EXPLORING the Factors and Aspects of

Composition, Applications, and Clinical Considerations

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Abstract

Clinicians today can choose from a large variety of resin-based materials for a composite restoration, based upon characteristics of the cavity, functional goals, esthetic expectations, and type of restoration. The ideal composite for each clinical situation is not easily determined, but a detailed knowledge of different characteristics of the individual resin-based materials can be critical in obtaining a particular esthetic or functional result. Direct composite restorations in posterior teeth have gained greater prominence in the past decades and are now considered the first choice of treatment. Thanks to materials with low shrinkage, possible side effects while treating cavities with unfavorable c-factors can be prevented. Another aspect that should be considered by the clinician is wear resistance, which is an important factor related to the gain of a morphological stability and long-term prognosis of the restoration. In addition, the improvement of polishing has been sought from companies that aim to offer high-performance products, especially in the restoration of anterior teeth. Indirect restorations today can also use composite materials, according to their ability to withstand occlusal loads and be used in adhesive cementations.

Key Words: composite materials, low-shrinkage materials, finishing and polishing, direct restorations, composite onlay

Composite Materials

Figure 1: Initial case involving Black Class IV cavity of #3 after fracture.

Introduction

Resin-Based Materials

The wide variety of composite materials available today provides many opportunities but can also cause confusion. Users of these materials should be familiar with their characteristics and distinctions.[1-3]

According to classifications proposed by Ardu and colleagues,[4] resin-based materials can be divided into conventional, hybrid, and microfilled categories, depending upon the filler size and characteristics. Hybrid-defined composite materials can be further divided into coarse, fine, and micro classifications, which can be additionally divided into homogenous and inhomogeneous subclassifications. Additionally, these materials can be placed into four different groups, according to the matrix nature:

- methacrylates
- ormocers
- compomers
- silorane-based.

Methacrylates

The most well-known materials are the hybrid composites. This technology, based on methacrylates and different types of filler coupled with silanes, has been continuously improved. Some disadvantages, such as volumetric shrinkage, bacterial adhesion, and side effects due to monomer release, still remain, but the new technologies offer improved materials. To reduce these negative factors, manufacturers have worked on materials adapting the individual components. The fillers are made of quartz, ceramic, silica, and other oxides. When filler content is increased, polymerization shrinkage, water absorption, and the linear expansion coefficient are reduced. Furthermore, compressive and tensile strength, modulus of elasticity, and wear resistance are generally increased.[5]

Nanohybrid composites are the newest family and probably the most widespread on the market today. They are designed to provide superior esthetic and wear resistance as well as excellent polishing and handling. Their agglomerated nanoclusters, interspersed with micro-sized particles, give them very acceptable wear characteristics. Consequently, they are considered "universal" materials suitable for anterior and posterior teeth.

These composites can have different types of filler particles: prepolymerized, finely milled agglomerated nanoclusters; larger (submicron-sized) glass or silica particles in the range of 0.4 m; and individual nano-sized particles (0.05m).

This family of materials has many desirable features regarding clinical application, as will be explained. Examples of these materials include the following:

- Filtek Supreme XTE and Filtek Z250 XT (3M ESPE; St. Paul, MN)
- IPS Empress Direct and Tetric Evo Ceram (Ivoclar Vivadent; Amherst, NY)
- Enamel Plus HRi (Micerium; Avegno (GE), Italy)
- Miris 2 and Synergy D6 (Coltène/Whaledent; Cuyahoga Falls, OH)
- Venus Diamond and Venus Pearl (Heraeus Kulzer; South Bend, IN)
- Herculite Ultra and Premise (Kerr; Orange, CA)
- G-aenial and Kalore (GC America; Alsip, IL)
- RefleXions XLS (Bisco; Schaumburg, IL)
- Esthet-X HD (Dentsply Caulk; Milford, DE)
- Estelite Sigma Quick (Tokuyama; Tokyo, Japan)
- Grandio (Voco America; Briarcliff Manor, NY)
- Clearfil Majesty (Kuraray; Houston, Tex).

Ormocers

With organically modified ceramic materials (ormocers) (e.g., Admira, Voco America), the methacrylate has been partially replaced by an inorganic network. According to some studies, the biocompatibility was not improved in all cases.[6,7]

Compomers

Compomers aim to combine the positive properties of glass ionomers with composite technology (e.g., Dyract [Dentsply Caulk] and Compoglass [Ivoclar Vivadent). However, this goal has only partially succeeded, because the fluoride release is low. The fluoride release of compomers increases quickly initially (in the first 24 hours), but decreases quickly, too.[8-11] Compomers are most suitable for restorations in the deciduous dentition due to their low abrasion resistance.[12-14]

> **Another important point to consider is the esthetic behaviors of resin-based materials.**

Siloranes and Low-Shrinkage Resin-Based Materials

Manufacturers have addressed problems related to shrinkage of resin-based materials in different ways, including increasing molecular weight and developing materials with ring-shaped molecules. For example, silorane (siloxanes and oxirans) replaces the chain monomers in the composite matrix via ring-shaped molecules (e.g., Filtek Silorane LS). These materials are hydrophobic and need to be bonded to the dental hard tissue with a specific adhesive system. According to some studies,[15-17] silorane's low shrinkage leads to a lower contraction stress; furthermore, these restorations were shown to have both low water absorption and water solubility.[18] Silorane has also been shown to have good mechanical properties.[19,20] The clinical application of these materials is limited to the posterior teeth, however, because few low-translucent colors are available.[2]

Some research in the dental literature does not support the use of silorane-based materials. In one clinical study, the marginal quality of the silorane composite was shown to be somewhat inferior to that of a nanohybrid composite.[21] In another study, silorane did not produce lower contraction stress than other composites.[22]

As aforementioned, other monomers with increased molecular weight have been developed for composites with reduced shrinkage. The urethane monomer TCD-DI-HEA (bis-(acryloyloxymethyl)tricyclo (5.2.1.02,6) decane), found in Venus Diamond and Venus Pearl, has been shown to produce lower-curing contraction stress than other composites marketed as low-shrinking.[22] Other low-shrinkage materials are available, such as the modified urethane dimethacrylate (UDMA) resin from DuPont found in Kalore, which has a relatively high molecular weight compared to bisphenol a glycidyl methacrylate (bis-GMA) and traditional UDMA. Another strategy is represented by dimer acid monomers used in N'Durance (Septodont; Lancaster, PA), which are also of relatively high molecular weight and have been shown to have high conversion of carbon double bonds while undergoing lower polymerization shrinkage than bis-GMA-based systems.[23,24]

Clinical Considerations

Direct Anteriors

In anterior restorations, the material mainly chosen, in many cases, is composite resin. In the past, micro-particle composites were especially preferred for their good polishing, but they showed low resistance to surface wearing.

Considering the fairly favorable c-factor in anterior areas (Black Class III or IV cavities[25]) **(Fig 1)**; and knowing that addictive morphological modifications may need to be made, there is no strong clinical indication to use low-shrinkage materials. Therefore, it is more appropriate to focus on different materials.

In anterior restorations, the goal is mechanical and wear strength. Furthermore, from an adequate polished surface, nanohybrids and nanofilled materials are recommended today. In vitro scientific studies have shown that various nanohybrids materials yield an excellent surface quality[26,27] and have low wear, thanks to increased wear resistance.[28-30] The nanofilled materials also possess preferred mechanical properties,[31] a relatively low shrinkage rate, and high strength.[32] These types of materials provide excellent results concerning surface roughness.[33] Additionally, some technologies have been further developed in this family of materials to improve the maintenance of polishing, creating clusters with the nanoparticles that constitute the material (e.g., Filtek Supreme XTE).

Another important point to consider is the esthetic behaviors of resin-based materials. Considering the translucency and opacity of both flowable and paste composites (generally photo-curable), it is advisable to choose the proper materials to recreate the different areas of natural dentin and enamel. Some systems offer many composite masses with intermediate translucency, which are very similar to one another, although they are possibly deficient in translucency effects, intensives, and stains.

The criteria of correct layering are already well known.[34,35] Under normal conditions, the stratification of the composite provides in the most superficial area an enamel that has good translucency characteristics. This makes it possible to highlight the contrast between the dentin and the translucent effects placed under it in a natural manner **(Figs 2-5)**.

Another preferred feature, available in some products currently on the market, is to have a composite light refractive index similar to natural tooth tissues. Generally, resin-based materials have a lower refractive index; therefore, in equal thicknesses (composite and tooth), the optical behavior is different. Materials with a high refractive index (e.g., Enamel Plus HRi) provide an anatomical stratification, with equal thicknesses compared to dental tissues.

Lastly, in anterior composites a proper finishing is needed to emphasize the major and minor morphologies, including a multiple-step polishing using burs, polishers, discs, and brushes, which helps smooth out rough surfaces and achieve depth perception. It was demonstrated that the surface finished using multiple-step polishing systems

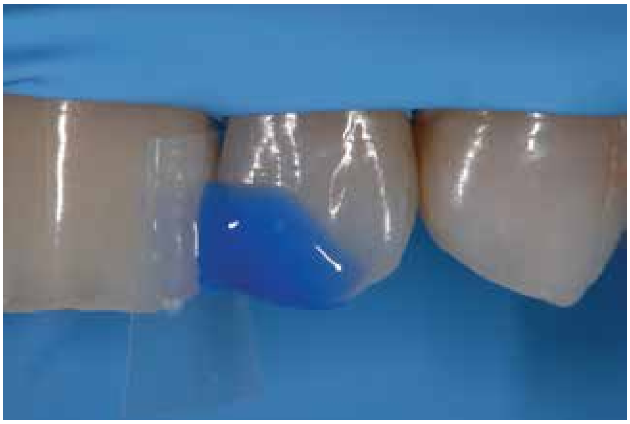

Figure 2: After gentle preparation, the isolation of the field and phosphoric etching are performed.

Figure 3: Adhesive procedures on hard tissues.

Figure 4: Palatal enamel is layered onto the dentin prior to applying effects and the final enamel covering.

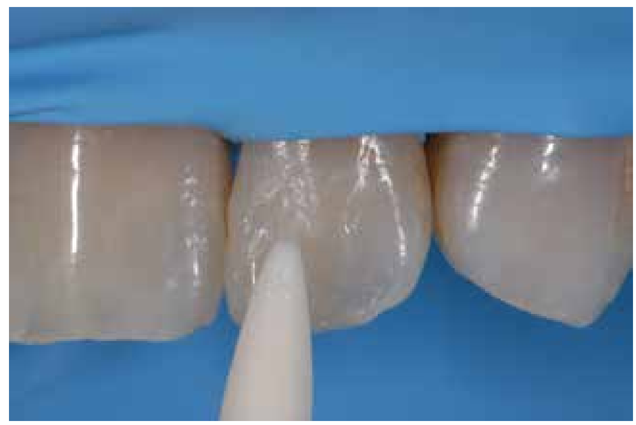

Figure 5: A layer of composite is applied using a special silicone tip.

Figure 6: A medium-grit polisher is used during the finishing procedure.

Figure 7: A fine-grit polisher is used during the finishing stage.

Figure 8: An aluminium oxide disc is employed during the finishing stage.

Figure 9: Diamond paste is applied with a brush during the polishing stage.

Figure 10: Final results one week after completion of the restoration.

Figure 11: Final results shown via a different photographic technique that highlights certain morphologies.

Figure 12: The initial case. Amalgam reconstructions on #6 and #7 and a composite filling on #5 will be replaced.

Figure 13: The old filling and secondary carious lesions are removed, and the cavity is prepared.

was superior to that obtained with one-step systems,[36] and three-step rubber polishers were more efficient than two-step and one-step polishing methods on nanoparticle and hybrid resin composites **(Figs 6-11)**.[37]

Flowable materials, which are usually less filled and less viscous compared to paste composites, often suffer from high shrinkage. These materials could best be used in Black Class I, II, or V cavities and in areas of cavitated enamel.[38]

Direct and Indirect Posteriors

As a posterior restorative, resin composite represents the primary choice today for most clinicians. In in vivo studies analyzing the prognosis of composite restorations, with 10 to 20 years follow-up, the annual failure rate was low: approximately 2%.[39-41] Gaengler and colleagues[39] described 10 years of follow-up of direct posterior composite with the following conclusions: "The early risk of failure is attributed to bulk fractures and partial loss of filling material. The longevity over 10 years is a maximum of 74.2%, and the very low secondary caries rate and the high percentage of correct anatomical form confirm the clinical safety of posterior composite restorations."

In clinical studies that have compared the follow-up of posterior restorations with amalgam and composite, the results are similar, although it can be assumed that some amalgams have a slightly greater longevity.[42-44]

Another study with 12 years of follow-up involving high caries-risk patients compared composite and amalgam restorations. Both materials showed higher failure rates, although in large cavities composite behaved better in patients with a lower caries risk.[45]

Posterior composite restorations can be made via a direct or indirect technique. It has been shown that, in a medium-sized cavity, indirect and direct composite restorations have revealed no differences in performance after many years.[46] The cavity should be analyzed carefully and a treatment evaluation should be performed to determine which restoration is preferred,[47]

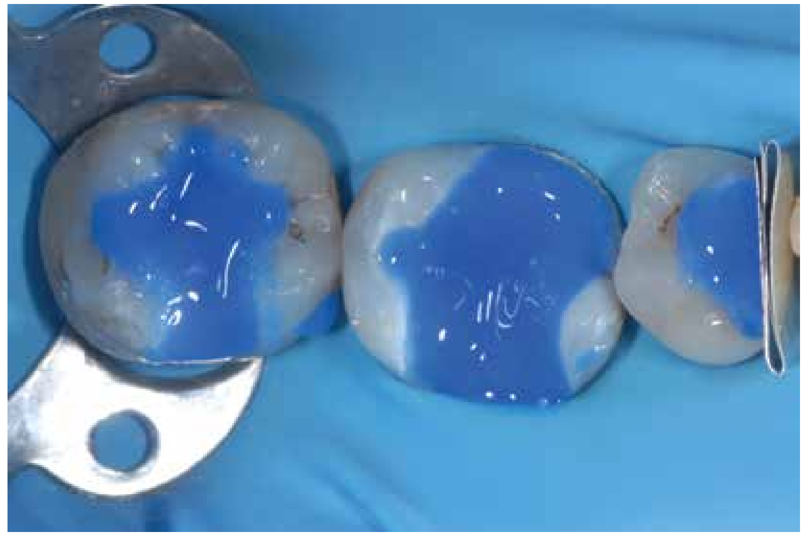

Figure 14: Etching phase during the adhesive procedure.

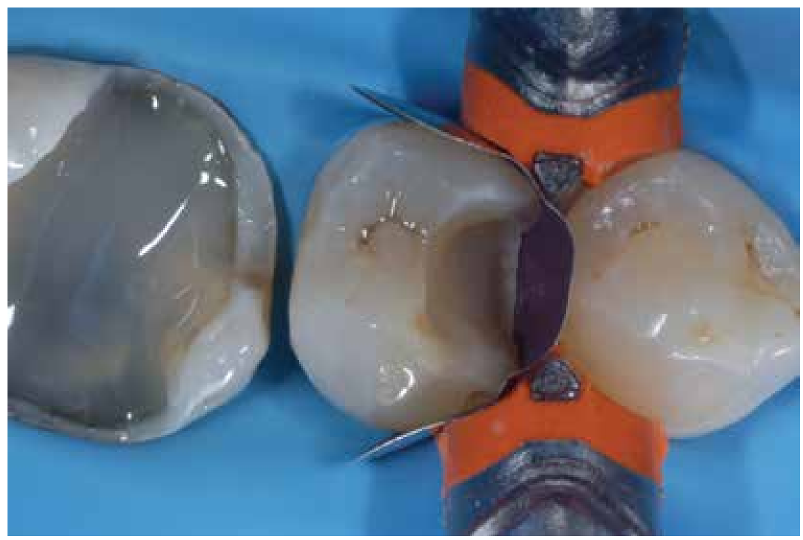

Figure 15: The matrix has been positioned for the buildup of the interproximal wall. Some flowable composite was placed on the dentin to support the cervical residual enamel.

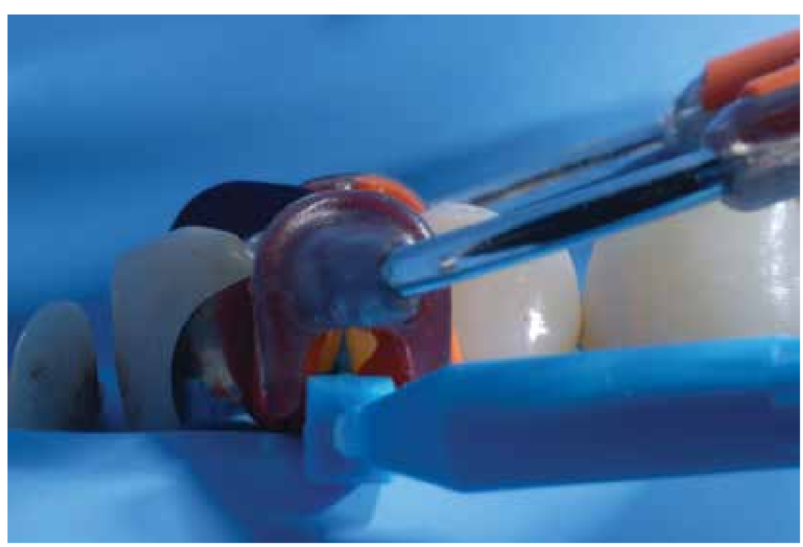

Figure 16: The matrix from a buccal point of view, demonstrating the relationship between the wedge, matrix, and ring.

Figure 17: Completion of the layering of direct restorations. The composite buildup on #6 must now be finished.

Figure 18: The cavity on #6 is prepared for the impression. Enamel margins are available on the full perimeter. A retraction cord is positioned to the closest margins to the gingiva.

Figure 19: Composite onlay before cementation.

Figure 20: Adhesive treatments of composite onlays: sandblasting (left), silane (middle), and bonding (right).

Figure 21: Cavity cleaning under rubber dam, before the adhesive cementation.

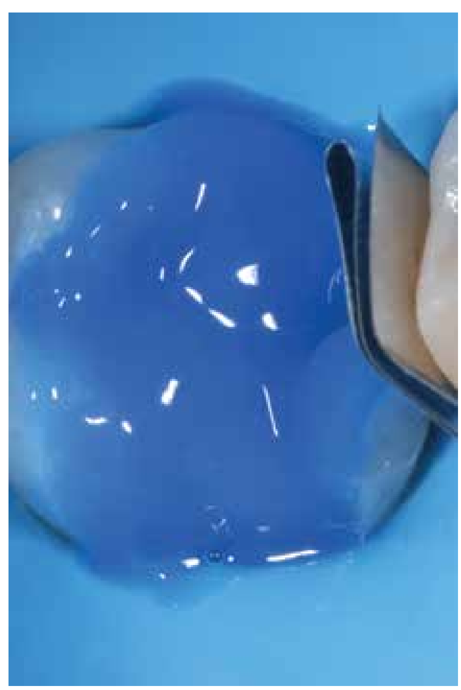

Figure 22: Cavity etching with phosphoric acid.

Figure 23: Cavity bonding.

Figure 24: Excess cement must be removed during onlay cementation of the seating phase.

Figure 25: Final results after one week showing a direct composite restoration on #5 and #7 and an indirect onlay composite bonded on #6.

and qualitative and quantitative evaluations of the residual cavity structures and the need to rebuild one or more cusps should be thoroughly considered. However, it is possible that teeth can be reconstructed within the same quadrant using either a direct or indirect technique **(Figs 12-25)**.

Direct posterior restorations are more susceptible to shrinkage stress compared to indirect restorations; hence, it may be desirable to use a material with low shrinkage and a favorable elasticity modulus. Furthermore, to minimize these negative effects, it is recommended to use an appropriate layering technique followed by proper curing for each layer.

In Black Class II cavities, positioning a sectional matrix can help provide a correct point of contact and result in a good interproximal morphology **(Figs 15 & 16)**.

Composite resins are also indicated in indirect onlays **(Figs 17 & 18)**. Some in vitro studies have compared indirect onlays with ceramic restorations and found that fracture resistance, when applying a normal masticatory load, was similar for both materials. With masticatory overload, however, the composite gave better results in terms of resistance and distribution of stress on the root below. In addition, composite resins layered and milled with CAD/CAM technology showed higher fatigue resistance than porcelain.[48,49] Other desirable features of composite resins include better management of the morphology and less shrinkage of the material, which is polymerized out of the cavity **(Fig 19)**.

Indirect composite restorations can be cemented adhesively, thanks to pre-treatments and proper procedures. Unlike cemented porcelain restorations, indirect composite restorations are sandblasted (using aluminium oxide or silica coating) and not treated with hydrofluoric acid.[50,51] The pre-treatment before the resin cement (that can be light-curable) can be represented by silane and hydrophobic resinous bonding **(Figs 20-25)**.

Summary

Composites have been shown to perform well in clinical situations. In the anterior region, they can be used to produce excellent esthetic results. Their response to stress also makes them suitable restorations in the posterior area, using either direct or indirect techniques. Nanohybrid materials are considered universally suitable for numerous clinical uses, flowable composites have specific indications, and low-shrinkage materials are recommended in particular clinical cases, especially in posterior cavities.

Proper polishing of composites, however, can represent a limitation compared to other esthetic materials, although it is not a major limitation. Lastly, some clinical studies[1] showed good outcomes with few clinical limitations, including marginal staining (a problem related more to adhesive systems than restorative materials), some discoloration, and edge chipping in high-stress situations.

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