Voco BioCeramic Composite Bridges the Gap Between Ceramic and Composite

by Dr. Clarence P. Tam

The goal of bioemulation or biomimetic dentistry is the reestablishment of lost tooth volume with prosthetic materials that replicate missing biologic components in the realms of biology, mechanics, function and aesthetics.[1] With enamel being a highly inorganic shell, this more mineralized, fragile layer is substratified by a more organic-rich collagenous mineral matrix—the dentin—which acts as the shock-absorbing zone and primarily imparts the fracture resistance of a tooth. Technological advances have allowed the chemical adhesion of these prosthetic replacements to residual tooth structure at shear-bond-strength levels that approximate the native dentino-enamel junction (DEJ).[2]

Key components to dental adhesive systems and resin composites are resin matrix monomers, which facilitate dispersion of the inorganic filler particles used and are responsible for chemical cross-linking to composite and to human dental tissues during both direct and indirect restoration procedures. The ability to adhere at levels approximating nature facilitate ultraconservative dentistry, where only diseased or mineralization-deficient structures compromising function need to be removed with virtually no regard for restoration-driven traditional preparation designs.

The importance of biocompatibility

There have been public concerns regarding the physicochemical stability of composite resins—in particular, the release of bisphenol A (2,2-bis[4-hydroxyphenyl] propane, or BPA), which if systemically absorbed has mild affinity to the human estradiol receptor, possibly stimulating unwanted biological effects and toxicity. Extreme oral levels of BPA were reported by Olea et al. in 1996, which initiated the watershed of public awareness.[3]

Derivations of BPA are commonly used in the synthesis of resin monomers and food-contact plastics. Dentally, their use is applied in both composite and resin-modified glass ionomer cements (RMGIC).[4] Among this group, the bisphenol A glycidyl dimethacrylate (bis-GMA) molecule and the more hydrophilic ethoxylated bis-GMA (bis-EMA) are ubiquitous in modern restoratives, and concerns revolve around whether some situations may be susceptible to hydrolytic or salivary esterase-based degradation to the native BPA. This, in conjunction with impurities of BPA that have been eluted from composite resin samples after polymerization, have led for greater preference of BPA-free composite resins, such as those synthesized with urethane dimethacrylate (UDMA) and triethylene glycol dimethacrylate (TEGDMA).

The oral release of BPA is initially greater under higher polymerization strength, but its long-term release is inversely commensurate with monomer conversion.[5]

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This suggests that high-powered polymerization in a rapid workflow may be detrimental, relative to aggressive composite shrinkage dynamics and BPA release from certain materials. Tichy et al. noted that high-powered polymerization was insufficient to cure the intaglio surface of a 2 mm composite increment adequately,[6] which reinforces the need to remove the oxygen inhibition layer after placement of BPA-monomer-derived materials.

Aside from hydrolytic degradation, the role of salivary esterases such as pseudocholinesterase and cholesterol esterase has been established in their ability to degrade bis-GMA and TEGDMA composites,[7] lending a further mode of failure to these materials from a safety perspective. Because TEGDMA is commonly used as a viscosity-lowering component of modern dimethacrylate-based resin composites, the cytotoxicity of it and its degradation products must not be overlooked.

A study by Schubert et al. revealed significantly lower cytotoxicity to human gingival fibroblasts from an organically modified ceramic composite material, **Admira Fusion** (Voco America), relative to traditional composites.[8] The biocompatibility of this material stems from its ability to utilize organically modified silica to form a siloxane network with an inorganic silica backbone and organic arms (trademarked as an "Ormocer"). These components are so densely positioned that monomer conversion is 100% and volumetric polymerization shrinkage is rated at 1.25%. Indeed, both the bulk-fill versions and traditional layering with this technology exhibited similar levels of clinical success over a two-year observation period, adding clinical efficiency to the list of benefits of this nontraditional composite.[9]

Fracture toughness is a key feature of composite resins used to replace missing dentin volume, especially in endodontically treated teeth. Ormocers were found to have some of the highest fracture toughness values in a study by Ilie et al.[10]

The material's Ormocer matrix is also responsible for its omnichromatic aesthetics. The nanoparticulate making up 60% of the total volume is grown through the sol-gel crystallization process, resulting in particles 20–40 nanometers in size and perfectly spherical. With its particulate size being smaller than visible wavelengths of light, the material neither diffracts nor refracts light; instead, its restoration takes on the appearance and color of its surroundings.

Case 1

A 35-year-old ASA II patient presented with Class II caries affecting teeth #4MO and #5DO. After excavation and rubber dam isolation (Dermadam, Ultradent), the preparations are shown with light cavosurface margin beveling (Fig. 1).

Fig. 1

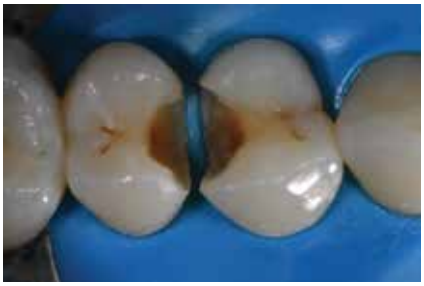


Fig. 2

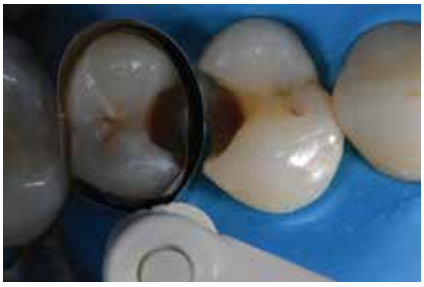
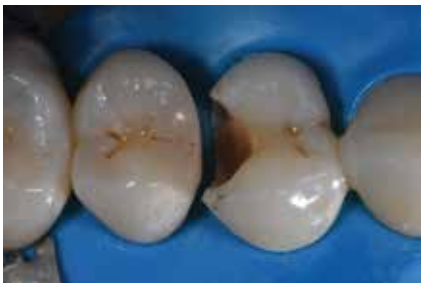


Fig. 3



After the use of 27-micron aluminum oxide (Prep Start, Danville Engineering) and a total-etch adhesive protocol (Peak Universal Bond, Ultradent), the restorations were completed with a matrix-in-matrix approach, used first on #4MO, using an Omnimatrix Tofflemire retainer externally (Ultradent) and a Firm Band (Garrison Dental Solutions) internally. The rationale for this approach is that the retainer squeezes the cervicoproximal aspect of the anatomically contoured sectional matrix band tightly and does not require a wedge to prevent overhangs (Fig. 2). This results in the efficient re-creation of precise proximoaxial contour (Fig. 3), before securing a sectional matrix retainer in the conventional approach to

Fig. 4

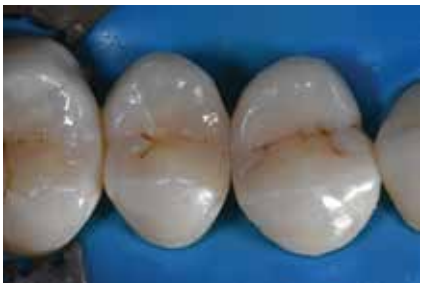
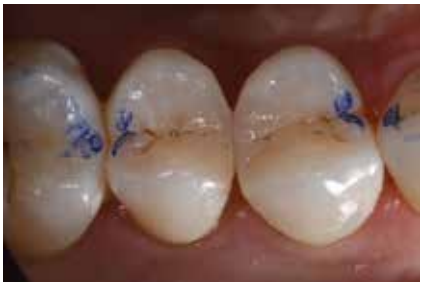


Fig. 5



complete the remaining restoration (Fig. 4).

In this series, **Admira Fusion Flow** (Voco America) in Shade A2 was used in a microlayered fashion to ensure maximal curing and polymerization and minimal shrinkage stresses in the proximal box floor before the marginal ridge was constructed using the universal-shaded, bulk-fill nano-Ormocer restorative **Admira Fusion x-tra** (Voco America). The matrix assembly was then removed, thus having converted #4MO into a Class I situation. The occlusal was layered in a similar fashion using the above materials.

The postoperative view (Fig. 5) exhibits excellent chameleon effect and contour reconstruction in these extensive lesions.

Case 2

A 21-year-old ASA I patient presented with multiple proximal D3 carious lesions affecting #13DO and #14MO/DO. After conservative excavation, the preparations were refined and the cavosurface margins beveled (Fig. 6).

After the use of 27-micron

Fig. 6

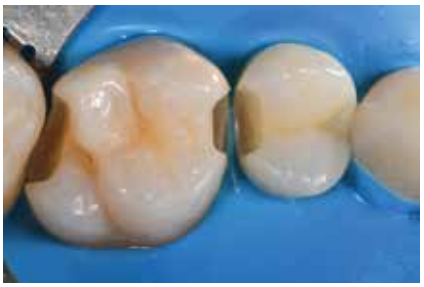


Fig. 7

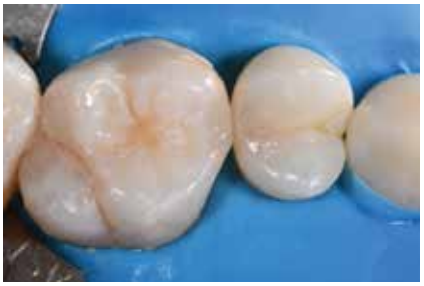
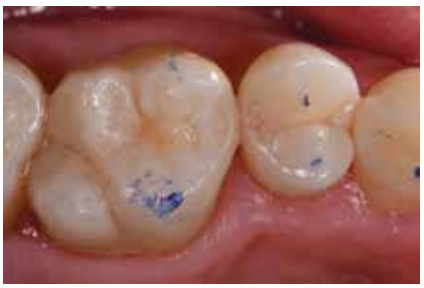


Fig. 8



aluminum oxide and a total-etch adhesive protocol, a sectional matrix system was affixed (Compositight 3D Fusion, Garrison) and the restorations were completed with **Admira Fusion x-tra** (Fig. 7), paying particular attention to establishing occlusal embrasure form interproximally. Dehydrated enamel is seen next to the restorations.

The occlusion-adjusted control view (Fig. 8) shows excellent aesthetic integration of this biocompatible composite material.

Case 3

A 62-year-old ASA II patient presented to the practice requesting removal of all her remaining amalgam restorations, citing health risks. On clinical examination, the amalgam on tooth #14O featured

Fig. 9

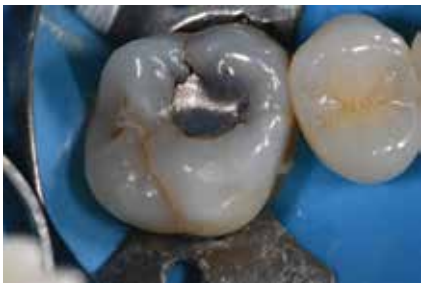


Fig. 10

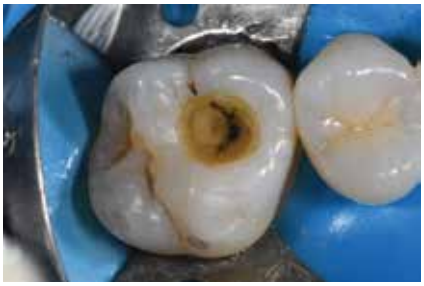


Fig. 11

marginal breakdown and subsurface staining and potential recurrent caries (Fig. 9).

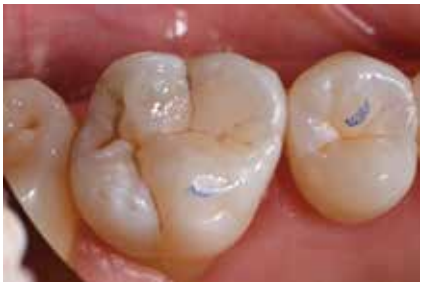
Under rubber dam isolation, the amalgam was removed and recurrent caries excavated to the caries removal end point (Fig. 10). The cavosurface margins were beveled before microparticle abrasion was applied. A total-etch adhesive protocol was employed before microlayering the floor horizontally with **Admira Fusion Flow** A2 as a microadaptation of the technique by Nikolaenko et al.[11] The stained dentin floor was then neutralized with multiple thin layers of an opaquer tint (**Final Touch White**, Voco GmbH, Fig. 11).

The occlusal capping composite was applied in increments, with the buccal lobes completed first

Fig. 12

Fig. 13

Fig. 14



(Fig. 12) before layering the palatal lobes. The fissures were characterized further using a brown tint (**Final Touch Brown**, Voco GmbH, Fig. 13). The occlusion-adjusted view (Fig. 14) shows excellent neutralization of low-value staining by the intermediate tint layer, which then was covered by **Admira Fusion x-tra**.

Conclusion

The quest for biomimetic materials has forced the spotlight on materials that not only perform like nature but also are biocompatible. There is a risk of direct and indirect cytotoxicity to various degrees with different direct materials, and with others there is the risk of functional failure with inadequate physical properties. The ideal enamel volume replacement is always via an indirect approach or semi-indirect approach, with the latter utilizing extraoral processing or polymerization and the former the use of inert silicate glass and zirconium/aluminum oxides, which minimize the use of exposed resin composite cements, while minimizing curing shrinkage and polymerization stress. Dentin properties are best matched to the use of composite resins with reference to flexural modulus, strength and fracture toughness.

Ultimately, the responsibility lies with the clinician to take a balanced approach considering risk/benefit and cost/benefit ratios in respect of biomaterials with the goal of providing inert functional replacements for the patient into the future. Modern Ormocer direct restorations present an innovative direct approach that minimizes biological risk and features physical properties that are a balanced match for simultaneous enamel-dentin volume replacements in suitable clinical scenarios.

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