SUPERCOMPOSITES

Building Naturomimetic Complex Direct Restorations Using a Modern Supercomposite

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Abstract: In contemporary clinical practice where emphasis is placed on minimally invasive dentistry, hyperfilled composites, termed “supercomposites,” can serve as a cost-effective, high-performance, and time-efficient esthetic restorative solution. Featuring compressive and flexural strength properties that match and often exceed those of natural teeth, when bonded adhesively in place these materials are capable of exhibiting excellent clinical performance over time. Cases presented in this report use one such composite, GrandioSO, in complex direct restorations to achieve the mimicking of various layers of tooth structure both physically and optically and provide long-lasting function.

Extension of lifespan and preservation of function have always been goals of modern medicine and fitness. Whereas the body can regenerate in some cases and fluctuate between hypertrophy and atrophy in the skeletal muscular system, the oral cavity is different. The permanent dentition contains a fixed quantity of dental structure, which is irreversibly lost once reduced by fracture or disease. The average rate of tooth substance loss ranges from about 15 µm to 29 µm per year[1]; thus, in a 100-year lifespan only 1,500 µm to 2,900 µm, or 1.5 mm to 2.9 mm, of loss should affect the attritive or functional surfaces. As the human lifespan prolongs over time, the maintenance of these aging dentitions presents a challenge involving dwindling residual tooth structure and the corresponding need for an increase in restorative volume. This conundrum usually is further complexified by limited patient financial resources that now need to be amortized over a longer life expectancy.

While the oral cavity is sometimes forgiving, it is mostly unforgiving. The gingivoalveolar complex features soft-tissue component levels that are dependent on the underlying osseous substructure and in most cases can regenerate completely to a level of 3 mm to 4 mm above the osseous crest. The crest, however, may feature irreversible loss due to periodontal disease, trauma, and/or surgical procedures, thus affecting soft-tissue architecture. Loss of dental structure similarly is significantly heightened in situations of traumatic or interarch fracture as well as rampant dental caries. Anterior teeth guide the functional occlusion into maximum intercuspation but are subjected to primarily lateroapical forces during function, exhibiting a significant tensile component, the coronal stiffness of which is recovered fully to control levels by bonded porcelain veneers.[2]

Posterior teeth demonstrate significant deformation under functional loads when structure is compromised by caries or trauma. The coronal recovery is always nearly 100% when a bonded porcelain restoration is placed[2]; however, in modern clinical practice where the emphasis is on minimally invasive dentistry, the fabrication of mini dental ceramic inlays may not be practicable from a cost and time efficiency perspective. As an alternate restorative solution, hyperfilled composites termed “supercomposites” feature compressive and flexural strength properties that mimic and often exceed those of natural teeth, and when bonded adhesively in place they can exhibit excellent clinical performance over time.

A material such as GrandioSO (VOCO, vocoamerica.com) features a compressive strength of 439 MPa, which exceeds that of natural enamel at 384 MPa and dentin at 297 MPa. The flexural strength is rated at 187 MPa and even after 5,000 thermocycles maintains impressive strength at 158 MPa relative to dentin at 165.6 MPa.[3] Peritubular, highly mineralized dentin and weakly mineralized intertubular dentin exhibited an elastic modulus of 40 GPa and 13 GPa, respectively.[4] The elastic (bulk) modulus of composites ranges from 12.79 GPa to 22.43 GPa, which, although suitable as a naturomimetic substitute for dentin, is less ideal for enamel, which has been quantified in a range of 72 GPa to 88 GPa independent of whether tested with rod orientation parallel or perpendicular to the nanoindentation device.[5] As such, it is prudent to ensure that heavily restored teeth are loaded primarily in compression and tensile forces that are generated from lateral excursive interferences are eliminated or minimized in the posterior dentition.

The following cases demonstrate the use of GrandioSO in complex direct restorations to mimic various layers of tooth structure both physically and optically and provide long-lasting function.

Case 1

A male patient, who was classified as ASA II but otherwise healthy, presented to the author's practice for dentoesthetic and functional improvement. His medical history was remarkable only for past hypercholesteremia and present chronic osteoarthritis. Restorative dental needs were identified to include removal of caries and replacement of failing restorations before implementation of an interdisciplinary treatment plan consisting of both orthodontics and reconstruction. Specifically, tooth No. 14 exhibited an existing mesio-occlusal (MO) restoration with recurrent caries noted radiographically along with a fractured marginal ridge leading to food impaction. Erosive pitting also was evident on the buccal cusp tips (Figure 1).

The tooth was anesthetized with 1.5 carpules of a 2% lignocaine with 1:100,000 epinephrine solution before a rubber dam was affixed. The old restoration and caries were excavated, and a hard dentin base was confirmed using a caries disclosing dye (Caries Detector, Kuraray America, kuraraydental.com) (Figure 2). Micro air abrasion was completed using 27-µm aluminum oxide powder with a metal strip protecting the adjacent tooth before a sectional matrix (Composi-Tight® 3D Fusion™, Garrison Dental, garrisondental.com) was assembled. The reason for sequencing air abrasion prior to matrix placement is that the matrix may simultaneously act as a proximo-axial retaining wall for protection. Air abrasion may significantly increase the restorative material bond to the metal, leading to difficulties in band removal, especially with the use of 10-MDP-based dental adhesives, which have an affinity for non-precious metals as well as hydroxyapatite.[6]

The marginal ridge was constructed in 0.5 mm to 1 mm horizontal increments, as per the technique described by Nikolaenko et al.[7] Although this technique theoretically increases C-factor forces, data suggests a significant bond strength advantage over oblique and vertical layering, even in small increments.[8] Following removal of the proximal matrix assembly, the now class I defect was microlayered on the pulpal floor using a white-shaded flowable composite (Herculite™ Ultra Flow, shade XL2, Kerr, kerrdental.com). This neutralizes the dark floor at a level of cavosurface margin minus 2 mm to allow for the capping composite material (Figure 3).

GrandioSO shade A2 composite was applied in lobes with the mesiobuccal (MB) lobe completed first together with the cusp of Carabelli fissure detail before the distobuccal (DB) was completed. A fine fissure-forming hand instrument (TNTAM1, Hu-Friedy, hufriedygroup.com) was used. The author's own interlobar staining technique was employed at this stage and the stain was placed against


Fig 1.


Fig 2.


Fig 3.


Fig 4.


Fig 5.


Fig 6.

Fig 1. Preoperative situation showing erosive defects and marginal and interproximal failure of old composite restoration on No. 14 MO with past occlusal trauma affecting the cusp of Carabelli. **Fig 2.** Preparation of tooth No. 14 MOP. **Fig 3.** Marginal ridge reconstruction and conversion of class II situation to class I. Microlayers of a white opaque flowable composite were used against the pulpal floor to visually neutralize stained dentin. **Fig 4.** Layering of MB and DB lobes. Placement of fissure stain against the vertical aspects of the lobes only. **Fig 5.** Completion of layering with fine tint line closely mimicking the natural tooth. **Fig 6.** Final occlusal-adjusted view of restoration.

the vertical aspects of the MB and DB lobes (FinalTouch® Brown, VOCO) before creation of the palatal cusp anatomy (Figure 4). The mesiopalatal (MP) lobe was completed next, with care taken to migrate toward and form an invaginated fissure form against the MB and DB lobes. The distopalatal (DP) cusp was completed last in a similar manner (Figure 5).

The rationale for placement of stain between the composite lobes on the vertical face is to allow for a subtle appearance of the fissure and a depth of realism, which is desirable, as seen in the post-adjustment immediate postoperative view (Figure 6).

This case represents a situation in which a direct solution was able to be used to preserve a maximum volume of residual tooth structure despite the presence of multiple defects encompassing an extensive existing resin restoration, to occlusal erosive pitting to cusp of Carabelli fracture, which might suggest the need to otherwise place an indirect restoration.

Case 2

A healthy, controlled ASA II female patient presented to the practice with a medical history significant for hypertension and polycythemia rubra vera, a condition of hyperproliferation of red blood cells in the marrow. Her medications comprised hydroxyurea 500 mg, aspirin 100 mg, cilazapril 500 mcg, and diltiazem SR 120 mg. Her chief complaint centered on discolored, aged composite restorations in the maxillary anterior sextant, for which she desired replacements. The teeth affected, Nos. 7 through 11, exhibited chromatic, stained, and radiolucent restorations.

The patient accepted a treatment option that included completing a course of nightguard bleaching using a 10% carbamide peroxide solution in custom bleaching trays (Opalescence™, Ultradent Products, ultradent.com) for a 2-week period. The results produced shades of Vita® 2M1 maxillary anteriors and 1M1 mandibular anteriors from a baseline shade of Vita® 4M1/3M2. A 7-day stand-down period was observed post-bleaching to allow for oxygen radical leaching from the tooth before the restorative appointment.

The patient was anesthetized using 2.5 carpules of 2% lignocaine with 1:100,000 epinephrine via buccal infiltration before a rubber dam was affixed using floss ties for improved access and isolation (Figure 7 and Figure 8). The existing restorations were removed, and the dentin base was checked using caries detector dye (Caries Detector). The margins were beveled (Figure 9 and Figure 10) based on Heintze et al via a meta-analysis that the anatomic form of class III restorations over time was better maintained with margin beveling relative to no beveling. Notably, though, beveling did not have an effect on marginal staining or deterioration over time.[9]

A total-etch adhesive approach was completed and the restorations were microlayered conservatively during the initial 5 minutes to decouple with time and create a secure bond.[10] The restorations were then layered to completion using a single shade of A2 GrandioSO with a focus on recreating marginal ridge and cingulum detail[8,11] in order to maximize tensile resistance during function on the severely compromised palatal surfaces. It is important to note that shade selection had been completed before administration of both topical and local anesthesia, as the risk of dehydration is great even with a short duration of lip retraction (Figure 11). The cingulum and lingual fossa were characterized using tints for increased realism (FinalTouch) (Figure 12 and Figure 13).

Magne and Douglas observed a significant reduction of coronal stiffness from the preparation of class III cavities that exhibits a large insult second only to endodontic treatment.[12] The resulting composite-restored coronal stiffness (1.13x control) is a vast improvement over the untreated class II cavities (1.30x control) but is incomparable to the perfect biomimetic coronal stiffness recovery exhibited by bonded porcelain veneers.

The post-rehydrated result showed excellent optical integration. A maximum volume of residual tooth structure was preserved and supported using a hyperfilled resin composite (Figure 14 and Figure 15). The restoration should last the patient for years to come. This case demonstrates the ability of modern supercomposites to replace large-volume deficits in a single-shade technique with a chameleon effect that visually occludes any perception that the teeth have been restored.

Discussion

Posterior teeth function well in centric occlusion, which features primarily compressive loads, but are weaker under tension. Magne and Douglas demonstrated a 96% recovery of coronal flexural compliance when the removed facial enamel was replaced with a dentin-bonded porcelain veneer.[13] Similarly, Magne found significant cuspal widening with two- and three-surface restorative defects (9 µm to 12 µm widening with a 100 N occlusal force), which were significantly reduced compared to that of the control values (0.4 µm widening) after a bonded porcelain restoration was placed.[2] It is well-established that a bonded composite restoration is only capable of partial coronal stiffness recovery relative to control.[14] In another study, Magne and Oganesyan inflicted a 150 N occlusal force while investigating the cuspal widening of various permutations of cavity preparations and noted that a connected double-ended MOD preparation is deleterious relative to significantly increased cuspal widening (179 µm relative to control at 2.7 µm).[15] Gonzalez-Lopez et al determined that cuspal deformation during both function and polymerization contraction is severe with MOD preparations. Therefore, it is necessary to preserve as much occlusal cross-isthmus natural structure, including the critical marginal ridge, as possible, with slot and tunnel preparations preferred for proximal lesions relative to the use of MOD preparations, because the cuspal flexure is significantly greater under both occlusal loading and polymerization restorative contraction for a connected double-ended proximal cavity preparation.[15,16]

Improvements in nanohybrids and nanofilled matrix and filler chemistry have resulted in restorative materials that exhibit excellent compressive strength, dentinomimetic flexural strength, wear resistance, and optical properties that closely match the elements of enamel and dentin. Marginal integrity is a function of minimal polymerization stress, which not only is material-specific but also relates to the importance of immediate dentin sealing and subsequent microlayering of low-shrinkage-stress resins with hybridization of the resin–dentin interface in the first 5 minutes post-curing.[17]

In anterior teeth, the concentration of tensile forces in function has been found to be greatest in palatal concavities and magnified when the facial enamel is thin or missing, whereas the forces were found to be lowest on the convexity of the palatal cingulum, marginal ridges, and facial cervical convexity.[8,11] These finite element method results attest to the need to preserve a maximum volume of native enamel, respecting its function in the preservation of coronal stiffness especially if direct restoratives are to be employed. Thus, it is critical to re-establish as much as possible the original convexity zones in any restoration, as this allows a maximum resistance to tensile forces.

Modern supercomposite materials are exciting because they are able to mimic various layers of tooth structure not only physically but also optically, in many cases performing as well as their bonded porcelain restoration counterparts. These materials offer the flexibility of repair and addition or modification via relayering if required without having to excavate the restoration in its entirety. These characteristics speak to a material used in an expanded function utilizing conservative direct techniques that embody the ethos of minimally invasive dentistry: that of responsible functional esthetics.

DISCLOSURE

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Fig 7.

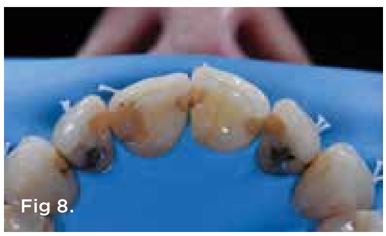
Fig 8.


Fig 9.


Fig 10.


Fig 11.

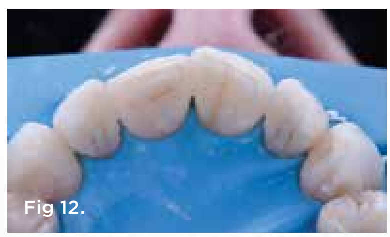
Fig 12.


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Fig 14.


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Fig 7 and Fig 8. Preoperative view of rubber dam–isolated old composite restorations, frontal view (Fig 7) and occlusal view (Fig 8). **Fig 9 and Fig 10.** Intraoperative view showing severe palatal structural compromise, especially in areas of marginal ridges and cinguli, frontal view (Fig 9) and occlusal view (Fig 10). **Fig 11.** Shade selection prior to rubber dam placement is key as dehydration optically induces transient visual opacity and increased value. **Fig 12 and Fig 13.** Palatal views of anterior restorations with anatomy and line angles/cingulum area recreated, with rubber dam (Fig 12) and after rubber dam removal (Fig 13). **Fig 14 and Fig 15.** One-week reassessment post-rehydration of the anterior teeth showing excellent optical integration, retracted view (Fig 14) and smile view (Fig 15).