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Finishing and polishing criteria for minimally invasive composite restorations

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To achieve the benefits that composite restorations can provide, it is incumbent on dentists to understand the importance of proper finishing and polishing techniques and how to incorporate them appropriately into everyday practice. A smooth surface finish is clinically necessary because the presence of surface irregularities from poor finishing and polishing can lead to staining, plaque retention, gingival irritation, recurrent caries, abrasiveness, wear kinetics, and tactile perception by the patient. However, finishing and polishing procedures for direct composite restorations are technique- and material-sensitive. This article describes the proper composite material placement considerations, as well as finishing and polishing techniques and materials, for providing highly esthetic, long-lasting restorations. By incorporating such protocol into their everyday practices, dentists can increase the long-term esthetic and plaque-resistant predictability of direct composite restorations.

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Compared to earlier generations of direct restorative materials, today's composite resins provide improved strength, resistance to wear, and esthetics, and have revolutionized the concept of minimally invasive dental treatment.[1] One of the most versatile materials, composites can be used for direct restorations, build-ups, cementation, diagnostic mock-ups, gingival stabilization, provisionals, and prototypes.[2] Composites are available in many forms, including hybrid, microfill, and nanofilled/nanohybrid formulations, and the materials have evolved, with the science behind them solving many of the problems experienced with materials of the past.[1]

Earlier generations of composite materials presented challenges, such as polymerization shrinkage and the potential for marginal leakage resulting in the development of secondary caries.[3] The benefits of newer formulations also eliminate many problems associated with amalgam.[4,5] Historically, amalgams could result in cusp fractures, increased rates of secondary caries, and potential toxicity from mercury.[4,5] Using composites for direct restorations helps to minimize some of these risks and eliminates those associated with mercury in amalgam.[4,5]

Further, the newer composite formulations demonstrate high polishability for maintenance over the life of the restoration. In addition to contributing to esthetic value and appearance, optimal surface polishability has been proven to reduce staining and plaque accumulation while minimizing wear.[3,6] Studies have shown that improper finishing and polishing can lead to gingival irritation, recurrent caries, abrasiveness, and tactile perception.[6,7] Therefore, to obtain the added benefits that composite restorations can provide, clinicians must understand the importance of proper finishing and polishing techniques and how to incorporate them into everyday practice.

Finishing and polishing composites

By definition, *finishing* is gross contouring or reduction to obtain the required anatomy for a restoration, while *polishing* refers to the reduction in roughness and scratches typically created by finishing instruments.[6,7] Properly finishing and polishing composite restorations offers many benefits that ultimately lead to a predictable, long-lasting, and highly esthetic result.[6,7] Regardless of the cavity class or location, a smooth surface finish is clinically necessary because the presence of surface irregularities from poor finishing and polishing can lead to staining, plaque retention, gingival irritation, recurrent caries, abrasiveness, wear kinetics, and tactile perception by the patient.[6,7]

For example, in the oral environment, bacterial survival depends on the ability of bacteria to attach to hard surfaces like teeth, filling materials, dental implants, and prostheses.[8] Clinical studies have demonstrated that surface roughness greatly impacts the initial adhesion and retention of microorganisms on hard surfaces; surfaces that are rougher typically retain more plaque than those that are smoother.[8] Additionally, it has been suggested that the threshold surface roughness where no further reduction

in bacterial accumulation can be obtained is 0.2 µ.[9] However, surface roughness above this threshold has been correlated with an increase in plaque retention, as well as the incidence of secondary caries, gingival irritation, and loss of esthetics due to discoloration.[8,9] In cases of patients with poor oral hygiene, these issues often are exacerbated and can lead to the onset of subclinical or clinical gingival inflammation.[8]

Proper finishing and polishing also reduces the incidence of wear and marginal breakdown as well as preventing the buildup and retention of plaque and promoting the oral health of the soft tissues surrounding the restorations.[9,10] Studies have shown that unpolished restorations demonstrate increased incidences of friction and, therefore, increased wear of opposing enamel on occlusal contact areas.[11,12] Contributing to this wear, improper finishing and polishing could cause topographical changes and can introduce subsurface microfractures in the composite.[13-15] For example, when finishing composite restorations, carbide-laminated burs and regular grit diamonds do not produce the marginal integrity that fine, extra-fine, and ultra-fine finishing diamonds do; coarse diamonds can remove excess composite material and could result in composite surface crazing or cracking.[14,16]

The manner in which direct restorations are finished and polished also affects patient comfort.[6] An improperly finished and polished surface remains rough and negatively affects the patient's tactile perception of a restoration.[6] Research has shown that a change in surface roughness of only 0.3 µm can be detected by the patient with the tip of the tongue.[6] Therefore, to ensure patient comfort with the restoration, the surface should be smooth and feel as natural as the surrounding dentition.[6]

Overall, proper finishing and polishing allows clinicians to achieve proper marginal adaptation of the restorations and maintain natural surface luster and contours necessary to mimic the surrounding dentition.[13] However, finishing and polishing procedures are technique- and material-sensitive. Just as classes of composite materials demonstrate different esthetic qualities and tensile strengths, polishability and maintainability in the long-term can vary, based on inherent particles and filler size.[7,17]

Research has demonstrated that composite filler size and the systems used to finish and polish restorations influence surface roughness and staining. Study results indicate that composites polished with finishing systems from the same manufacturer exhibit less surface roughness and staining.[17] Hybrid composite resins—which contain matrix and filler particles of varying hardness, as well as a combination of large and small particles—achieve a smooth, flat surface when finished with 12- or 30-fluted carbide burs.[18,19] Using diamond burs could lead to crazing, composite loss, and surface irregularities that can affect a restoration's wear resistance.[16,18] Polishing hybrid composite restorations is best accomplished with aluminum oxide polishing pastes.[18] Microhybrid composites achieve the smoothest surface when polished with silicone polishing systems.[7]

Microfill composites can suffer fractures and other damage when finished with carbide burs. Microfilled composites are more appropriately finished with wet finishing diamonds.[18] Restorations created with these composites are ideally polished with 1 µm grit aluminum oxide polishing pastes.[18]

The literature indicates that nanofilled composites have been successfully polished using respective combinations consisting of 40 µm diamonds, 42 µm silicon carbide polishers, 6 µm silicon carbide polishers, and polishing paste.[20] Additional research suggests that diamond polishing points, diamond paste, and urethane-backed aluminum oxide disks also produce clinically acceptable levels of smoothness during the polishing process.[21]

Composites

Adhesively bonded composite restorations demonstrate esthetically acceptable results that conserve sound tooth structure and offer the potential for tooth reinforcement. The least invasive and most predictable restoration of teeth to normal form and function, tooth-colored composites provide patients and dentists with cost-effective and long-lasting solutions for a variety of indications. There are, however, certain criteria that composites must meet.

In general, composites should mirror natural tooth structure in color and translucency, withstand function in high stress-bearing areas over time, have seamless or undetectable margins, and allow for a polish that can be maintained over the life of the restoration. Now available in a variety of formulations for different indications, today's composites provide many added benefits, specifically in finishing and polishing, compared to the conventional materials of the past. For example, hybrid or microhybrid composites—universally referred to as *microhybrids*—are heavy-loaded materials that demonstrate high strength and opacity similar to that of natural dentin and enamel.[22,23] Additionally, microhybrids are less likely to chip or fracture because they

Fig. 1. Slightly underexposed before showing the depth of color, chroma, and translucency.

Fig. 2. Putty matrix trimmed to the facial incisal line angle, shown here on tooth No. 8 using a customized typodont.

Fig. 3. Putty matrix with first increment of the 3-D characterized build-up showing lingual enamel increment. (Note that the preparation to the free gingival margin and removal of the incisal edge in this case was performed for teaching purposes only. Rarely would teeth need to be prepared this aggressively.)

demonstrate excellent strength and the ability to withstand functional stresses.[22,23] Microhybrids blend with the natural dentition to create an esthetic restoration, allowing the practitioner to mimic dentin and enamel morphology.[22,23]

An issue with this class of composite materials, however, is their inability to maintain a polish; they tend to lose surface gloss over time and are less stain-resistant than other generations of composite.[17,22-24] Filler particles in microhybrids have been shown to "pluck out" during the polishing process and normal lifespan in the oral cavity, and, as a result, restorations can lose gloss or luster over time.[24] Studies have demonstrated that although it might not be as easy to maintain a polish as it is for other classes of composites, hybrids tend to be resistant to surface microfractures during finishing, for reasons that are believed to be directly related to the presence of inorganic fillers and their ability to absorb energy.[17,25]

In comparison, microfill composites demonstrate high polishability that lasts for the long term.[22,23] Many authors have gone so far as to deem the smoothness achieved with microfill composite materials as "permanent."[25] A direct effect of the inclusion of colloidal silica particles in the polymer matrix, small fillers and a resin-rich surface promote an excellent and maintainable polish.[26] Additionally, microfills demonstrate a higher resistance to wear and abrasion and a translucency that is similar to that of natural enamel.[22,23] This class of composites lacks the strength required in functional areas and often translucency is too great.[22,23] Despite its high polishability, this class of composites demonstrates a higher susceptibility to stain than newer generations of composite.[17]

The newest class of composite materials, nanofills have the *potential* to maintain greater strength, long-term polishability, and stain resistance.[17,27,28] Studies have illustrated that nanofilled materials exhibit the lowest incidences of roughness and wear after finishing and polishing and on recall when compared to other classes of dental composites.[29] This class of composites demonstrates the smoothest polished surface and lowest surface roughness, regardless of the polishing system used.[7] Additionally, with a greater resistance to wear, nanofilled materials offer the most ideal mechanical and optical properties.[27,28] Further, nanofilled composites display opacity similar to that of natural enamel and dentin, with translucency similar to that of enamel.[27,28] Demonstrating high strength, nanofilled composites also are less likely to chip in high-stress areas.[27,28] The only true disadvantage to nanofilled composites is the lack of *in vivo* long-term studies, because the material science is relatively new.[27-29]

Composite placement considerations to enhance the finishing and polishing processes

Using a typodont with denture teeth (Premium teeth, Heraeus Kulzer, Inc.), the following protocol demonstrates proper material placement considerations and finishing and polishing techniques and materials for providing highly esthetic, long-lasting restorations for teeth No. 7 and 8 (Fig. 1). By incorporating such protocol into everyday practice, dentists can increase the long-term esthetic and plaque-resistant predictability of direct composite restorations.

After developing a proper treatment plan, including identification of patients for whom composite restorations would be contraindicated (for example, those who have occlusal issues or bite

Fig. 4. Completed 3-D layer achieved to full contour using Bisco Aelite composite system (All-Purpose Body & Aelite Enamel Esthetic).

Fig. 5. Articulating paper aids with and confirms correct outline form, line angles, and axial inclination when establishing primary and secondary anatomy.

Fig. 6. Using the detailed finishing and polishing sequence results in the correct color, translucency, luster, and polish.

their fingernails), selection of the proper composite class, and evaluation of the patient's existing dentition, utilize the proper tools and protocols to ensure the best results. This involves taking steps during the placement process that will lead to the least amount of adjustment to the restoration once the composite has been built up. For example, polyvinyl siloxane matrixes provide placement limits in terms of volume of composite material three-dimensionally and can be used as adjuncts to help maintain the proper incisal length and edge thickness (Fig. 2 and 3).[30,31] By doing so, finishing and polishing will be predictable and much simpler (Fig. 4–6).

Reduction guides

When creating direct resin restorations, preparation is of the utmost importance (Fig. 7). Overly aggressive preparation for the sake of esthetics often leads to unnecessary loss of tooth structure.[32] Although necessary in some extreme cases, this loss of tooth structure typically can be avoided with the use of a reduction guide.[32] Further, reduction guides have proven useful in controlling midlines in cases requiring diastema closure and when complex bonding is required.[32]

Proper handling

Whether the composite material is placed on the facial surface, interproximally, or around the gingival tissues, the manner in which the composite is handled can greatly affect the appearance of a restoration. To handle composites properly, ensure that no air voids are present in the increments being placed. Further, placing smaller increments predictably, instead of placing bulk quantities of material at once, helps to ensure proper control of the material. Sensitivity can be eliminated by completely curing each composite increment and allowing the restorations to reach their full photocure potential.

Undetectable margins

To create undetectable margins in the esthetic zone that are not only esthetic but also resistant to leakage, a starburst bevel should be used, followed by etching beyond the bevel.[32-35] The outer layer of composite must be rolled while wearing clean gloves to improve sculptability and prevent voids. The material should then be placed, supercured, and allowed to "relax" for at least five minutes to allow the material to settle.[33-35]

Next, the margin should be addressed and finished back

Fig. 7. Before image of tooth No. 7 demonstrating the starburst bevel in the rare instance where preparation might be required to allow for an undetectable restoration.

between where the etch-and-bevel ends. To ensure the best results, rubber wheels and polishers should not be used on the margins, because the rubber tends to become easily embedded in this area.[13,35,36]

Finishing and polishing technique considerations

Once the composite has been placed, a proper finishing and polishing protocol ensures a quality restoration. By understanding the following caveats of composite finishing and polishing, a predictable and long-lasting result can be achieved without concern for recurrent issues and further removal of healthy tooth structure.[37]

Gross contour (anterior restorations)

To properly finish composite after successful layering and 3-D anatomical construction (using an

Fig. 8. A red-stripped, flame-shaped, fine diamond is used to establish outline form and facial planes.

Fig. 9. A yellow-stripped, flame-shaped, extra-fine diamond further develops the proper contours.

Fig. 10. A green-stripped, coarse diamond is used with very light pressure and an electric handpiece to place texture in a prepolished direct composite restoration.

Fig. 11. A coarse disc (Bisco Composite Disc System) is used to establish transition line angles and incisal edge planes.

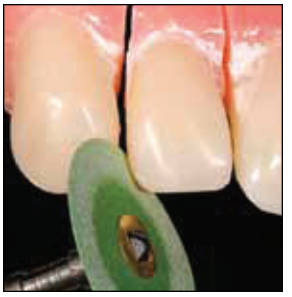

Fig. 12. A medium disc is used to initiate finishing protocol.

incisal putty matrix), the restoration should be evaluated for similar harmony and balanced width and length across the central incisors, as well as to balance with the laterals and canines. The flap door facial matrix often proves useful in ensuring that a proper facial contour has been achieved.

Removal of excess materials and recontouring is performed first. To that end, a variety of finishing devices have been proposed, including coated abrasive disks, carbide burs and stones, fine diamond burs, and resin- or silicone-impregnated burs.[7,14]

Gross contours can be established using a red-stripped diamond (8863-012, UCLA Anterior Aesthetic Restorative Kit, Brasseler USA), coarse discs, and a yellow-stripped diamond (863EF-012) (Fig. 8 and 9). Note that research indicates the lowest incidence of defective margins occurs when all three types of finishing diamonds (fine, extra-fine, and ultra-fine) are used.[14]

Texture and anatomy

Texture must be imparted on the restoration and the tertiary anatomy must be fine-tuned to impart realism. Texture can be placed using a multitude of armamentarium, including gross coarse diamonds (for example, No. 6856L-020, UCLA Anterior Aesthetic Restorative Kit) (Fig. 10), No. 557 cross-cut burs, and rubber points and wheels used both vertically and horizontally, preferably and most easily with electric handpieces (for example, NSK electric handpieces, Brasseler USA).

Again, to simplify this process, the matrix should be used and the composite should be layered carefully to ensure accurate and precise placement.[1] At this stage, the line angles will become more well-defined and the clinician should have a logical, sequential, and predictable method of finishing and polishing which ultimately will lead to a restoration surface that will accept and reflect light.[12] Further, the surface should not display voids, defects, stains, or pits.

Prior to finalizing and mirroring the natural dentition in luster, coarse and medium discs are used which, in many cases, will lessen any of the initial texture placed in the restoration (Fig. 11 and 12). A well-polished material can be the outcome, so the texture can be reapplied to play into realism.

Polishing

Achieving the appropriate luster and polish on a composite restoration is crucial because it contributes to factors other than esthetics. A proper polish that lasts for the long term reduces the adhesion of bacteria and plaque to the restoration and prevents marginal leakage.

Additionally, when polished correctly, composite restorations demonstrate improved resistance to staining. The life of the restoration also will be extended by eliminating the need for early removal purely for esthetic purposes.

To complete polishing of esthetic direct composite restorations, a system from the same manufacturer that incorporates polishing paste, points, cups, and wheels and silicone brushes is recommended.[17] The use of assorted polishing instruments has been shown to produce variations in surface roughness after polishing.[7] To obtain the final luster and polish, a goat-hair chamois brush (Brasseler USA) or a regular chamois brush with polish paste should be used. When using goat-hair chamois brushes, they should be wet and well-coated with polishing paste (Enamelize, Cosmedent, Inc.) with firm pressure initially, then used dry with adequate polishing paste at high speed to complete restoration polishing (Fig. 13). Again, run the brush vertically and horizontally. During this process, fine or medium discs again might be needed, after which the goat-hair brush is used to finalize the polishing protocol (Fig. 14).

Verify occlusion

The final step in any direct composite restoration, occlusion should be verified one last time after finishing and polishing.

Case report

A 29-year-old woman came to the clinic unhappy with the space between teeth No. 8 and 9 (Fig. 15 and 16). With no removal of tooth structure and only an additive direct technique, composite restorations were placed to close the diastema (Fig. 17). Using a matrix, a nanohybrid universal composite (Venus Diamond, Heraeus Kulzer, Inc.) was placed according to a 3-D characterization layering technique and the finishing and polishing protocol described in detail above was followed. The final restorations mirrored each other and the surrounding dentition enhanced the patient's smile (Fig. 18).

Fig. 13. A goat-hair brush with composite polishing paste is used to achieve appropriate luster.

Fig. 14. 3-D characterized composite, mirroring and emulating the denture tooth (Heraeus Kulzer, Inc.) in contour, color, and luster.

Fig. 15. Preoperative view showing the patient's diastema.

Fig. 16. Retracted preoperative view showing the diastema and incisal edge wear.

Fig. 17. Close-up view showing maverick coloring and polychromicity built into the restoration using the nanohybrid composite.

Fig. 18. View of the restorations the day after completion, showing an improved esthetic result.

Summary

In the case described above, the clinician was able to restore function and esthetics by following placement and finishing and polishing protocols noted here. By doing so, the risk for recurrent issues such as secondary caries, gingival inflammation, staining, plaque buildup, and marginal leakage, among

other factors, was greatly reduced. Further, by precisely planning the case prior to completing any preparation or placement, the clinician was ensured a more predictable, esthetic, and much simpler restorative solution. When addressing a case such as the one presented here, remember the keys to success—observation, strategic control, careful selection, and manipulation of the desired material during placement, finishing, and polishing—for achieving a long-lasting and desirable composite restoration.

By adhering to the requirements of the specific composite and restoration, the ideal contour, finishing, polish, and luster were achieved in the restorative result. Incorporating an appropriate polishing sequence and system based on the materials used can enable dentists to provide patients with composite restorations that demonstrate predictable long-term esthetics, plaque and stain resistance, and function.

Author information

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