What other biomaterial has so many uses: Flowables

Douglas A. Terry[1]

Introduction

1996 was an exciting year around the world. The Dow Jones reached a record high of 6,000; the Nobel Prize in Chemistry was awarded to Curl, Kroto and Smalley for their discovery of fullerenes, a molecule composed entirely of carbon; General Motors launched the first electric car of the modern era; e-bay opened its door for business; DVD s hit the market in Japan; Will Smith made his electrifying performance in "Independence Day"; David Bowie was inducted into the Rock and Roll Hall of Fame; and flowable composite resins were developed and introduced to the world as a revolutionary restorative biomaterial.[1] The average individual would probably rank this discovery the least significant of events, yet this milestone dramatically effected the practice of adhesive dentistry.

The evolution of adhesive dentistry with filled adhesives and sealants was the catalyst that sparked this development and discovery of flowable composite resins.

Although, it was not until 1996[1] that these biomaterials had their own identity and became known as flowables. These "first generation" formulations were designed to simplify the placement technique and expand the range of clinical applications for composite resins.[1,2] These early flowable formulations were configured by utilizing the identical filler particle sizes of conventional hybrid composite, while reducing the filler load and/or increasing the diluent monomers.[3,4] Thus, a multitude of variations in viscosity, consistency, and handling characteristics were available to the discriminating clinician for many of the restorative and aesthetic challenges presented to them each day.

These biomaterials were marketed by manufacturers for a wide range of applications which included all classifications of anterior and posterior composite restorations, amalgam margin repair, block out materials, composite repair, core build-up, crown margin repair, cavity liners, pit and fissure sealants, porcelain repair, anterior incisal edge repair, preventative resin restorations, provisional repair, porcelain veneer cementation, composite veneer fabrication, tunnel preparation restorations, adhesive cementation, restoring enamel defects, air abrasion cavity preparations and void repairs in conventional composite resin restorations.[1,5] Unfortunately, these earlier flowable formulations demonstrated poor clinical performance with inferior mechanical properties such as flexural strength and wear resistance compared to the conventional hybrid composites.[1,2]

In fact, the mechanical and physical properties of composite materials improve in proportion to the volume of filler added6 and the filler content of these earlier flowable formulations were reported to be 20 to 25% less than that of the universal composite materials.[1] Numerous mechanical properties depend on this filler phase, including

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Figure 1a: Preoperative occlusal view of a defective composite restoration with recurrent decay on the mandibular left first molar.

Figure 1b: The completed posterior restoration reveals the harmonious Integration of flowable composite resin (G-aenial Universal Flo, GC America) and tooth structure.

Figure 2a: Preoperative view of saucer-shaped noncarious cervical lesions on the mandibular left cuspid and first premolar.

Figures 2b: The post-treatment view of the finished and polished restorations utilizing a nano particle hybrid flowable composite resin (G-aenial Universal Flo, GC America).

compression strength and/or hardness, flexural strength, the elastic modulus, coefficient of thermal expansion, water absorption, and wear resistance.[6] Thus, a reduction in the filler content of these first generation flowables substantiates the reports by Bayne et al, that the mechanical properties of these low viscosity materials were approximately 60 to 80% of those of conventional hybrid composites.[1] One scientific study reports that a comparison of flowable light-cured composite resins and conventional composite resins of the same brand name had very different characteristics and mechanical properties.[7] Early attempts to utilize these flowable formulations in a wide variety of applications resulted in shortcomings that led to confusion and uncertainty for clinical predictability and performance when using these biomaterials. Thus, the unfavorable marketing mentality of the manufacturer proved unsuccessful and required limitations on the expanded applications previously suggested. Clinicians realized that the applications for these first generation flowable composites were not the same nor were they adequate substitutes for the highly filled conventional composites.

Since the past provides information to improve the future, the lack of evidenced based research and clinical trial data on these flowable biomaterials requires clinicians to evaluate their individual mechanical properties for determining whether a new material's properties are equal or superior to those of existing materials. Although there is not a direct correlation of a material's mechanical and physical properties to clinical performance it might suggest the potential success of a restorative biomaterial for a specific clinical situation.[1] However, clinical longevity for restorations developed with these biomaterials remain to be determined through clinical studies and trial data for each specific clinical application.

Figure 3a: Preoperative view of maxillary centrals with incisal fractures.

Figure 3b: Completed transitional veneers using a next generation flowable composite resin (G-aenial Universal Flo, GC America). (b)

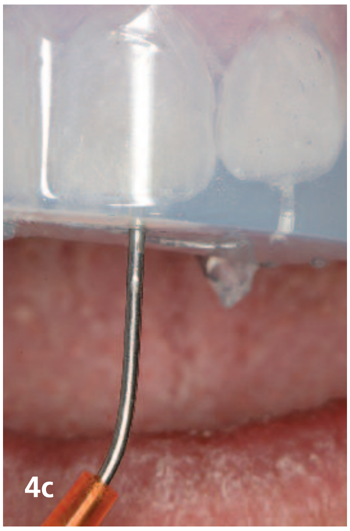
Next generation flowable composite resins

Presently, there are a multitude of flowables that are undergoing evaluation and continuous improvement through scientific research and development. These next generation flowable composites are being reengineered as alternatives to conventional hybrid composites. As with every profession, the continual development of new technology improves the ability of the scientist, manufacturer and clinician to measure more effectively, thereby possessing the ability to create a more ideal composite. However, the search continues for an ideal restorative material which is similar to tooth structure, resistant to masticatory forces, has similar physical and mechanical properties to that of the natural tooth and possess an appearance akin to natural dentin and enamel. As the mechanical properties of a restorative material approximate the enamel and dentin, the restoration's longevity increases.[8] An ideal restorative material should fulfill the three basic requirements of function, esthetics and biocompatability.[9] In addition, optimizing the adhesion of restorative biomaterials to the mineralized hard tissues of the tooth is a decisive factor for enhancing the mechanical strength, marginal adaptation and seal, while improving the reliability and longevity of the adhesive restoration.[8] At present, there is no restorative material which fulfills all these prerequisites. However, nanotechnology used in dental applications may provide some of these solutions.

Restorative material selection

For selection of the proper material for any particular clinical situation, the anticipated utilization requires two consideration factors- the mechanical and/or aesthetic requirements. Although, there are other compounding variables that should be considered prior to restorative treatment because they also have the potential to influence the clinical behavior and material performance.

These include the placement technique, cavity configuration, anticipated margin placement, curing light intensity, tooth anatomy and position, occlusion, patients' oral habits and ability to isolate the operative field.[10-15] In view of the previous considerations, it is understandable that clinicians have uncertainties about selection of biomaterials and techniques to optimize the materials' properties and



Figures 4 a-d: The composite mock-up is the key to success in function, aesthetics and phonetics. This composite prototype was developed from the indirect/direct technique utilizing a diagnostic wax-up, clear vinyl polysiloxane matrix and a next generation flowable composite resin.

achieve predictable, long term results. A review of the aforementioned consideration factors (i.e., mechanical and aesthetic requirements) for choosing a composite resin system for a specific clinical situation may provide insight into future selection and application.

Mechanical and aesthetic requirements

In composite resin technology, particle size and the amount of particles represent crucial information in determining how best to utilize the composite materials. Alteration of the filler component remains the most significant development in the evolution of composite resins,[16] because the filler particle size, distribution, and the quantity incorporated dramatically affects the mechanical properties and clinical success of composite resins,[17] In general, mechanical and physical properties of composites improve in relationship to the amount of filler added. Many of the mechanical properties depend on this filler phase, including compression strength and/or hardness, flexural strength, the elastic modulus, coefficient of thermal expansion, water absorption, and wear resistance.

The aesthetic appearance of the surface of a composite resin restoration is also a direct reflection of the particle size. Aesthetic restorations require biomaterials to have optical properties similar to tooth structure. Since composite resin does not have hydroxyapatite crystals, enamel rods, and dentinal tubules, the composite restoration requires developing an illusion of the way light is reflected, refracted, transmitted, and absorbed by dentin and enamel microstructures. Re-creating a natural anatomical surface requires a similar orientation of enamel and dentin. Newer formulations of composite resins possess optical properties that render the tooth polychromatic. In addition, the filler particle sizes and distribution can influence the color and aesthetics of a restoration through a phenomenon called "double-layer effect" or also known as the "chameleon effect", or "blending effect."[18-20] This mechanism applies to the relationship between natural tooth structure and aesthetic materials. It occurs when a composite material is placed as a restoration and diffused light enters from the surrounding hard dental tissues, when emitted from the restoration the shade is altered by absorbing color from the

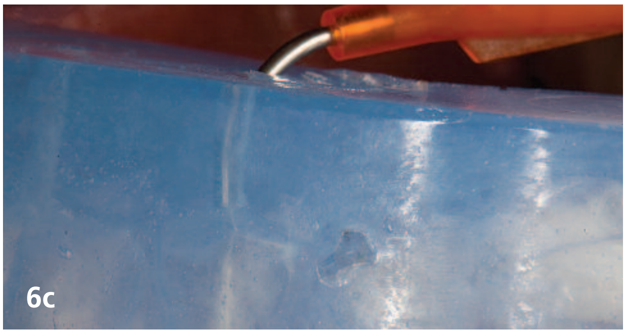
Figure 5: These advanced formulations of flowables have the potential to increase wear resistance and can be utilized as sealants and preventative resin restorations.

tooth and adjacent teeth. This color alteration depends on the scattering and absorption coefficients of the surrounding hard dental tissues and restorative material, which can produce an undetectable color match by blending with tooth color.[21] Furthermore, the surface quality of the composite restoration is influenced by the composition and the filler characteristics of the composite.[22,23] Newer formulations of nanocomposites have altered filler components with finer filler size, shape, orientation and concentration, improving not only their physical and mechanical properties but also their optical characteristics. These nanosized particle hybrid composite resin systems allow the resin to be polished to a higher degree which can influence color integration between the material and tooth structure.

Nanotechnology with composite resins

Nanotechnology or molecular manufacturing[24] may provide composite resin with filler particle size that is dramatically smaller in size, can be dissolved in higher concentrations and polymerized into the resin system with molecules that can be designed to be compatible when coupled with a polymer, and provide unique characteristics (physical, mechanical, and optical). In addition, optimizing the adhesion of restorative biomaterials to the mineralized hard tissues of the tooth is a decisive factor for enhancing the mechanical strength, marginal adaptation and seal, while improving the reliability and longevity of the adhesive restoration. Currently, the particle size of many of the conventional composites are so dissimilar to the structural sizes of the hydroxyapatite crystal, dental tubule and enamel rod, there is a potential for compromises in adhesion between the macroscopic (40 nm to 0.7 um) restorative material and the nanoscopic (1 to 10 nanometers in size) tooth structure.[25] However, nanotechnology has the potential to improve this continuity between the tooth structure and the nanosized filler particle and provide a more stable and natural interface between the mineralized hard tissues of the tooth and these advanced restorative biomaterials.

A recently developed nano-hybrid flowable composite resin system (G-aenial Universal Flo, GC America) may possess the physical, mechanical and optical properties to provide these mechanical and physical requisites. These properties and the clinical behavior of this biomaterial formulation is contingent upon its structure. This new resin filler technology allows a higher filler loading because of the fine filler size, uniform shape and distribution of particles. This unique resin filler chemistry allows the particles to be situated very closely to each other and this reduced interparticle spacing and homogeneous dispersion of the particles in the resin matrix increases the reinforcement and protects the matrix.[26-28] In addition, the proprietary chemical treatment of the filler particles allows proper wettability of the filler surface by the monomer and thus an improved dispersion and a stable and stronger bond between the filler and resin. Research studies clearly indicate the significance that filler content and coupling agents represent in determining characteristics such as strength and wear resistance.[28-32] Recent studies report that flowable composites have comparable shrinkage stress to conventional composites.[4,33,34] According to the manufacturers, this next generation flowable resin formulation is purported to offer mechanical, physical and aesthetic properties similar or greater than many conventional hybrid composites.[35] The material's clinical attributes include easier insertion and manipulation, improved adaptation to the internal cavity wall, increased wear resistance, greater elasticity, color stability, enhanced polishability and retention of polish, and radiopacity similar to enamel. With the competent mechanical properties reported, this evolutionary designed formulation is indicated for use in anterior and posterior restorative applications.



Figures 6 a-e: Provisional restorations are fundamental in the development and management of soft tissue profiles during periodontal plastic surgery procedures. This indirect/direct restorative application with a next generation flowable was used to replicate the diagnostic wax-up and for soft tissue management during connective tissue surgery. The interim restoration reflects the final prosthetic treatment.

Restorative applications for next generation flowable composite resins

In view of the previous considerations, it is understandable that clinicians have uncertainties about selection of biomaterials and techniques to optimize the materials' properties and achieve predictable long term results. The following discussion may provide insight into future selection and application for these next generation flowable materials.

Anterior and posterior composite restorations

Today, improvements in resin technology, optimization of material properties and the development of innovative techniques for placement have made the direct composite resin restoration more user friendly and reliable. Until recently, flowables were clinically indicated and acceptable as filling materials in low-stress applications such as cavity liners, sealants, preventative resin restorations, small Class I restorations, Class II substructure, small Class III restorations, and Class V restorations.[1] However, the utilization of a recently developed optimized nano particle hybrid flowable composite resin (G–aenial Universal Flo, GC America) allows the clinician to implement a single restorative material that appears to have all the improved mechanical and physical properties, while using stratification techniques to create internal color. In addition, studies have shown that using flowable composites reduces restoration microleakage and the occurrence of voids.[36-39] Other studies indicate that incremental layering techniques can be effective in reducing the effect of contraction stress and improving marginal sealing.[5,40-42] Controlled polymerization has also been suggested to reduce marginal gap, increase marginal integrity, and reduce shrinkage with flowable composites.[43-48] By utilizing precise restorative placement techniques,

Figures 7 a, b: Provisional splinting is a technique for stabilization and immobilization of teeth. This procedure utilizes a light-cured adhesive and flowable material applied to acid-etched enamel surfaces in combination with flexible stainless steel orthodontic wire.

conservative adhesive preparation designs [35] and a more thorough adhesive protocol these advanced formulations (G-aenial Universal Flo, GC America) can be utilized for Class I (Figure 01 a, b), Class II , Class III , Class IV), and Class V restorations (Figure 02 a, b) diastema closures and direct veneers (Figure 03 a, b).

Composite mock-up

The composite mock-up is an excellent tool for increasing the patient's understanding and education of the clinical procedure through a visual prototype. This composite prototype allows the patient and the restorative team (ceramist, clinician and the surgeon) to establish parameters for lip profile, incisal length and orientation to the gingiva, and to simulate the final result. An indirect/direct technique, which uses a clear matrix, can be used to translate this information to the oral cavity. This process can be performed intra-orally without anesthesia and can provide proper lip position and phonetic considerations.[49] (Figure). A clear vinyl polysiloxane impression (Memosil 2, Heraeus Kulzer) can be used to replicate the diagnostic wax-up. The matrix can be placed intra-orally, and used as a transfer vehicle for the flowable composite (G-aenial Universal Flo, GC America) to be injected. This composite mock-up should occur prior to finalization of the treatment plan to ensure that patients' and the restorative teams' expectations have been addressed. (Figure 04 a-d)

Sealants and preventative resin restorations

Next generation flowables can be utilized as composite surface sealants pit and fissure sealants and preventative resin restorations. These highly filled nano materials can be cured in a thin film and with a minimal air-inhibited layer and are designed to seal any cracks or microscopic porosities that may have formed during the finishing procedures of direct and indirect restorations and to seal occlusal pits and fissures. These formulations have the potential to increase the wear resistance of posterior composite resin restorations since the interparticle spacing is reduced and the filler particle density is increased and thus provide more reinforcement and protection of the resin matrix.[26-28] (Figure 05)

Provisionals: fabrication, modification and repair

Provisionals are the key to function, aesthetics and phonetics and the roadmap to success in aesthetic reconstruction.[6] Composite provisionals can be efficiently fabricated by making an initial impression with a clear vinyl polysiloxane impression material (Memosil 2, Heraeus Kulzer) of the preoperative stone or diagnostic wax-up model. After a separating medium is applied to the preparation, the clear matrix is placed and a flowable composite resin can be injected into the coronal space with a predetermined shape and contour. Modifications in shape, length, and contour as well as the elimination of any surface defects can be accomplished by the incremental application of flowable composite resin after surface preparation. Also, long term provisionals can be utilized for the shaping and development of gingival contour for edentulous regions (ie, ovate pontic design) and for the manipulation and shaping of interproximal papillae during prosthetic implant therapy. In addition, provisionals can be aesthetically enhanced by cutting back the facial or buccal surface and placing a final flowable composite layer after surface preparation with composite primer and any internal characterizations are completed. (Figure 06 a-e)

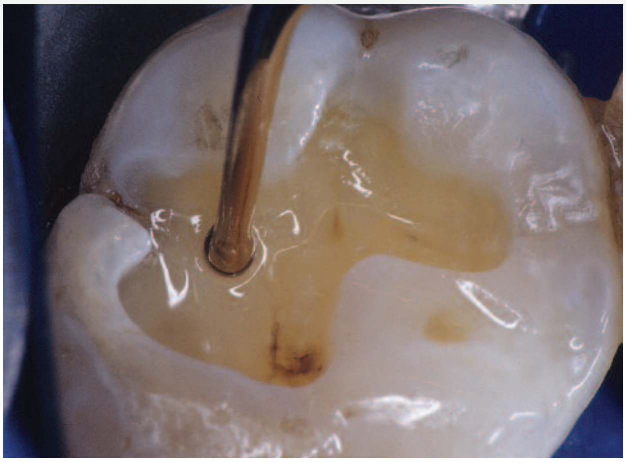


Figure 8: A flowable composite resin (G-aenial Universal Flo, GC America) ensures a more intimate contact with the dentin bonding agent resulting in enhanced internal adaptation. These materials can be used in combination with conventional hybrid composites or independently to compensate polymerization shrinkage stress by flow.

Composite tooth splinting

Provisional splinting[50] is a technique utilized for the stabilization and immobilization of teeth. This procedure has widespread use in dentistry- orthodontics, periodontics, oral surgery, pedodontics, and general dentistry. It provides tooth fixation through application of a light-cured flowable or chemically cured composite material to acid etched enamel surfaces in combination with flexible stainless steel wire,[51] orthodontic brackets[51,52] or fiber reinforced ribbon. Accepted clinical applications include: provisional fixed partial denture placement,[50] to prevent super-eruption of opposing teeth,[50] fixed orthodontic retainer,[50] periodontal splinting,[50] connection of implants to natural teeth,[50] support for root resection,[50] stabilization of traumatically displaced,[50] transplanted and root fractured teeth,[51] and orthodontic extrusion of fractured teeth.[53,54] (Figure 07 a, b)

Enhancing internal adaptation

In certain cavity configurations, there are no free surface areas present within the cavity. Thus, the ratio between the free and bonded restoration surfaces (C-factor)[55-57] is high, creating shrinkage stresses that are higher than the bond strength.[58] This can result in partial delamination from the tooth structures interface complex generating marginal gaps and/or enamel fractures.[59] The process of selective bonding creates free surfaces within the cavity reducing the configuration factor of the restoration. The liner seals the dentin yet does not adhere to the restoration, therefore the gap formation is confined to the internal aspect of the cavity, creating a free surface within the cavity and thus reducing the C-factor. This enables more flow during polymerization resulting in a more stress resistant marginal adaptation.[60]

The combination of flowable and viscous composite ensures a more intimate contact with the dentin bonding agent because of their lower viscosity and results in enhanced internal adaptation.[61] These next generation flowable composites are filled 69% by weight with an average particle size of 200 nm. The low modulus composite acts as an elastic buffer that compensates polymerization shrinkage stress by flow, eliminating mastication discomfort and theoretically eliminating cuspal deformation or gap formations and reduced microleakage.[38,62-81] If the elastic modulus is low, the composite will stretch to accommodate the inherent modulus of the tooth. Therefore, the internal layer may absorb polymerization shrinkage stress of the resin composite by elastic elongation.[82,83] Also, the lower viscosity flowables may enhance the wetting capacity[61] of the restoration resulting in a more complete interfacial internal adaptation, reducing void formations[84] which can contribute to a weakened surface and microleakage. By understanding this complex mechanism between polymerization shrinkage and adhesion, the clinician can select application techniques and restorative materials that prevent gap formation at the time of placement for each individual clinical situation. (Figure 08)

Intraoral repair of fractured ceramic restorations

Application of composite resins for the intraoral repair of ceramic restorations can increase the longevity and improve the aesthetics of fractured restorations and offer the patient and dentist a cost effective alternative to replacement.85 Intraoral repair of a preexisting porcelain restoration is a technique that requires knowledge of biomaterial chemistries. The adhesion between ceramic material and composite resins is the result of a physico-chemical interaction at the ceramic-resin interface involving two simultaneous mechanisms-chemical bonding and micromechanical interlocking.[86] A proper surface preparation is essential for successful repair. Some of the various surface treatments that have been recommended for achieving the micromechanical interlocking mechanism of adhesion with different types of all-ceramic systems include mechanical roughening of ceramic surface with a coarse diamond bur, airborne-particle abrasion using alumina particles, and etching with

Figures 9 a, b: An intraoral repair of the maxillary right cuspid on a fixed silica-based porcelain bridge using a highly filled flowable composite resin (G-aenial Universal Flo, GC America).

hydrofluoric acid. Because of the different chemical structure between silica-based and high -strength ceramics, different chemical surface treatments are required. The following are the author's standard protocols for bonding composite resin to different ceramic microstructures.

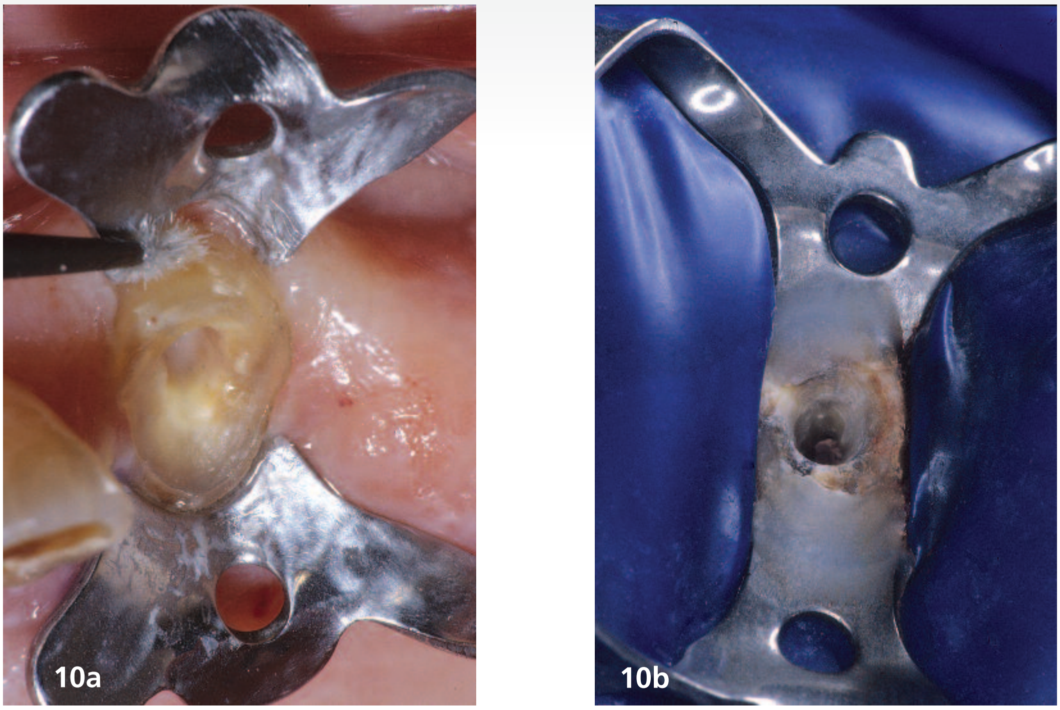
Silica-based ceramic restorations

The fractured surface of the intact silica based ceramic restoration should be acid etched with 4% to 9.8% hydrofluoric acid (HF) to create surface roughness and the application time depends on the crystalline content of the specific ceramic substrate. A higher crystalline content requires less acid etching time and concentration. A silane coupling agent is then applied to the etched ceramic surface. It is important not to place an excess or thick layer of silane because additional layers of hydrolyzed silane will not bond to the porcelain surface and can result in a less than optimal porcelain bond.[87,88] For any exposed tooth structure it should be conditioned with total etch or self etch technique. Any exposed metal substructure can be microetched prior to these surface treatments and a metal primer applied. A flowable or conventional composite shade should be selected depending upon the color of the substrate (i.e.,opaque, translucent) and injected over the region and adapted with a sable brush and/or a long bladed interproximal instrument. (Figure 09 a, b)

High-strength ceramic restorations

Traditional bonding procedures (i.e., acid etching and silane application) for silica-based ceramics cannot provide long-term durable bonds to the silica-free, acid resistant, high strength ceramic materials (i.e., alumina, zirconia). Conventional acid etchants do not sufficiently roughen the dense surface[89] of these materials and the chemical reaction from silanization of these non silica-based ceramics is not possible. However, silane application can provide increased wettability.[89-102] Silica/silane coating or application of a phosphate-monomer-containing ceramic priming agent after air-borne particle abrasion increases the shear bond strength between zirconium-oxide ceramic and composite resin.[103,104]

The authors' surface treatment protocols for high-strength ceramics (i.e., aluminum and zirconium oxide) include two



Figures 10 a, b: After the dental dam clamp is placed, a self-etch adhesive (G-aenial Bond, GC America) is applied to the tooth structure and light cured. (a) A flowable composite resin is placed and light-cured. This technique stabilizes, secures and seals the working field prior to endodontic and/or restorative procedure. (b)

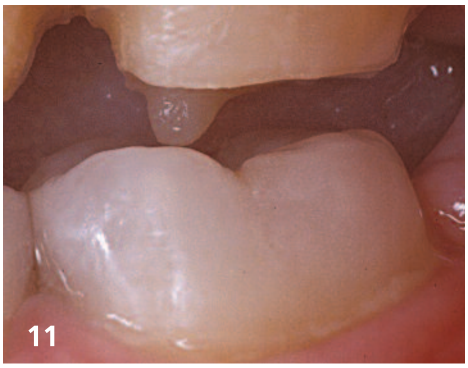
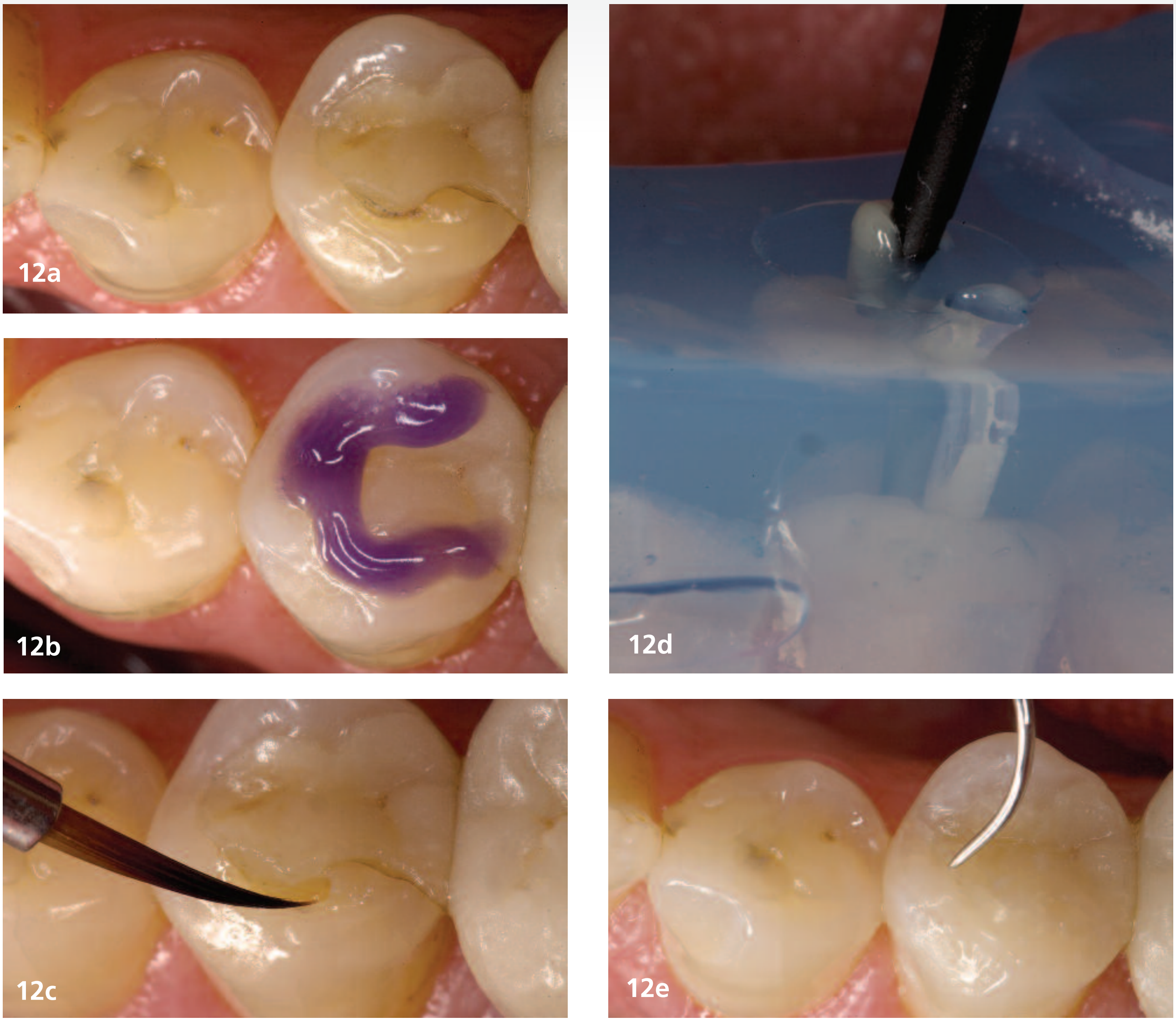


Figure 11: During full arch crown preparation, a conical stop can be made with flowable composite resin on the supporting cusp of the prepared terminal tooth. This allows the vertical dimension to be maintained and serves as a third point of reference for a stable occlusal relationship when occluding the definitive stone models.

methods. One method requires silica coating of the fractured surfaces of the intact restoration with CoJet-Sand (Rocatec/CoJet System, 3M™ ESPE™) followed by an application of a silane coupling agent (ESPE Sil). The application of a silica layer to high-strength ceramics such as zirconia creates binding sites for the silane molecules while the silane provides wettability and a chemical coupling with the methacrylate based composites. Another user-friendly method involves an application of a commercial primer that contains phosphonate or phosphate monomers to the fractured surfaces of the intact restoration. Phosphate monomers form covalent bonds with the zirconia surface and have polymerizable resin terminal ends that copolymerize with the methacrylate based composites. The recent developments of several special ceramic primers indicate their importance. Currently, there are several ceramic primer systems for zirconia surface preparation available such as Monobond Plus (Ivoclar Vivadent); Clearfil Ceramic Primer (Kuraray); AZ-Primer (Shofu Dental); Metal/Zirconia Primer (Ivoclar Vivadent); and Z-Prime Plus (Bisco). Air-particle abrasion with small aluminum oxide particles (e.g., 30 m) before application of a ceramic primer is recommended to further increase bond strengths of composite resins to high-strength ceramic materials.

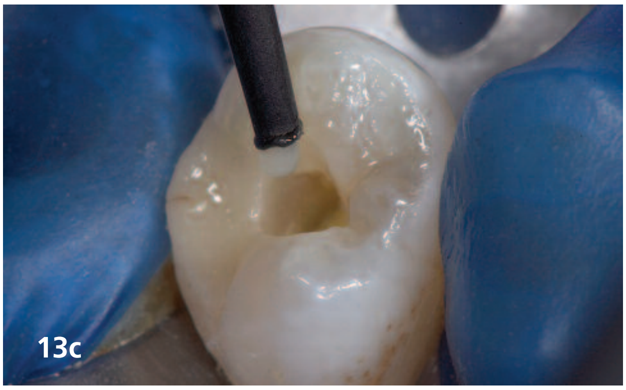
The surface treatment for any exposed tooth structure remains the same (i.e., self-etch or total etch). A flowable or conventional composite resin shade should be selected depending upon the color of the substrate (i.e.,opaque, translucent) and injected or placed over the region and adapted with a sable brush and/or a long bladed interproximal instrument.



Figures 12 a-e: An indirect/ direct technique can be used to restore anatomical morphology from tooth wear or fracture. (a) Acid etching of the cavo surface. (b) After silane is applied to the aged composite resin, an adhesive is applied to the tooth structure, air thinned and light cured. (c) A clear vinyl polysiloxane material is used to replicate the preoperative model, the clear matrix is placed over the treatment area and the flowable composite resin (G-aenial Universal Flo, GC America) is injected through a small opening above the tooth and light cured for 40 seconds. (d) The resurfaced composite restoration restores wear resistance and aesthetics. (e)

Stabilizing, securing, and sealing dental dam clamp

This procedure allows retention and stabilization of the dental dam clamp with flowable composite resin. The clamp is applied before the dam, it is positioned and stabilized digitally and a selective etching procedure is utilized. The enamel is spot etched for 15 seconds with a 37.5% phosphoric acid gel, rinsed for 5 seconds and air dried. A self-etch adhesive (G-aenial Bond, GC America) is applied to the enamel and dentin, coronal to the jaws of the clamp and allowed to dwell for 10 seconds, dried for 5 seconds and light cured for 10 seconds and dried. A flowable composite resin (G-aenial Universal Flo, GC America) is applied and light cured for 10 seconds. This procedure allows stabilization, isolation and seals the working field during the endodontic or operative procedure.[82] (Figure 10 a, b)



Figures 13 a-d: After endodontic treatment, the access opening (i.e., tooth, composite) is roughened with a diamond bur. (a) After silane is applied to the roughened composite surface, a self-etch adhesive (G-aenial Bond, GC America) is applied to the surfaces and allowed to dwell for 10 seconds, air dried and light cured for 10 seconds; (b) A light cured flowable composite resin (G-aenial Universal Flo, GC America) is injected into the opening, contoured and light cured for 40 seconds; (c) The transitional seal of the endodontic access opening reduces the potential for bacterial contamination. (d)

Creating a vertical stop for inter-occlusal records

Flowable composite resin can be used as accurate inter-occlusal record for the orientation of models for fixed prosthetic restoration. This method uses conical stops of composite resin prepared in the enamel of the abutment or made of a conical composite core which maintains the vertical dimension of occlusion and acts as a third point of reference for a stable occlusal relationship when occluding the definitive stone models.[105] (Figure 11)

Resurfacing or repairing composite restorations

Cyclic tension and compressive stresses that occur in the mouth during chewing or parafunctional habits can reach a fatigue limit and can result in tooth structure loss.[106-108] These repeated flexural forces can also cause adhesive failure of adhesive restorations at the dentin resin interface which can result in microleakage, and partial or complete debonding of the restoration.[109] A restorative material properly bonded to the enamel and dentin substrate will reduce marginal contraction gaps, microleakage, marginal staining and caries recurrence, improve retention, reinforce tooth structure and dissipate and reduce functional stresses across its interface throughout the entire tooth while improving the natural aesthetics and wear resistance.[110-114] An indirect/direct technique can be used to restore anatomical morphology from wear or fracture. The aforementioned procedure uses a clear matrix that can be fabricated from an preoperative or diagnostic wax-up model. After preparing

Figures 14 a-c: Fractured ceramic denture teeth can be efficiently repaired at chairside. (a) After silane and adhesive are applied to the silica-based ceramic material, a next generation flowable composite resin (G-aenial Universal Flo, GC America) is placed, contoured, and light cured. (b) The finished and polished repaired ceramic denture teeth. (c)

the margins and surface treatment of the tooth structure and biomaterial, the matrix can be placed over the treatment area and the flowable composite resin (G-aenial Universal Flo, GC America) is injected through a small opening above the tooth and light cured. (Figure 12 a-e)

Sealing endodontic access openings

The primary goal for endodontically treated teeth is to achieve long-term apical periodontal health.[115] The advancements in endodontic materials and techniques have allowed the clinician to attain an optimal apical seal to prevent bacterial leakage.[116,117] However, when the coronal portion of the root canal system is not properly sealed it can become a potential source of bacterial invasion and failure of the endodontic treatment. [117-124] Thus, complete sealing of the endodontic access opening between appointments and after endodontic treatment is essential for achieving endodontic success.[125] One study indicates that a good coronal seal results in significantly less occurrence of periradicular inflammation.[115,126] An inadequate coronal seal can allow saliva to reach the apical region of the tooth in as little time as three days [115,119] and endotoxins from microorganisms such as Actinobacillus actinomycetemcomitans within 20 days. 127 There are various intermediate materials (i.e. Cavit G , zinc oxide-eugenol, and glass ionomers)[117,125,128] that are used to close the existing coronal restoration but may not provide an adequate seal and some may interfere with required future adhesive procedures. One material and method that can be utilized for sealing the endodontic access opening is a simple technique that involves self-etch adhesives and/or next generation flowables. This bioadhesive procedure can restore or provide a transitional seal until a new restoration can be placed. (Figure 13 a-d)

Repairing denture teeth

Denture teeth are fabricated from several different materials (i.e.,ceramic, acrylic, composite) and there are a infinite number of shapes and sizes. Generally, fractures to denture teeth occur as emergency situations and require replacement. Replacement can be achieved with relative ease in the laboratory with an adequate inventory of denture teeth. However, with the proper surface treatment these fractures can be repaired with next generation flowable composite resins at chairside. (Figure 14 a-c)

Eliminating cervical tooth sensitivity

There are numerous and varied etiological factors and predisposing influences to cervical dentin hypersensitivity. More than 90% of hypersensitive surfaces occur at the cervical region on the buccal and labial aspects of the involved teeth. In the ideal anatomical position, most teeth

Figure 15: Cervical dentin hypersensitivity can be effectively eliminated using an application of self-etch adhesive and a flowable composite resin.

have only the enamel exposed to the oral environment, and dentin that is protected by enamel or cementum is not sensitive. Cervical tooth sensitivity occurs when this enamel or cementum layer is removed and the underlying dentinal tubules are open and exposed to the oral environment.[129] Management of cervical dentin hypersensitivity begins with prevention and elimination of the predisposing factors associated with continued dentinal tubule exposure. One effective treatment strategy is to occlude the distal terminal ends of the exposed dentinal tubules. Adhesive resin impregnation is a clinical technique that has increased in popularity in recent years and is currently considered one of the most definitive and rapidly acting methods of desensitization. This procedure reduces sensitivity with the application of a dentin adhesive and flowable composite to form a hybrid layer, and this resin barrier prevents continued diffusion of toxins and bacterial invasion toward the pulp while producing minimal adverse pulpal inflammation. (Figure 15)

Conclusion

As we compare the old and the new in history only the evolution of time can provide the answers of knowledge, wisdom and truth. Knowledge of a concept of the past and a desire to create, are limited by the materials clinicians have available to them for restorative procedures. Advancements in composite resin technology continue to improve the practice of dentistry. Continuing technological breakthroughs allow the clinician to not only comprehend the "building blocks" of the ideal composite restoration, but also to implement and maximize the potential of new materials to attain more predictable and aesthetic results. While new ideas and concepts continually flood the marketplace, one should not discount the power a new product may have on plan, design or procedure. These developments promise to simplify the clinical applications for aesthetic and restorative techniques and ultimately improve the level of healthcare provided for the contemporary dental patient. Since only the passage of time can provide the answer to the success of a material, future clinical trials will be required to determine the long-term benefits of this new resin formulation. The clinical applications provided in this article demonstrate the potential of this nanoparticle composite formulation to create a new dimension in treatment possibilities for a wider range of clinical situations.

- Suggested Reading: For more Information see "Aesthetic & Restorative Dentistry: Materials Selection & Technique" 2nd edition by Douglas A. Terry, Willi Geller at www.quintpub.com

- To see a video presentation of this article, use your smartphone's QR Reader on the following icon

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