Achieving Aesthetic and Restorative Excellence Using an Advanced Biomaterial: Part I

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ABSTRACT

The following article of a 2 part series provides a review of composite resin technology and demonstrates the application of core clinical concepts in the restoration of the maxillary anterior segment taking aesthetic consideration of the anatomic variations of the adjacent teeth to produce direct composite resin restorations in harmony with the surrounding dentition.

Historical Perspective of Composite Resin Technology

Composite resin technology has continuously evolved from its inception as introduced to dentistry by Raphael Bowen as a reinforced "Bis-GMA" resin system. Since this time, numerous improvements have been made in the design of composite resin materials. A major breakthrough in composite technology surfaced with the development of photo-curable composite resins. These light initiated composite resins were more color-stable than the earlier self-cured composites and had smaller filler particles which improved wear resistance.[1,2] Later, microfill resins were introduced with a submicron average particle size which resulted in high polishability and wear. A continued metamorphosis brought reduced particle size and increased filler loading significantly improving light-cured composite resins for universal use in the anterior and posterior restorations.[2]

However, the search continues for an ideal restorative material which will be similar to tooth structure and its resistance to masticatory forces, have 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.[3] An ideal restorative material should fulfill the three basic requirements of function, aesthetics and biocompatibility. 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. At present, there is no restorative material which fulfills all these prerequisites. However, recent advancements in composite resin technology may provide some of these solutions.

This article demonstrates the restoration of the maxillary anterior segment taking aesthetic consideration of the anatomic variations of the adjacent teeth to produce direct composite resin restorations in harmony with the surrounding dentition. Although stratification techniques are still necessary, by understanding the dimensions of color, the properties of composite resins, and the morphology of the tooth, the clinician will attain more predictable and aesthetic results. Utilizing a recently developed nano hybrid composite resin system with improved mechanical, physical and optical properties, this article describes the clinical concepts and methodological approach for preparing, restoring and finishing the maxillary anterior dentition with composite resin. The learning objective of this article is to review the make-up of composites, to describe the mechanical and physical significance of these properties of composite resin and to understand how the knowledge has been utilized by the researcher, manufacturer, and clinician to develop a new formulation of composite resin. These practical clinical observations and research will assist the practitioner in attaining precise, predictable and pleasing aesthetic results.

Infrastructure of the Selected Composite Resin System

Understanding the rationale for the use of a specific composite resin system requires a discussion of the system's infrastructure. Three phases comprise the infrastructure of composite resins - the organic phase (matrix), the dispersed phase (filler) and the interfacial phase (coupling agent).[4] In composite material technology, the term composite is a multiphase

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material formed from a combination of these three phases which differ in composition or form, remain bonded together, and retain their identities and properties. Composites maintain an interface between components and act in concert to provide improved specific or synergistic characteristics not obtainable by any of the original components acting alone.[5] An optimal physical mixture requires blending the properties of each phase to acquire the advantages of their best properties. A detailed description of the attributes of each phase of the infrastructure for this specific composite resin system explains and predicts the overall properties and clinical performance of the system.

The Organic Phase (Matrix)

The organic or matrix phase is generally composed of a wide variety of mono- and difunctional acrylates with the larger chain molecules undergoing less polymerization shrinkage than the smaller chain monomers. The organic phase of this composite resin system differs from most commercial dental composite resins in that it consists of a mixture of base monomers which include urethane dimethacrylates (UDMA), dimethacrylate co-monomers, and a recently developed DX-511 monomer which provide a solidifying liquid for composite resin. Although 80 - 90% of commercial dental composites [6] consists of a high molecular weight monomer system referred to as "Bis-GMA" (an abbreviated term for bisphenol A-glycidyl methacrylate), it was the philosophy of research scientists, chemists, and the manufacturer to avoid the incorporation of a chemical (Bis phenol A) which has had implications of leaching estrogenic monomers into the environment. Other matrix components include an initiator (eg, camphoroquinone and amine for visible light activation), co-initiators, polymerization inhibitors (to extend working time and storage stability) and various pigments. [7-9]

The new Dupont molecule, DX-511, is a recent monomer family based on urethane dimethacrylate chemistry that is compatible with and complements the current composite and bonding systems. This monomer has a long rigid molecular core and flexible arms in the structure. The long rigid core prevents the monomer deformation and reduces polymerization shrinkage. On the other hand, if the molecular core is flexible, the monomer may fold and will occupy less space, causing a loss in dimension. The molecular weight of this monomer is 895 which is twice that of Bis-GMA or UDMA. A high molecular weight monomer reduces the polymerization shrinkage, since it contains only a small number of double bonded C=C, which is a factor of polymerization shrinkage. However, if the monomer chain becomes too long, reactivity decreases. To overcome this challenge, flexible arms were created on the new Dupont monomer, thus increasing the potential for reactivity. This new monomer technology provides low shrinkage and thus a reduction in shrinkage stress at the restorative-tooth interface. The possible clinical manifestations include the potential for minimizing marginal contraction gaps, microleakage, marginal staining, and caries recurrence, while also dissipating and reducing functional stresses across the restorative-tooth interface and improving the natural aesthetics and wear resistance.

The Dispersed Phase (Filler)

The mineral component of a composite which is a filler, is termed "the dispersed phase" and was pioneered at a time when the strength of plastics and elastomers noticeably improved with the addition of small particles or fillers. [10] Altering the filler component remains the most significant development in the evolution of composite resins.[10] The addition of fillers in dental composites provide dimensional stability, strength and reinforcement to the soft resin matrix. [11-16] Fillers of most commercial dental composites include ground quartz, alumina silicate, pyrolytic silica, lithium aluminum silicates, borosilicate glass and other types of glass, some of which contain oxides of heavy metals such as barium, strontium, zinc, aluminum or zirconium (for radiopaque characteristics). [17,18] Produced by milling or grinding, air abrasion, precipitation, ultrasonic interaction, erosion or through condensation, these fillers vary in particle size depending on the manufacturing process.[16,19] In general, mechanical and physical properties of composites improve in relationship to the amount of filler added. Alterations in the filler particle size, distribution, and quantity incorporated dramatically affects the mechanical properties and clinical success of composite resins. [20] 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.

There are five types of fillers in this composite resin system which include: pre-polymerized filler particles (i,e., strontium glass, lanthanoid fluoride), strontium glass, fluoro alumina silicate glass, and non-aggregated nano sized silica. The newly developed pre-polymerized fillers are called HDR (High Density Radiopaque) fillers and contain 60% by weight of 400 nm modified strontium glass and 20% by weight of 100nm lanthanoid fluoride. The nano sized modified strontium glass is dispensed in the HDR filler and reinforces the strength and surface hardness of the pre-polymerized HDR filler. Since the ability to polish increases as the filler particle size decreases, [16] the addition of nano sized lanthanoid fluoride filler particles enhances the polishability performance of the material. The strontium glass used is specially selected to match the refractive index of the UDMA resin matrix.

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Generally, the refractive index of commonly used barium glass is higher than the refractive index for UDMA resin and this discrepancy decreases the light transmittance characteristics of the resin and thus the translucency of the material. A silanated lanthanoid fluoride and strontium (with barium) glass were incorporated into the matrix, which provides radiopacity. The nano lanthanoid fluoride increases the radiopacity while not diminishing or altering the translucent properties of the composite resin since it does not block visible light. The improved handling characteristics of the material are a result of increasing the viscosity, which is made possible by increasing the filler content of the composite resin. [21] This is accomplished by using various size particle ranges with optimum filler concentration and by controlling the volume level of the new monomer. This increase in the percentage of inorganic filler loading by volume generally increases the fracture durability of the material. [16] In addition, the fracture resistance increases as the interparticle distance decreases because less distance reduces the load-bearing stress on the resin and inhibits crack formation and propagation. [16, 22] Also, the increase in viscosity provides the clinician with improved handling and manipulation prior to the photo-curing process. Not only does this characteristic save time, but it also facilitates post-cure contouring and surfacing of the restoration. Furthermore, it eliminates some of the subsurface crazing that commonly is a product of extensive surfacing with a finishing bur. This, in turn, generates a surface that is more wear resistant. In addition, one of the inherent challenges so characteristic of earlier generation composite resins was “stickiness” or ”tackiness” of the unpolymerized composite resin surface, which resulted in a tendency for the plastic placing instrument to pull the material from the preparation (particularly the cavosurface angles). While the amount may be only slight, it can lead to marginal staining and microleakage. Increasing the filler content of the composite resin has had a positive effect on this undesirable property.

The Interfacial Phase (Coupling Agent)

The third basic component of composite resins, the interfacial phase or the coupling agent, includes either a bipolar coupling that connects the resin matrix and the organic filler, or a copolymeric or homopolymeric bond between the organic matrix and the partially organic filler. [19,23] Since there is no chemical bond between the filler particles and the matrix of conventional composites, the coupling agents act as the adhesive and ionically bond to the inorganic filler while simultaneously bonding to the organic matrix, thus reducing the gradual loss of filler particles from the composite surface. [16] The most commonly used are vinyl, epoxy and methyl silanes.

The interfacial phase for this composite resin system involves a description of the interfaces between each of the filler components. The interface between the pre-polymerized filler and resin matrix involves three types of molecular interaction – covalent bonds, hydrogen bonds and hydrophobic interactions. The covalent bonds are derived from double carbon bonds(C=C) between the pre-polymerized fillers and the methacrylate matrix monomers which cross-link with each other and although the pre-polymerized fillers are mostly cured there are still residual double carbon groups remaining. The hydrogen bonds are derived from polar constituents such as – OH, – NH, and – C=O groups. The hydrophobic interactions involve molecular bonds between organic groups such as alkyl groups.

The interface between the nano silica and resin matrix involves a dimethyl-treated silica. This hydrophobic treatment improves the intimate contact between the silica and the matrix because both ingredients attract each other. Also, this type of dimethyl-treated silica is more stable than silica treated with methacryloxy-silane, which results in an improved shelf life with a reduced possibility of stiffening of the material during storage.

The interfacial bonding between the inorganic fillers (i.e., strontium glass, fluoro alumina silicate glass) and the resin matrix involves silane coupling. This proprietary chemical treatment of the filler surface improves the bond between the filler and matrix phase. The chemical bond allows for a stronger bond between the filler and resin thus increasing surface hardness, wear resistance and polishability.

Preoperative Considerations

The diagnostic work-up is the foundation of any successful restorative therapy.[24,25] Preoperative considerations during the diagnostic work-up are essential for the development of optimal functional and aesthetic restorations. Thus, during the initial diagnosis and treatment planning stages, consideration should be given to tooth type, location in the arch, size and type of carious lesion, treatment of decayed or non decayed unrestored teeth or restoration replacement and relationship between occlusal function and preparation boundaries. Other factors that should be considered are type of restorative technique (i.e., direct, semi/ direct or indirect), quantity and quality of remaining tooth structure, mechanical forces on remaining structures, presence of defects, and the parameters for extension of the preparation to the aesthetic zone.[26.27]

Prior to any restorative treatment, there are several preliminary considerations that can influence the final aesthetic and restorative result that include

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shade determination and restorative material selection.

Shade determination

Shade determination is a fundamental prerequisite to creating natural and aesthetic restorations when utilizing composite restorative systems. [24,28] Thus, particular attention should be given to matching the color of natural teeth with composite resin materials. The preoperative shade of the tooth to be restored, existing restorations and surrounding dentition should be determined before any restorative treatment is initiated. When teeth dehydrate, air replaces the water between the enamel rods, changing the refractive index that makes the enamel appear opaque and white. [24,29,30] This de-hydration of the tooth from prolonged drying can result in improper shade matching. [24,31] Also, the proper light source is an essential consideration in shade selection. To obtain an acceptable shade determination, it is advisable for the viewer (i.e. technician, clinician, and assistant) to observe the color matching under three different lighting conditions- daylight, color-corrected light and dim light. [24,32-34] Various shade modification lights may be useful in detecting small variations in hue and intensity of color such as the Full Spectrum Hand Held (Great Lakes Lighting), the Shade Wand (Authentic Products), Demetron Shade Light (Kerr/Sybron), Rite-lite Shade Matching Light (AdDent Inc) and the Lumin Shade Light (Vident). [24,35]

A photographic shade comparison of the natural tooth color with corresponding shade tabs provides a wealth of information to the clinician for the selection of the ideal restorative material. Detailed shade information and anatomical morphological characteristics can be acquired from a high-magnification view. The color close up photograph can provide minute shade details particularly on the incisal edge where "maverick" color nuances exist. These images can be modified into black and white images to distinguish surface texture, while also distinguishing differences in value of natural teeth and existing tooth colored restorations (i.e., ceramic, composite) A shade communication diagram can be developed from this photographic information. This diagram can consist of a simple sketch of the translucency patterns, color transitions, crazing, hypocalcification spots, occlusal stain patterns, and gingival to incisal blending. A more complex diagram can detail the opaque, dentin liner, dentin, intercolor contrasts, developmental grooves, shape of embrasures, as well as surface contours and textures such as prominences, convexities, facets, angles, and plane areas. [24]

Restorative material selection

Restorative material selection is a preoperative consideration which should be performed in the diagnosis and treatment planning phase prior to restorative treatment. When utilizing composite restorations, the following clinical assessments should be considered:

- Anticipated dimensions and geometry of the preparation design and location of the margins, [36,37]
- Tooth position in the arch, [36,38]
- Location of proximal and occlusal contact sites,
- Interrelationships with adjacent teeth and periodontal tissues, [39]
- Size and the number of restorations, [26]
- Structural defects (i.e., incomplete fractures, erosion lesions, abrasion lesions), [36,40]
- Intra-arch and inter-arch protective functions,
- Tooth anatomy and resistance,
- Occlusion,
- Aesthetics
- Patients' oral habits (i.e., nail biting),
- Occlusal parafunctions (i.e., bruxism and clenching),
- Ability to isolate the operative field. [26,36]

Consideration of particle size, distribution and quantity incorporated represent crucial information in the determination of how to best use composite materials. The specific classification of restoration required will determine the type of composite chosen for placement. Anterior restorations require materials that provide sculptability, fracture resistance, color stability, stiffness, fatigue-strength, hardness, radiopacity, while conferring polishablity and the capacity to retain a surface smoothness over time. Most of the current small particle composite resins possess all of these characteristics. A unique low-shrinkage hybrid composite resin (Kalore, GC America) that provides increased filler loading, 1.72 % volumetric shrinkage (one of the lowest currently available data on file, GCC Tokyo), radiopacity, an optimal blending effect and an ease of placement without slumping, was selected.

Anterior Composite Resin Preparation Design Concepts

The preparation design for anterior teeth (i.e., Class III, IV, V, veneer) generally involves the incisal edge, cervical region and/or the interproximal zone. The preparation usually requires minimal tooth preparation and the margins of the preparation are generally confined to the enamel and, if completely mineralized and well supported by dentin, significantly contribute to the retention and strength of the composite restoration. A conservative intraenamel preparation should preserve as much of the natural enamel as possible. To increase the enamel-adhesive surface a chamfer 0.3 mm deep and approximately 2 mm in length should be placed around the entire margin that is in enamel to increase the enamel-adhesive interface. The chamfer preparation defines

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the finish line and it allows a greater bulk of material to be placed at the restorative margin that increases fracture resistance [41] and reduces the stress at the restorative interface.[42] The lingual component of the chamfer should be placed coronal or apical to the contact area[43] and when enamel is present, a 0.5 mm bevel should be placed, but only on the enamel margin. Beveling increases the bonding surface area, and decreases microleakage by exposing the ends of the enamel rods for etching, and improves blending of the resin with tooth structure.[44] It is recommended that a scalloped shape bevel be placed to minimize the transition zone between the enamel and the restoration. Bevels should not be placed on lingual surface margins that are in areas of centric contact or subjected to heavy occlusal forces, as composite has a lower wear resistance than enamel does for withstanding such forces. [45]

In addition to these specific preparation design principles, a number of general guidelines [24] for anterior preparations should be considered:

- The cavity outline is extended only to include carious enamel, provide access to the carious dentin, remove any residual staining, and provide access for the application of restorative materials.
- Healthy tooth structure should be removed only when the preparation outline requires extension to a point beyond or within the previously indicated functional stops. [46]
- To allow for a better resin adaptation, all internal line angles should be rounded [47] and cavity walls smoothed.

These new principles of design and general guidelines for adhesive restorations replace the traditional mechanistic approach to restoration of teeth, while initiating applications of biomechanical concepts.

Anatomical Morphological Design Concepts

Since composite does not have hydroxyapatite crystals, enamel rods, and dentinal tubules, the final composite restoration requires the clinician to develop an illusion of the way light is reflected, refracted, transmitted, and absorbed, by these microstructures of the dentin and enamel when restoring the tooth surface.[29] Recreating the restored surface requires a similar orientation of enamel and dentin and the restorative composites should be selected according to the anatomic structure they will replace. New generation nano hybrid composite resins possess most of the optical properties which render the tooth polychromatic. Dentin shades are available in a variety of shades and translucencies and enamel shades have been developed which are highly translucent, fluorescent and opalescent. Color modifier and opaquing resins are also available which make possible an infinite number of color combinations.

Layering concepts have evolved using the optical properties of the tooth as a reference for composite evaluation. [48] The layering concept attempts to reproduce the color and aesthetics of the tooth using the optical properties of dentin and enamel shades in varying combinations along with color modifiers and opaquers. The polychromatic effect can be observed when different restorative composites of varying refractive indexes, shades, and opacities are stratified. [49] By utilizing an anatomic stratification with successive layers of dentin, enamel, and incisal composite, a more realistic depth of color can be achieved as well as surface and optical characteristics that mimic nature. [49,50] However, the successful determination and transfer of color to an aesthetic restoration still depends on the clinician's understanding and interpretation of color and its relationship to the anatomical morphology of the tooth.

The continuous network of the dentin and enamel forms a complex internal morphology. Each has different microstructural characteristics and these differences influence the natural optical properties of the tooth [49,51] by altering the way light is reflected, refracted, transmitted, and absorbed.

The dentin is a living tissue and constitutes the largest portion of tooth structure. The dentin has been referred to as a "composite" of hydroxyapatite, collagen, and water. [52] Most of the color of the tooth occurs in dentin. The dentin layer contains varying distributions of yellow, orange, and red, and remains thickest at the gingival and middle thirds of the anterior teeth. The anatomic crown of a tooth is comprised of an acellular calcified material known as enamel, which is the hardest tissue in the body. [53] Human adult enamel is an inert, high-energy crystalline structure with high intermolecular forces and has been called a composite bioceramic. [54] The inorganic composition of mature enamel consists of hydroxyapatite crystals. The enamel prisms are filled with millions of small, elongated, tightly packed carbonated apatite crystallites that vary in size and shape.[21,55] This highly mineralized composition provides its capacity to transmit and/or reflect light. [51,56,57] The more the enamel reflects light the clearer and more opaque it is perceived. Thus, the enamel is the principal determinant of the value or brightness of the tooth or restoration. The thickness of the enamel varies according to the shape of the tooth and the location on the crown. The thickest area of enamel is normally located at the crest of the cusp or incisal edges, whereas the thinner regions are usually over the slope, at the cervix or within the fissures and pits of multi-cuspid teeth. [53]

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The aesthetic quality of a composite restoration is associated with its ability to simulate the natural visual characteristics of the aforementioned microstructure of dentin and enamel. The hue or color of the restoration is principally determined by the artificial dentin component. Natural dentin has a higher opacity and chroma than enamel. When selecting composite dentin shades, it is important to also consider opacity. Opacious dentin shades, in addition to strength, provide the chroma necessary to disguise discolorations and to block light transmission in the interproximal zone and incisal region of the restored tooth. It is often necessary to extend this layer to the DEJ in order to "hold" the shade. Otherwise the final restoration will appear darker – lower in value. Enamel composite shades contribute significantly to the total aesthetics of a restoration. Tooth enamel is virtually colorless, but possesses much of the optical properties which contribute to the vitality of the tooth – translucency, fluorescence, opalescence and gloss. These characteristics are exemplified on cuspal tips and marginal ridges of posterior teeth and incisal edges and proximal incisal surfaces of anterior teeth. The enamel layer - which has a white or gray appearance- remains thickest at the incisal edge of anterior teeth and thinnest at the cervical region. Contemporary composite enamel shades have high translucency, are fluorescent and opalescent and maintain a high gloss clinically. The clinician must understand that artificial enamel shades tend to alter the value of the shade of a restoration. Enamel shades can be used on incisal edges and cuspal surface, but the color of the restoration depends ultimately on dentin shades. The artificial enamel layer follows the contours of the established dentin layers, and should vary according to the desired effect. This allows color variation to be achieved by altering the thickness of the composite layers used to replace the dentin and enamel. For example, when the thickness of the dentin layer is decreased and that of the enamel layer is increased the composite restoration will become lighter in color.

Because of the variety of colors and their orientation within natural teeth, selecting appropriate shades of composites remains difficult. Because of the color variation found in natural teeth it has been typically difficult to achieve an exact color match between direct restorative restorations and tooth structure without complex stratification procedures. A phenomenon that exists for some dental composites and ceramics that can influence color matching is the "double-layer effect" also known as the "chameleon effect," or "blending effect."[58-60] 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 and when emitted from the restoration the shade is altered by absorbing color from the 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. [61] There are several factors that determine and/or interact with the scattering and absorption coefficients of the dental tissues and restorative materials which include filler particle size and distribution, surface roughness, gloss, restoration size, optical properties of the surrounding tissues, translucency and shade. [60, 62-66]

Since most composite resin's standard shade guides are manufactured from unfilled methacrylates, they do not accurately represent the true shade, translucency, or opacity of the final polymerized restorative material. [67] In addition, many of the composite resins are synchronized to the Vita Lumin shade guide, which was designed for porcelain, not resins. Considering the need for further refinement in almost all shade guides, the clinician and the ceramist may benefit from the fabrication of custom shade tabs.

Fundamental Concepts for Finishing and Polishing Composite Resin

Successful finishing and polishing of any composite restoration is determined by the type of restorative material used, the shape of the finishing device and is defined by surface morphology of the tooth and restoration. [68] Since the geometry and shape of the natural teeth and these devices essentially remain the same, the only variable is the continual changes in the formulation of the restorative material.

Thus, the surface quality of the composite is not only influenced by the polishing instruments and polishing pastes but also by the composition and the filler characteristics of the composite. [69,70] Newer formulations of small particle hybrids and microhybrids have altered filler components with finer filler size, shape, and orientation and concentration, improving their physical and mechanical characteristics, and allowing the resin composite to be polished to a higher degree. [71] The variation in hardness between the inorganic filler and the matrix can result in surface roughness since these two components do not abrade uniformly.[71,72] Accordingly, it is imperative that the surface gloss between the restorative material and tooth interface are similar because the gloss can influence color perception and shade matching of the restoration and tooth surface.[71, 73]

Restorative materials of the past (i.e., amalgam, gold) required finishing and polishing procedures to refine anatomical morphology, contours, marginal integrity, and occlusion, while enhancing the surface smoothness of the restoration. The objectives of

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finishing and polishing techniques of tooth-colored adhesive restorations are the same today, except the development of adhesive materials has introduced a new element to the restorative equation: aesthetics. The appearance and vitality of composite can be influenced by finishing and polishing procedures. An optimally finished composite restoration should provide a smooth surface that will prevent plaque accumulation and resist stain.[74] It should also possess ideal contours and emergence profile for improved tissue compatibility.[74] Additional benefits of a proper finish are anatomical form for occlusal harmony, shade coordination to surrounding dentition, symmetrical surface texture to adjacent or opposing natural teeth, improved marginal adaptation and integrity, longevity and aesthetics.[74] Aside from the actual finishing and polishing, the final challenge for the operator is long term restorative maintenance of the surface polish. An understanding by the patient and clinician of the importance of periodic and routine maintenance of composite restorations and of utilizing proper finishing devices, polishing techniques and protective surface glazes at the maintenance visit may provide the benefit of increased longevity of the restoration.[24,69,75,76]

Finishing focuses on contouring, adjusting, shaping, and smoothing the restoration, while polishing concentrates on producing a smooth surface luster and highly light-reflective surface.[77] As Pratten and Johnson have indicated, there is no statistical difference between finishing and polishing anterior and posterior restorative materials. The consideration factors for finishing and polishing any restoration depend on the instrument shape, the surface shape and texture of the tooth and restoration, the surfaces of the finishing and polishing instruments, and the sequence and amount of time allotted for the restorative treatment.[78]

While several acceptable finishing and polishing protocols exist, the authors provide the following clinical suggestions:

- Minimize finishing procedures through careful preoperative occlusal registration and careful composite shaping prior to curing. At least one study revealed that a reduction in finishing results in less damage to the composite and improved wear and clinical performance.[79]
- Select finishing and polishing devices that have shapes that correspond to anatomical contours of the restored tooth.[80]
- Finishing diamonds may demonstrate resin matrix crazing and significant filler particle loss for hybrids, affecting the wear resistance of posterior hybrid composite resin restorations.[69]
- High- speed finishing with mutilated carbide burs for a hybrid composite resin produces a smooth, flat surface, no disrupted surface free from striations and grooves left by diamond burs.
- Wet finishing with diamonds is more appropriate for microfilled composites and carbide finishing burs are contraindicated for microfills.[69]
- The use of surface sealant has been shown to reduce the wear rate of posterior composite resins [81] improved resistance to interfacial staining [82] and decreases microleakage around composite resin restorations.[82-84]
- Place composite surface sealant and cure prior to polishing with silicone points because silicone surface contamination may prevent adhesion of sealant.

Clinical Concepts Demonstrated

The following clinical procedure illustrates the aforementioned clinical concepts using a methodological approach for preparing, restoring and finishing the maxillary anterior dentition with a recently developed nano hybrid composite resin system. (Figures 1 a,b -13 a,b)



Fig 1 a,b: A 37 year old patient presented with a diastema and existing composite resin restorations on the maxillary centrals during orthodontic treatment. The orthodontist had proceeded with a unidisciplinary treatment and referred the patient for occlusal and aesthetic evaluation after the patient indicated her concerns. The aesthetic parameters were evaluated by having the orthodontic brackets removed. Patient indicated during diagnosis and treatment planning that she wanted a conservative aesthetic enhancement. The new interdisciplinary treatment plan indicated modification of the spatial contours with direct composite bonding while the occlusal parameters would be treated using orthodontics to provide anterior guidance and posterior disclusion.

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Fig2: Custom-fabricated shade tabs were developed from the nano hybrid composite (Kalore, GC America) and compared to the existing teeth.

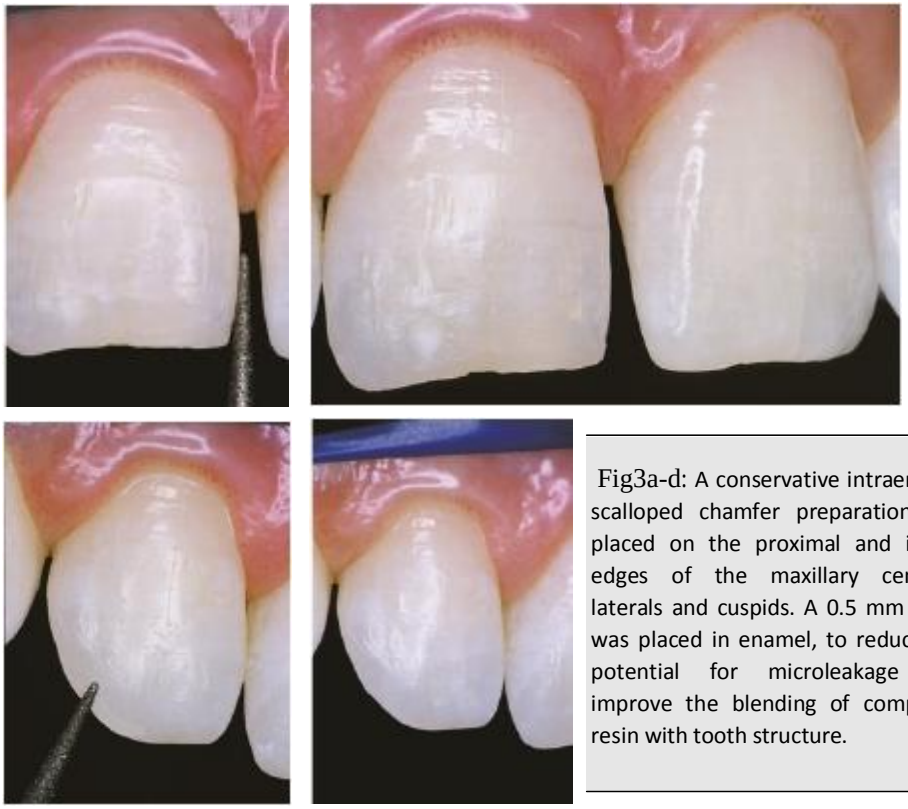


Fig3a-d: A conservative intraenamel scalloped chamfer preparation was placed on the proximal and incisal edges of the maxillary centrals, laterals and cuspids. A 0.5 mm bevel was placed in enamel, to reduce the potential for microleakage and improve the blending of composite resin with tooth structure.

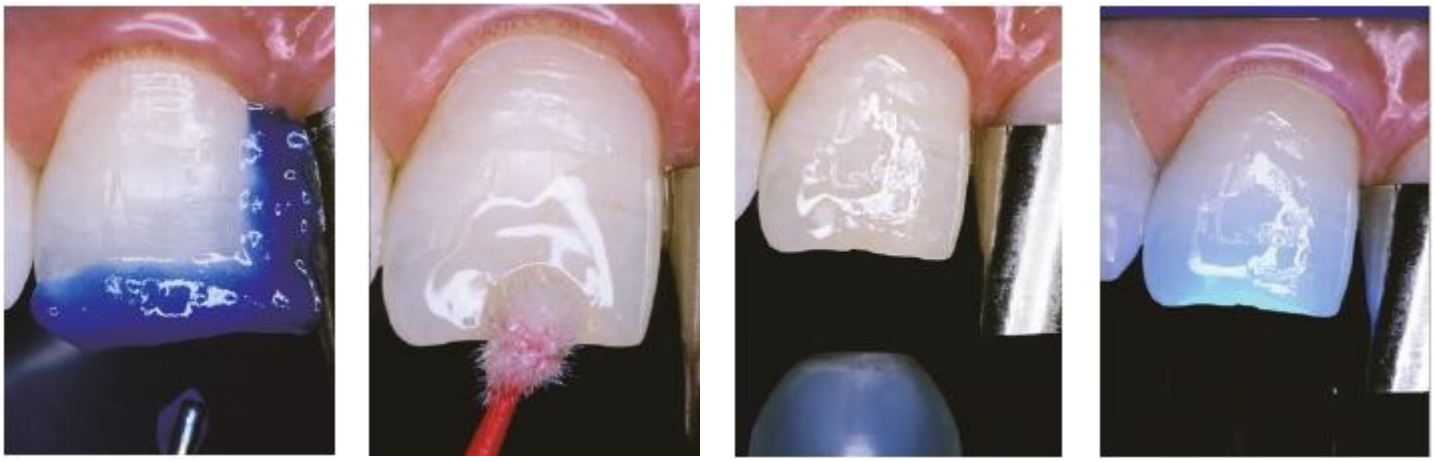


Fig4 a-d: The preparation was acid etched using a 35% orthophosphoric acid (Gluma Etch 35 Gel, Heraeus Kulzer) for 15 seconds, rinsed, and lightly air dried (a).A single- component adhesive was applied with an applicator tip (b). The adhesive was air-thinned and light cured for 20 seconds (c,d).

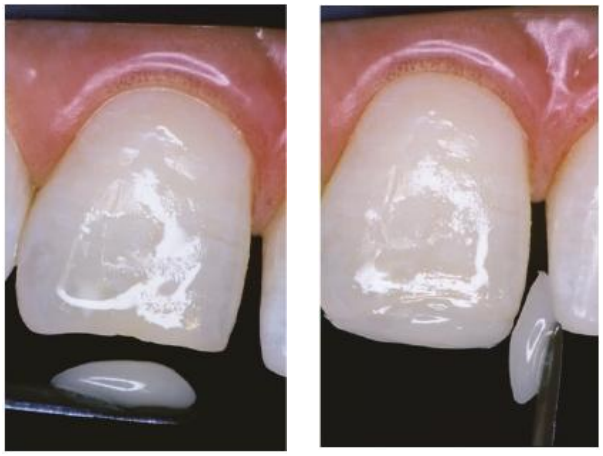


Fig5a,b: An elongated increment of opacious shaded hybrid composite resin (Kalore, GC America) was applied to the incisal and mesioproximal aspect of the maxillary right central, sculpted, smoothed and light cured. It is important to monitor the proximal and facial parameters from the incisal aspect to allow adequate space for the artificial enamel layer. A thin layer of translucent shaded incisal hybrid composite (Kalore, GC America) was placed and smoothed over the opacious core.

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Fig 6: The initial finishing was accomplished with a 30-fluted carbide finishing bur (ET-9, Brasseler USA) .





Fig 7a,b: The incisal edge of the composite was contoured with finishing and polishing discs.(a) The proximal surface and contour were smoothed with finishing strips used sequentially according to grit and range from fine to extra-fine (Finishing and Polishing Strips, KerrHawe) (b).



Fig 8: Glycerin was applied to the proximal surface of the maxillary right central with un-waxed floss as a separating medium (Proximal Adaptation Technique). It is important to use a very small amount of glycerin and not allow contamination of the adjacent surface. Magnification is recommended.







Fig 9 a-c: After the tooth was adhesively conditioned, a thin opacious shaded hybrid composite resin (Kalore, GC America) was applied to the incisal and mesioproximal aspect of the maxillary left central, sculpted, smoothed and light cured.A thin layer of translucent shaded hybrid composite (Kalore, GC America) was placed and smoothed over the opacious core with a #2 sable brush.

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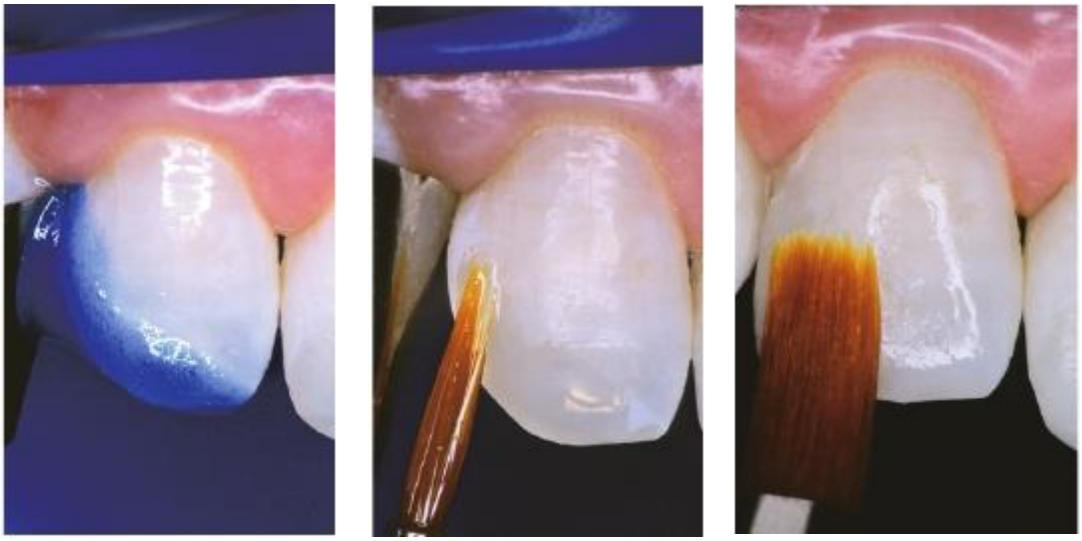


Fig 10 a-c: The preparation on the maxillary right lateral was etched for 30 seconds with a 35% orthophosphoric acid (Gluma Etch 35 Gel, Heraeus Kulzer) extending the etchant several millimeters beyond the margin.(a) A single-component adhesive was applied with a #00 sable brush, air-thinned and light cured for 20 seconds.(b) After the opacious dentin core was developed and light cured, a thin layer of translucent shaded hybrid composite (Kalore, GC America) was placed, contoured and smoothed with a #2 sable brush.(c)

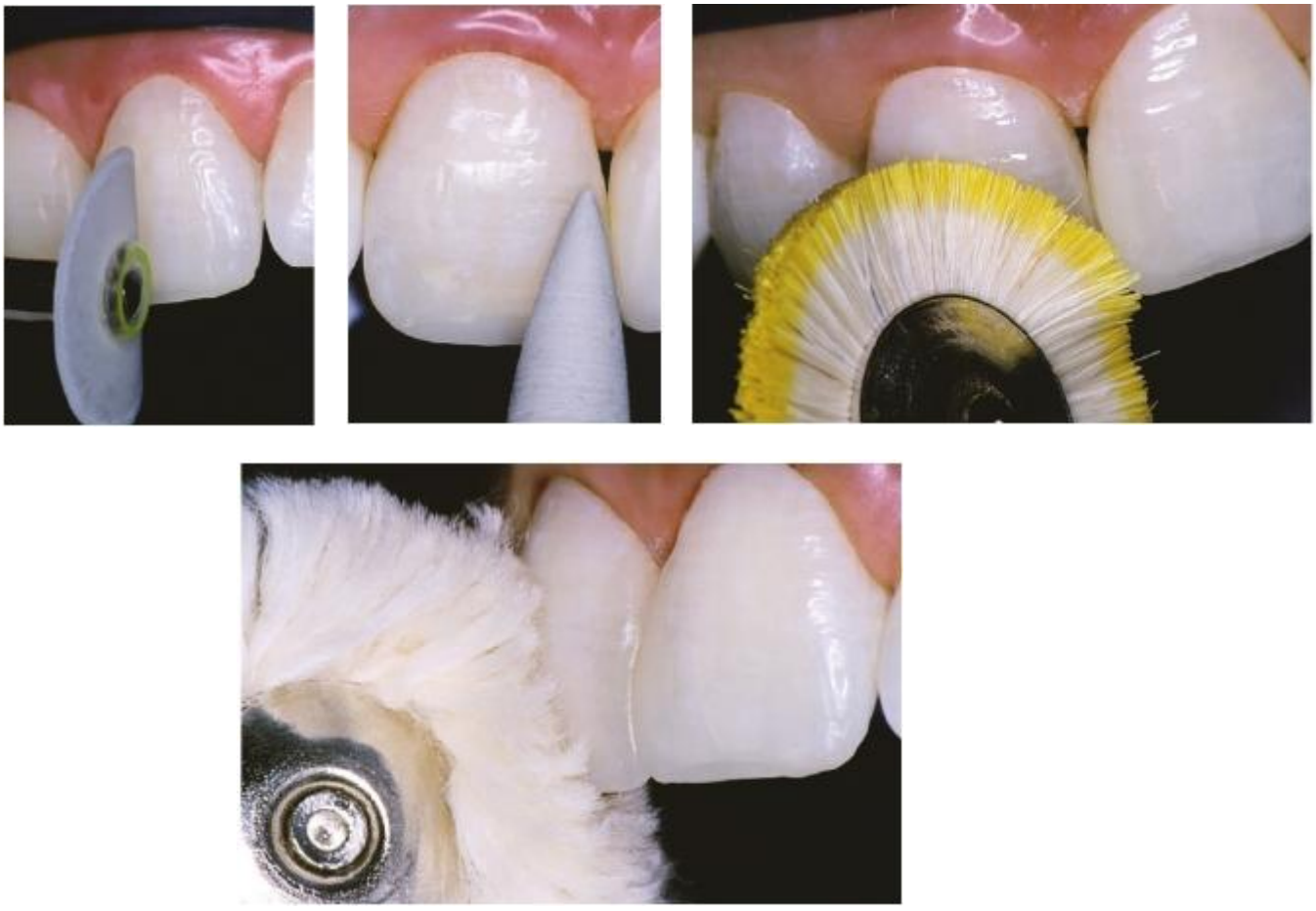


Fig 11 a-d: The proximal, facial, and incisal angles were finished with aluminum oxide finishing discs.(a) Pre-polish and high shine silicone points (Diacomp, Brasseler USA) were used to increase the smoothness of the composite restoration. (b) The definitive luster and surface reflectivity was accomplished with a goat-hair brush and diamond polishing paste (Gradia DiaPolisher, GC America, Alsip, IL). (c) A final polishing surface gloss was achieved with a dry cotton buff using an intermittent staccato motion applied at conventional speed. (d)

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Fig 12. The completed restorations reveal the significance of applying form, color, and a minimal invasive procedure with an advanced biomaterial to achieve a harmonious integration of composite resin with existing tooth structure.





Fig 13a,b: A natural aesthetic result for the personality of the patient can be predictably achieved when aesthetic and restorative principles coincide with an interdisciplinary team approach.

Conclusion

The ultimate goal of continuous material research and development is to enhance the practice of dentistry. While the long-term benefits of this next generation formula remains to be determined in future clinical trials, this article has demonstrated that when proper clinical concepts and techniques are combined with the physical, mechanical, and optical properties of an innovative biomaterial, the restorative result can provide preservation and conservation of tooth structure, tooth reinforcement, and aesthetics. Although the recent world news commentaries may fail to report the technologic advancements that led to the development of this advanced biomaterial, another milestone in the practice of dentistry has occurred on the end-less quest for the ideal restorative material. Part II of this article will address the consideration factors for achieving clinical success with posterior composite resin restorations.

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Suggested Reading: For more information see "Aesthetic & Restorative Dentistry: Material Selection & Technique" at www.everestpublishingmedia.net, www.quintpub.com and www.amazon.com .

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