

Composite resin restorations: a simplified approach

Douglas Terry and Karl Leinfelder discuss the fundamental principles for achieving predictable long-term success with directly placed composite resin restorations for anterior and posterior teeth and describe a simplified technique that uses restorative adhesive concepts with a nano hybrid composite to develop precise anatomical morphology, function and aesthetics

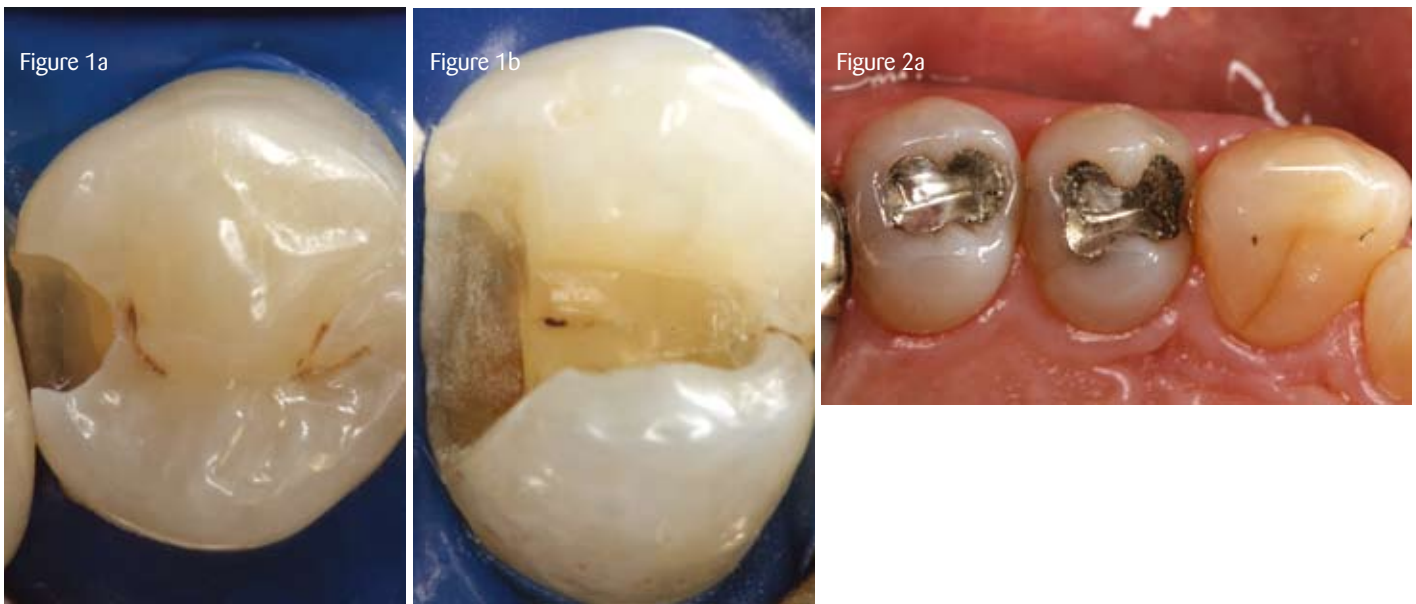
Composite resin restorations were first recommended as a substitute for metallic restorations shortly after their introduction in the late 1960s. Unfortunately a series of well controlled clinical studies demonstrated that they were completely unacceptable for such a purpose (Phillips et al, 1972; Phillips et al, 1973; Lutz et al, 1984; Leinfelder et al, 1980; Leinfelder and Roberson, 1983). The clinical performance of the initial formulations was disappointing (Rubinstein and Nidetz, 1995). The initial formulations were chemically cured and their use was indicated for Class III, IV, and V restorations. The filler particles were large and the filler content was low (Jackson and Morgan, 2000). Therefore, early attempts to use these formulations in the posterior dentition resulted in shortcomings, which included: inadequate resistance to wear (Jackson and Morgan, 2000; Bichacho, 1996; Dietschi et al, 1995a; Full and Hollander, 1993; Dietschi et al, 1995b; Eames et al, 1997) fractures (Bichacho, 1996; Eames et al, 1997), microleakage (Jackson and Morgan, 2000; Bichacho, 1996; Mazik, 1992), secondary caries (Ruyter, 1988; Hornbrook, 1996), marginal breakdown (Dickerson, 1991), post-operative sensitivity (Dickerson, 1991; Leinfelder, 1996), improper interproximal contact and contour (Mazik, 1992), inadequate marginal adaptation (Leinfelder, 1996), colour instability (Rubinstein and Nidetz, 1995; Bichacho, 1996), inadequate polishability (Rubinstein and Nidetz, 1995), pulpal irritation (Full and Hollander, 1993) and endodontic therapy (Rubinstein and Nidetz, 1995).

Unfavourable clinical performances of the past that gave composite resin such a poor reputation were not only limited to insufficient physio-mechanical properties and wear resistance, but also used inappropriate restorative techniques and preparation designs for composite resin for the particular clinical situations (Dietschi et al, 1995a; Dietschi et al,

1995b; Luescher et al, 1977; Lutz and Kull, 1980; Lacy, 1987). Undoubtedly, these and other problems associated with posterior composite resins could be attributed to inserting materials designed for anterior teeth into posterior preparations. Little or no thought was given to the type of cavity design for either Class I or II cavity preparations. Furthermore, no information was available to the clinician or the designer of such materials as to what properties were necessary to withstand occlusal forces. Consequently, the entire history associated with the development of composite resins and associated techniques has been characterised by trial and error both in the laboratory as well as at the chair.

Today, after more than 40 years of concentrated efforts through science and clinical trials, it has been concluded that composite resins can be used successfully as a substitute for amalgam and gold (Mazer and Leinfelder, 1992; Mazer and Leinfelder, 1988; Dickinson et al, 1993; Wendt and Leinfelder, 1992). As compared to metallic restorations however, the associated procedures are largely different and complex. The number of specific procedural steps and the amount of time required to complete multiple surfaced composite restorations is appreciably greater. Furthermore, based upon the chemistry and mechanical characteristics of the composite resin, the cavity preparations recommended for their use is considerably different than those used for the corresponding metallic restoration (ie. amalgam, gold) (Leinfelder, 1996).

Many of the restorative concepts and principles for metallic restorations are still being used with current adhesive dentistry. However, dramatic changes in our understanding and control of the caries process, with a reduction in the incidence and severity of caries and even our process of detecting decay with chemical agents has subjected our clinical judgment to rethinking these past



Figures 1a and b: The adhesive preparation for composite restorations (a) allows a more conservative design than its amalgam counterpart (b)
Figure 2a: Pre-operative occlusal view of defective amalgam restorations with recurrent decay

preparation designs and principles that were applicable to a different era. The need for ‘extension for prevention’ has been replaced with more a conservative approach to tooth preparation, the ‘adhesive preparation design’. The traditional methods of experience and skill for discerning decay from stained tooth structure have been supplemented with innovations such as caries detecting agents and improved illumination and optical aids to enhance vision (Laswell and Welk, 1985). Also, the differing physical and mechanical characteristics of the restorative materials require a protocol that is divergent from that of earlier restorative materials. Unfortunately, many clinicians continue to use yesterday’s procedures with today’s restorative materials and wonder why they continue to have microleakage, recurrent decay and sensitivity. Presently, the effect of this misdirection could be one of the reasons for the relatively short longevity of the composite restorations in the general dental practice (Moffa, 1989; Qvist et al, 1990). Advances in material science and adhesive technology require the clinician to modify non-adhesive restorative techniques for application to restorative adhesive concepts. The application of these concepts should be considered during diagnosis, material selection, preparation design, adhesive protocol, restorative placement techniques, restorative finishing and maintenance (Leinfelder, 1991; Baratieri et al, 1998, Ferracane, 1992; Liebenberg, 1996a) and even individual patient selection.

After years of *in vitro* and *in vivo* investigations, it is now possible for the clinician to develop a durable, long-lasting restoration that is aesthetically indistinguishable from natural tooth structure. Exact shade matching and localised characterisation is entirely possible. However, the attainment of ultimate aesthetics can take a considerable amount of time and experience. While such a goal is highly

desirable, it may not be appropriate for all clinical situations. In this regard there is an alternative approach that can be taken that is simpler but based upon sound scientific principles. It is the purpose of this paper to describe the entire process by which anterior and posterior composite resin restorations can be accomplished in a more efficient period of time. The objective of this article is to provide the clinician with the fundamental principles for achieving predictable long-term success with directly placed composite resin restorations for anterior and posterior teeth. This article discusses these principles and describes a simplified technique that uses restorative adhesive concepts with a nano hybrid composite (Grandio, Voco, www.voco.de) to develop precise anatomical morphology, function and aesthetics.

Restorative material selection

In the past, the physical and mechanical properties of the individual composite systems (ie. hybrid, microfill) had inherent limitations that confined their use to specific procedures. To achieve an optimal restorative result and compensate for these inequities required one to select and layer both a hybrid and a microfill resin system. These intricate layering techniques further complicated some clinicians’ ability to achieve consistent and reliable results. Thus, newer formulations of microhybrid composite resins have been designed with the concept of combining dentine colour and enamel value in relationship to the natural tissue anatomy. These composite restorative systems not only simplify the replication of the optical properties of the natural tooth, but have similar physical and mechanical properties to that of tooth structure. With the selection of these improved biomaterials, the clinician is able to

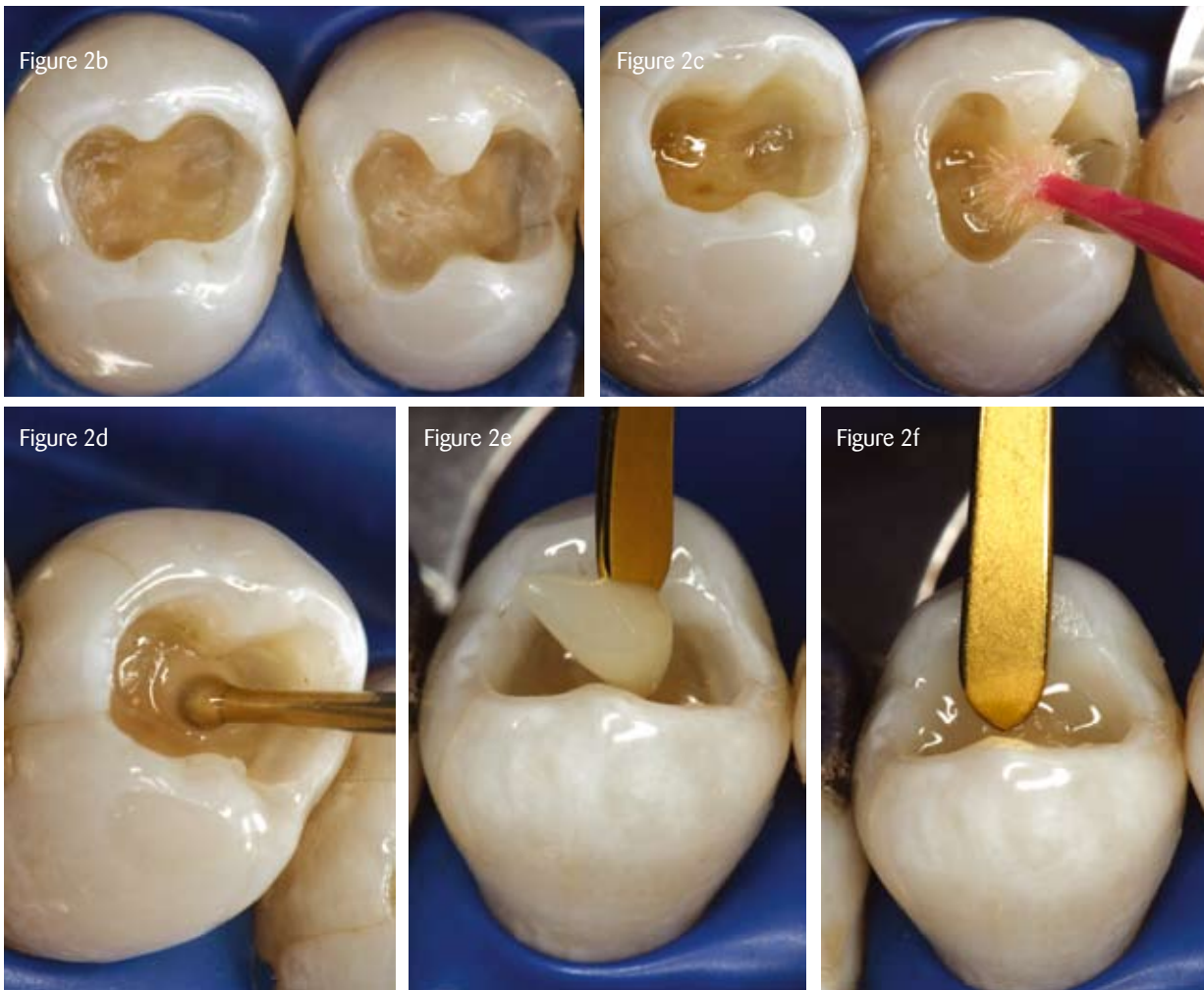


Figure 2b: The occlusal outline is extended only to include carious enamel, provide access to the carious dentine, and remove any residual amalgam staining **Figure 2c:** After the preparation is acid etched, a single-component adhesive is applied **Figure 2d:** An A3 shaded flowable composite (Grandio Flow, Voco, www.voco.de) is applied as a cavity liner and uniformly distributed on the pulpal floor with a ball-tipped instrument **Figures 2e and f:** An elongated A3 shaded hybrid composite increment (Grandio, Voco) is placed and adapted in an oblique layer with a curved metal instrument (TINL-R, Brasseler USA, www.brasselerusa.com) against the cavity wall

preserve, conserve and reinforce tooth structure with more conservative preparation designs.

Adhesive preparation design

Early operative concepts sanctioned the removal of healthy, sound tooth structure in order to perform the necessary restorative procedure (Simonsen, 1985). Cavity designs were formulated with a specific geometric outline form for specific regions on the tooth and designed to prevent the future possibility of caries. Metallic restorations would not adhere to the dental tissues; hence a mechanical approach was required to enhance the resistance and retention form. The modern adhesive preparation design employs a biologic approach that provides restoration retention through adhesion while providing reinforcement and strength to existing tooth structure. Metal-free direct restorative systems depend upon the use of adhesive preparation designs that are more conservative and require more thorough adhesive

techniques (Lutz, 1996; Lutz et al, 1996; Dietschi and Spreafico, 1999; Ouellet, 1995). There are no geometric outline preparation forms. Consideration should be given to tooth type, location in the arch, size and type of carious lesion, treatment of decayed or non-decayed unrestored teeth or restoration replacement and relationship between occlusal function and preparation boundaries. Other factors that should be considered are type of restorative technique (ie. direct, semi/direct or indirect), quantity and quality of remaining tooth structure, mechanical forces on remaining structures, presence of defects, and the parameters for extension of the preparation to the aesthetic zone (Dietschi and Spreafico, 1999; Wilson et al, 1997).

The original cavity preparations for direct restorative materials, both anterior and posterior, were designed by GV Black nearly 100 years ago. These principles of design, however, are still applicable in the modern dental practice by simply modifying these basic principles so that they apply to modern materials, techniques, and technology (Terry, 2004).



Figure 2g



Figure 2h



Figure 2i



Figure 2j

Figure 2g: The adapted increment is light cured through the cusp using the ramp curing mode to minimise polymerisation stresses and enhance marginal adaptation. **Figure 2h:** A final increment of incisal shaded hybrid composite (Grandio, Voco) was placed and the occlusal anatomy was developed with a PKT-3A (Brasseler USA).

Figure 2i and 2j

The following adhesive design principles are modifications of the original design principles and should be considered for posterior and anterior composite resin restorations.

Posterior composite resin preparations

The original basic preparations were developed primarily for amalgam. The posterior preparations were based upon a number of principles. The first of these was dimension (Schultz et al, 1966). Since the fracture resistance of amalgam is heavily based upon minimal bulk, the preparations by composite resin standards were relatively large. Also, the proximal aspect of the Class II cavity preparation was designed to include the areas of greatest bacterial count and plaque concentrations. Since amalgam does not bond to the walls of the cavity preparation, a space of several microns commonly exists between the restoration and the prepared surfaces. This of course, leads to a potential for microbial invasion and secondary caries.

The preparation design for posterior composite resins is considerably different than its amalgam counterpart (see Figures 1a and b). To begin with, the preparation commonly is smaller in dimension. The reason of course, is that through the process of hybridisation, the restoration

becomes an integral part of the tooth itself. Under such a condition, there is no microscopic space between the restoration and the walls of the cavity preparation. Properly generated margins preclude the potential for microbial ingress. And because of this relationship, the proximal margins of the Class II preparation need not be extended beyond proximal contact. The same rule holds for the location of the gingival margin.

Another dramatic difference between the posterior composite resin and an amalgam restoration relates to the concept of 'extension for prevention'. Black's posterior cavity preparation extended to include all adjacent regions that were highly susceptible to primary caries. This was a viable precept since the rate of caries a century ago was considerably greater than at the present time and caries was not diagnosed as a bacterial disease (Mount and Ngo, 2000). Addition of fluoride to the water as well as other sources such as tooth paste and the emphasis on oral hygiene have reduced the incidence of caries tremendously. Based upon this principle, the practice of extending the preparation into potentially vulnerable areas of the tooth is no longer necessary for bonded composite resin restorations. The outline form should only follow the extent of the carious lesion.

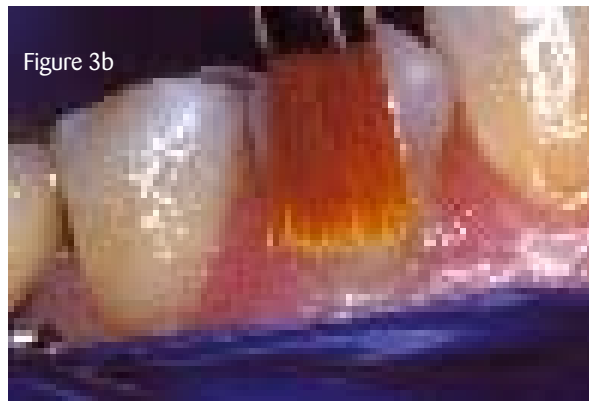


Figure 3a: Pre-operative view of saucer-shaped noncarious cervical lesions on the mandibular right premolars **Figure 3b:** After the initial dentine layer was applied, a second translucent enamel layer (Incisal, Grandio, Voco) was smoothed cervico-incisally with a sable brush **Figure 3c:** Completed composite restorations. Note the bioaesthetic integration at the dento-gingival interface

All of these factors then mandate a modification in the dimension and design of the posterior cavity preparation. In the case of pit and fissure decayed regions on the occlusal surface, it is suggested that the cavity preparation be limited only to the region of the tooth that is affected by caries and then restored.

In the case of Class II cavity preparations, the amount of sound tooth structure that can be left intact is even more impressive. Assuming the presence of a small carious lesion on one of the proximal surfaces of a posterior tooth, it is advised to generate a preparation that is considerably smaller in all dimensions as compared to Black's original cavity designs. No attempt should be made to open the proximal contacts with the adjacent tooth as is required with amalgam. The width of the preparation should be as narrow as possible, since the wear resistance of the restoration is a direct function of dimension (Leinfelder, 1991). Also, increased bucco-lingual width of the preparation can trespass into the centric holding areas.

The distance between the proximal-occlusal surface and the extension onto the occlusal table should not exceed 2.0mm. Finally, assuming minimal caries in the proximal region, the distance from the gingival margin and the cervical line should be at least 2.0mm. Such a condition ensures maximum enamel on the gingival floor for optimal bonding of the composite restoration. It also minimises the deflection of the proximal aspect of the restoration when subjected to occlusal loading.

Numerous clinicians as well as a number of in vitro studies have suggested that bevelling of the occlusal cavo-

surface angle should be accomplished for all Class I and II cavity preparations. The presumption is that placing bevels actually extends the surface area of enamel for bonding, thereby decreasing the potential for leakage along the margins. This supposedly contributes to the fracture resistance of the restored tooth. While this theory sounds credible with many clinicians employing this technique, at least one study has demonstrated that bevelled restorations commonly undergo a higher rate of wear as compared to those that are not bevelled (Isenberg and Leinfelder, 1990). The actual increase in wear over a two-year period possibly can be attributed to a higher potential for involving the antagonist cusp. This of course can be credited to the fact that bevelling automatically increases the width of the cavity preparation.

Bevelling of the gingival margin however, should be encouraged since it effectively increases the thickness of the enamel surface in this region. Bevelling of the buccal and lingual extensions of the proximal aspect of the preparation should also be recommended. Finally, it is probable that bevelling of the occlusal surface should be considered when the preparation is rather extensive buccal-lingually. Under such a condition, the bevelling may actually increase the strength of the restored tooth.

Anterior composite resin preparations

The preparation design for anterior teeth generally involves the incisal edge, cervical region and/or the interproximal zone. The preparation usually requires minimal tooth



Figure 4a: A pre-operative facial view of the fractured maxillary central incisors. **Figure 4b:** An opacious increment is placed as the internal dentine core and a second small increment of incisal-shaded hybrid composite (Grandio, Voco) encapsulates this core **Figure 4c:** Completed composite restorations using the simplified duo shade placement technique

preparation and the margins of the preparation are generally confined to the enamel and, if completely mineralised and well supported by dentine, significantly contribute to the retention and strength of the composite restoration. To increase the enamel-adhesive surface a chamfer is placed around the entire margin that is in enamel. The chamfer preparation defines the finish line and it allows a greater bulk of material to be placed at the restorative margin that increases fracture resistance (Bichacho, 1996) and reduces the stress at the restorative interface (Leinfelder, 1994). Also, a lingual chamfer should be placed coronal or apical to the contact area (Miller, 1999) and when enamel is present, a bevel should be placed, but only on the enamel margin. Bevelling increases the bonding surface area, and decreases microleakage by exposing the ends of the enamel rods for etching, and improves blending of the resin with tooth structure (Strassler, 1992). Bevels should not be placed on lingual surface margins that are in areas of centric contact or subjected to heavy occlusal forces, as composite has a lower wear resistance than enamel does for withstanding such forces (Sturdevant et al, 1995).

In addition to these specific preparation design principles, a number of general guidelines for posterior and anterior preparations should be considered:

- The cavity outline is extended only to include carious enamel, provide access to the carious dentine, remove any residual staining, and provide access for the application of restorative materials.
- Healthy tooth structure should be removed only when the preparation outline requires extension to a point beyond or within the indicated functional stops (Liebenberg, 1996b).

- To allow for a better resin adaptation, all internal line angles should be rounded (Small, 1998).

These new principles of design and general guidelines for adhesive restorations replace the traditional mechanistic approach to restoration of teeth, while initiating applications of biomechanical concepts.

Selecting an adhesive strategy

The chemical treatment of enamel and dentine by acids to provide adhesion between resins and dentine substrates (eg. enamel, dentine) has become a standard clinical procedure in adhesive dentistry (Buonocore, 1955). The removal of the smear layer raises the surface energy and alters the mineral content of the substrate so that it can be infiltrated by subsequently placed adhesive primers and resins (Roberson et al, 2002; Alex, 1995; Erickson, 1992; Eliades, 1984). The mechanism of adhesion is similar for enamel and dentine—a micromechanical entanglement of monomers into the enamel microporosities or collagen interfibrillar spaces created by acid dissolution of mineralised tissues (Perdigao and Geraldeli, 2003; Nakabayashi et al, 1982). When evaluating restorative success, the marginal integrity achieved by this procedure becomes a priority since an intact restorative-tooth interface is essential to the exclusion of bacteria and the interfacial hydrodynamic equilibrium of the dentino-pulpal complex.

Contemporary bonding philosophies adopt either the total-etch or self-etch technique for successful bonding to dentine (Buonocore, 1955; Perdigao and Geraldeli, 2003; Eick et al, 1997). Both of these adhesive strategies permit

the formation of a resin-reinforced zone, (also known as the resin-infiltrated layer, or hybrid layer), the primary bonding mechanism of many current adhesive systems (Swift et al, 1995; Van Meerbeek et al, 1992). Hybridisation is a process by which the inorganic support (hydroxyapatite crystals) is first removed and then replaced with a low viscosity monomer or dentine bonding agent. Using phosphoric acid (total etch) or a low pH monomer (self etch) the dentine is demineralised. In comparison to acid-etch the self etch adhesives do not allow a discrepancy between the depth of demineralisation and depth of resin infiltration because both processes occur simultaneously (Perdigao and Geraldini, 2003). Therefore, the potential for post-operative sensitivity is less with self etch systems because the smear plugs are not removed before the application of the adhesives. This hybridisation of the exposed dentine with an adhesive system is now considered the most effective way of protecting this pulp-dentine interface, and bonding the composite resin to the tooth structure providing resistance to microleakage and retention of the restoration, regardless of the depth of the preparation (Baratieri et al, 1998; Van Meerbeek et al, 1998; Cox and Suzuki, 1994; Cox et al, 1987). Also, once the evacuated intercollagenous spaces are filled with the dentine bonding agent, sealing the dentine tubular openings, the potential for odontoblastic fluid movement is eliminated. This in turn reduces appreciably the possibility of post-operative sensitivity. Furthermore, hybridisation allows internal adaptation for stress relief at the restorative interface while eliminating sensitivity. The adhesive layer may absorb polymerisation shrinkage stress of the resin composite by elastic elongation (Van Meerbeek et al, 1998; Lindberg et al, 2000) thus, reducing internal stress at the internal tooth-restorative interface resulting in improved marginal and interfacial adaptation with reduced gap formation.

Regardless of the generation of adhesives, it is important that sufficient time be given to the etching process as well as the process of resin diffusion into the decalcified intercollagenous zones. Once achieved the surface is sufficiently air dispersed for the purpose of thinning the bonding agent, it is light-cured for 10 to 15 seconds. Failure to adequately reduce the thickness of the residual bonding agent can readily result in a radiographic misinterpretation. Specifically, post-operative radiographs of the restored tooth may suggest secondary caries due to the presence of a thick and radiolucent region between the restorative material and the wall of the preparation.

The use of flowable composites as a stress absorbing lining material between the adhesive system and the restorative composite resin has been suggested for large restorations (Estafan and Estafan, 2000). The combination of flowables and viscous composite ensures a more intimate contact with the dentine bonding agent because of the lower viscosity and has resulted in enhanced internal adaptation (Frankenberger et al, 1999). Nearly all the currently available composite resin formulations exhibit a viscosity that is considerably greater than their predecessors. Consequently, special attention must be given to the method by which the unpolymerised composite resin adapts to the prepared

surfaces. Undoubtedly, the best method for achieving this goal consists of using a flowable composite resin. Due to an inherently lower contact angle between it and the surface, the flowable wets the hybridised surface extremely well (Frankenberger et al, 1999). In other words, the flowable resin wets and flows into all the intimate details of the prepared cavity, resulting in a more complete interfacial internal adaptation and may reduce the formation of voids, which can contribute to a weakened surface and microleakage. Since the chemistry of the hybridised layer and the flowable composite resin is similar, an excellent chemical bond is generated between the two systems.

The flowable composite resin also possesses another interesting characteristic. These composites act as an elastomer and buffer the polymerisation shrinkage stress by flow, which theoretically eliminates cuspal deformation or gap formation and reduced microleakage (Prager, 1997). Due to a lower elastic modulus than the restorative material, it will strain appreciably more when subjected to a stress. Specifically, as the overlying composite resin undergoes curing shrinkage during the process of polymerisation, it begins to pull on the surface of the flowable composite resin. Therefore, if the elastic modulus is low, the composite will stretch to accommodate the inherent modulus of the tooth and the internal layer may absorb polymerisation shrinkage stress of the resin composite by elastic elongation (Van Meerbeek et al, 1998; Lindberg et al, 2000). This stretching or straining of the flowable prevents the material from being pulled from the surface of the preparation; thereby insuring excellent marginal integrity. By understanding this complex mechanism between polymerisation shrinkage and adhesion, the clinician can select adhesive strategies and restorative materials that can reduce the potential for interfacial stress and gap formation at the time of placement for each individual clinical situation.

Furthermore, in order for the flowable resin to exhibit elastic elongation, it must be of minimal dimension. It is therefore recommended that the thickness of this intermediate agent be at least 0.5 to 1.0mm. In addition, the flowable liner should cover all the dentine of the prepared cavity. While permissible to contact the enamel portion of the cavity preparation, it is important that it not contact the occlusal margins. Generally, these agents are rendered wettable by increasing the diluent of the composite and reducing the filler content. As a result, they exhibit a number of properties that are appreciably inferior to the overlying composite resin restoration. Some of these properties included reduced resistance to wear, greater polymerisation shrinkage and greater water sorption. Finally, it is important to state that the flowable composite resin should be cured before the restorative composite resin is placed over it. Failure to do so may cause a thinning of the flowable resin in some regions, thereby reducing the potential for straining or stretching during curing of the overlying composite resin.

Simplified placement technique

The method of restoring the prepared tooth has been the

subject of considerable discussion. A myriad of restorative techniques have been developed to avoid the limitation of depth of cure, to reduce the effects of polymerisation shrinkage, improve the marginal adaptation and seal (Dietschi et al, 1995b; Lutz and Kull, 1980; Eick and Welch, 1986; Koenigsberg et al, 1989; Tjan et al, 1992), to enhance aesthetic results (Tjan and Glancy, 1988; Kovarik and Ergle, 1993), and provide the clinician with maximum benefit for their application (Davidson and Feilzer, 1997). Several of the incremental stratification techniques include: horizontal, vertical oblique, centripetal, three-sided light-cure, and centripetal build-up technique. These various methods are recommended according to the type and dimension of the cavity preparation (Terry, 2004).

While it is commonly believed that segmentally filling the preparation generates the least pull on the buccal and lingual cusps, not all literature agrees. In a study conducted at the University of Minnesota, Douglas and colleagues demonstrated that bulk fill produced the least strain on the opposing cusps (Versluis et al, 1996). Although these stratification techniques allow the clinician to provide beautiful results, the use of intricate multi-layering with numerous shades of composite may not be efficient, realistic, or practical for the modern dental practice. In an effort to simplify, improve efficiency and expedite the insertion and carving stages, the authors offer the following duo-shade modified placement technique. A low-shrinkage hybrid composite resin system should be selected that has dentine and enamel shades.

This modified placement technique uses one continuous increment (ie. hot dog shaped) that is placed and adapted in an oblique layer with a curved metal instrument (TINL-R, Brasseler USA, www.brasselerusa.com) against the cavity wall. The increment is cured through the cusp and the original cavity floor becomes part of the cavity walls. This process reduces the ratio of cavity volume to area of the cavity walls, which results in a substantial reduction in the marginal contraction gap (Hansen, 1986). A second elongated increment is adapted in the same oblique manner against the opposing cavity wall and light cured through the cusp.

For small to medium sized occlusal and approximal cavity preparations the internal dentine core requires two incremental placements. A final enamel layer is filled all the way to the occlusal margins. At this point a burnisher such as the PKT-3A (Brasseler USA) is used to remove any residual composite material. Procedurally, the composite condenser is pressed against the occlusal surface. Using finger pressure the instrument is used to trace the entire margin of the preparation. Such a technique not only eliminates all residual composite extended beyond the preparation but it also fills in any region that may have been somewhat underfilled.

Upon completion, the same burnishing instrument can be used to develop the central fissure, buccal and lingual developmental grooves and the incline planes. After light curing, the rubber dam is removed and the occlusion is evaluated in centric, protrusive and lateral excursions.

This same duo shade placement technique can also

be used in direct anterior composite restorations. The magnitude of the shrinkage stresses, however, generated from polymerisation shrinkage is less for most anterior composite restorations, since the ratio of bonded to unbonded surfaces is generally less for these restorations. Therefore, using stratification techniques to minimise the effects of shrinkage stress is a minor clinical consideration. The author's prefer to use a long bladed interproximal carver for placement and adaptation and a sable brush to smooth the surface. A curved metal instrument (TINL-R, Brasseler USA) can be used to shape the lingual surfaces of anterior restorations.

For class III and IV composite resin restorations an opacious dentine increment is placed as the internal core and a second enamel layer encapsulates this core. For the Class V, this same placement procedure can be used with a translucent or opacious dentine core depending upon the colour of the substrate. Although for deeper cervical restorations, placement of the dentine core in two sequential increments allows for an overall stress reduction by allowing more yielding of the free surface of the restoration to the underlying contracting bulk. Placing the occlusal dentine segment with higher bond strength to enamel first and then the gingival segment may reduce the potential for microgapping at the gingival margin.

Finishing and polishing

Successful finishing and polishing of any composite restoration is determined by the type of restorative material used, the shape of the finishing device and is defined by surface morphology of the tooth and restoration. Since the geometry and shape of the natural teeth and these devices essentially remain the same, the only variable is the continual changes in the formulation of the restorative material.

Thus, the surface quality of the composite is not only influenced by the polishing instruments and polishing pastes but also by the composition and the filler characteristics of the composite (Jefferies, 1998; Wilson et al, 1990). Newer formulations of small particle hybrids and microhybrids have altered filler components with finer filler size, shape, and orientation and concentration, improving their physical and mechanical characteristics, and allowing the resin composite to be polished to a higher degree (Chung, 1994). The variation in hardness between the inorganic filler and the matrix can result in surface roughness since these two components do not abrade uniformly (Chung, 1994; Chen et al, 1988). Accordingly, it is imperative that the surface gloss between the restorative material and tooth interface are similar because the gloss can influence colour perception and shade matching of the restoration and tooth surface (Chung, 1994; Stanford et al, 1985).

Restorative materials of the past (ie. amalgam, gold) required finishing and polishing procedures to refine anatomical morphology, contours, marginal integrity, and occlusion, while enhancing the surface smoothness of the restoration. The objectives of finishing and polishing

techniques of tooth-coloured adhesive restorations are the same today, except the development of adhesive materials has introduced a new element to the restorative equation: aesthetics. An optimally finished aesthetic adhesive restoration should provide a smooth surface that will prevent plaque accumulation and resist stain (Horton et al, 1977). It should also possess ideal contours and emergence profile for improved tissue compatibility (Horton et al, 1977). Additional benefits of a proper finish are anatomical form for occlusal harmony, shade co-ordination to surrounding dentition, symmetrical surface texture to adjacent or opposing natural teeth, improved marginal adaptation and integrity, longevity and aesthetics (Horton et al, 1977). Aside from the actual finishing and polishing, the final challenge for the operator is long-term restorative maintenance of the surface polish. An understanding by the patient and clinician of the importance of periodic and routine maintenance of composite restorations and of using proper finishing devices, polishing techniques and protective surface glazes at the maintenance visit may provide the benefit of increased longevity of the restoration (Jefferies, 1998; Goldstein, 1989; Strassler, 1990).

Finishing focuses on contouring, adjusting, shaping, and smoothing the restoration while polishing concentrates on producing a smooth surface luster and highly light-reflective surface (Schwartz et al, 1996). As Pratten and Johnson have indicated, there is no statistical difference between finishing and polishing anterior and posterior restorative materials. The consideration factors for finishing and polishing any restoration depend on the instrument shape, the surface shape and texture of the tooth and restoration, the surfaces of the finishing and polishing instruments, and the sequence and amount of time allotted for the restorative treatment (Pratten and Johnson, 1988).

While several acceptable finishing and polishing protocols exist, the authors provide the following clinical suggestions:

- Minimise finishing procedures through careful pre-operative occlusal registration and careful composite shaping prior to curing. At least one study revealed that a reduction in finishing results in less damage to the composite and improved wear and clinical performance (Duke, 1993).
- Select finishing and polishing devices that have shapes that correspond to anatomical contours of the restored tooth (Terry, 2002).
- Finishing diamonds may demonstrate resin matrix crazing and significant filler particle loss for hybrids, affecting the wear resistance of posterior hybrid composite resin restorations (Jefferies, 1998).
- High-speed finishing with mutilated carbide burs for a hybrid composite resin produces a smooth, flat surface, no disrupted surface free from striations and grooves left by diamond burs.
- Wet finishing with diamonds is more appropriate for microfilled composites and carbide finishing burs are contraindicated for microfills (Jefferies, 1998).
- The use of surface sealant has been shown to reduce the wear rate of posterior composite resins (Dickinson and Leinfelder, 1993) improved resistance to interfacial

staining (Kemp-Scholte and Davidson, 1988) and decreases microleakage around composite resin restorations (Kemp-Scholte and Davidson, 1988; Estafan et al, 2000; Barone-Smith and Dickens, 1999).

- Place composite surface sealant and cure prior to polishing with silicone points because silicone surface contamination may prevent adhesion of sealant.

Clinical concepts demonstrated

The following clinical procedures illustrate a simplified direct bonding duo-shade technique that uses the aforementioned restorative adhesive concepts with a small particle hybrid composite to develop precise anatomical morphology and function (see Figures 2, 3 and 4).

Conclusion

Modern clinicians have many of the same clinical challenges on selecting the appropriate restorative material and treatment modality as their colleagues of the 19th century. However, advances in material science and technology have provided the 21st century clinician with the knowledge to transform the mechanical approach of operative dentistry into a biological philosophy, strategy and design. This article has demonstrated these biologic principles and concepts while providing a simplified technique for achieving predictable long-term success with directly placed composite resin restorations.

References

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