dissolved and softened smear layer can be blown away from the surface when the excess of the primer is removed. Also, the primer is known to show some antibacterial effect. Even if some bacteria and smear layer remained, excellent clinical performance and durable bonding prove that it would not be a problem.

Enamel bonding

Another concern may be the bonding to enamel, since the acidity of the self etching primer is considered to be much lower than that of phosphoric acid. Actually, etching effect of the self-etching primer is much less than that of the phosphoric acid etchant (Figure 6, 7). However, a recent study revealed that SE Bond showed more stable bonding to both cross-cut enamel prisms and longitudinallycut enamel prisms than the adhesive with phosphoric acid etching (Figure 8) (Shimada et al., Operative Dentistry, 28:20-27, 2003). The phosphoric acid etching may be too strong to etch the longitudinally cut prisms, which resulted in the separation of enamel prisms just beneath the bonding interface (Figure 9, 10). In the clinical situation, the cavity walls consist of mostly longitudinally cut enamel prisms. As shown in the Figures 7, the SEM of the enamel after the self-etching primer application does not look great, however, we etch the tooth for the bonding, but not for the SEM.

Unfortunately, the uncut enamel surface is much more acid resistant than ground enamel, and the self-etching primer is not strong enough for strong bonding (Kanemura et al., American Journal of Dentistry, 27:523-530, 1999). In the cases of the bonding of fissure sealant and direct composite veneer without cutting the enamel surface, phosphoric acid etching is recommended.

Post operative sensitivity

According to a clinical evaluation of post-operative tooth sensitivity after resin composite restorations, teeth restored with the materials utilizing self-etching primer showed the less post-operative sensitivity than bonding materials using phosphoric acid etching (Figure 11, Unemori et al., Journal of Dentistry, 29:7-13,2001). It is considered that adhesive materials with self-etching primer have the advantage of better bonding performance and less technique sensitivity in the bonding procedure compared to those materials with phosphoric acid etching.

Opdam et al. (American Journal of Dentistry 11:229-234, 1998) evaluated the post operative sensitivity with class I restorations. Post operative sensitivity was observed with 25% of the cases restored with the adhesive using phosphoric acid etching, whereas none of the cases restored using a self etching primer, Clearfil Liner Bond 2.

The desensitizing effect of the adhesive resin monomers is considered to contribute to decrease the post operative tooth sensitivity. The desensitizing effect of adhesive primer application to hypersensitive teeth was confirmed in clinical studies (Tagami et al., Dental Materials Journal 6:201-208, 1987, Suda et al., Dental Materials Journal 9: 163-166, 1990).

The mechanism of the desensitizing effect was postulated due to the coagulation of dentinal fluid or precipitation of protein in dentinal fluid, such as globulin and albumin, resulting in a reduction in dentin permeability (Tagami et al., Arch oral Biol 39 suppl: 146S, 1994). Self etching primer is expected to show the desensitizing effect since the self etching primer shows the coagulation of protein.

` Based on our work, SE Bond is believed to have the best advantage in preventing post operative sensitivity, as compared with the adhesives using phosphoric acid. After the phosphoric acid etching, the primer application has a possibility of decreasing the sensitivity; however, the etching increases dentin permeability by enlarging tubule diameters. SE Bond, which does not require any strong acidic treatment, and is not technique sensitive as compared to the wet bonding technique, provides a successful restoration.

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