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The Evolution of Direct Composites

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During the past 60 years, the use of composite resin for direct restorations in anterior and posterior teeth has increased significantly,¹ largely due to the esthetic demands of patients and concerns regarding mercury in amalgam fillings. Because composite resins require little to no preparation, minimally invasive procedures can be used to preserve tooth structure and provide natural-looking results.² Composite resin also may eventually replace silver amalgam for direct restorations.³

EARLY HISTORY

In the mid 20th century, acrylic resins replaced silicate cements as the only esthetic material.⁴ Although acrylics offered benefits over silicates, bonding was difficult.⁴ Buonocore, the first to introduce an orthophosphoric-acid technique, improved but did not completely solve the adhesion problems.⁴ The Bis-GMA monomer developed by Bowen in 1962 was a final attempt to improve the physical properties of acrylics.⁴ However, because this latest iteration of acrylic required mixing the base paste with a catalyst in-office, proportion, mixing process, and color errors were still common.⁴

In the 1970s, the first acrylic resin replacement was introduced: composites.⁴ At this time, polymerization through electromagnetic radiation appeared to solve historical mixing problems.⁴ However, particles were too large, only four shades

were available, and resins were difficult to polish.⁴ In addition, acid-etch techniques often damaged tooth structure, leading to aggressive endodontic therapy.⁴ Newer composite filling materials provided esthetic results; however, incremental layering and the effects of shrinkage were not well understood.⁴

The first microfill composites were developed in the 1980s with the understanding that adhesion began inside the tooth.² Although these composites demonstrated high polishability and enamel-like translucency, chipping and bulk fracture prevented their use in high-stress-bearing areas.²

EVOLUTION OF COMPOSITES

Dental composites typically are composed of three chemical materials: an organic matrix, an inorganic matrix, and a coupling agent. Because composite resins require a bonding procedure for durability and reliability, they must be biocompatible and bond well to both enamel and dentin.⁵ Direct restorative materials also are required to resist masticatory forces and demonstrate mechanical properties similar to those of natural teeth.⁵ Composite resins must also be easy to use if they are to replace silver amalgam for direct fillings.⁵

In the 1990s, microleakage, which can ultimately lead to secondary caries and sensitivity, still caused concern.² Between 24 and 32 shades of composites were

available, and composite layering remained a technique embraced mostly by more elite clinicians.² However, dentists did begin to architecturally build teeth and the chemistry of composites did improve with the development of microhybrids.² With a heterogeneous aggregate of fillers, the physical characteristics and polishability of composites also improved.² Unfortunately, however, microhybrids did not retain their final gloss.²

Today's composite resins produce highly esthetic, long-lasting restorations for many indications.² Through an understanding of advanced layering techniques, microleakage and fracture rate concerns have decreased significantly.³ Fewer shades of composites with better chameleon effects improve esthetic outcomes, while enhanced filler particles promote excellent polishing, finishing, and longevity.³ To build dentin and enamel characteristics, material and particle refraction indices and integrated value scales enable proper shade selection.³

Increasingly used for anterior and posterior restorations, composite resins have evolved considerably.⁶ Modern composite resins demonstrate greater durability, better handling characteristics, less shrinkage, improved polishing, enhanced bond strengths, and highly esthetic outcomes.^{6,7} However, composite placement remains technique-sensitive and post-polymerization shrinkage can still be an issue.^{6,7}

COMPOSITE TYPES

Recent modifications to composite resins have improved their physical and mechanical properties.¹ With a variety of shades, translucencies, effects, opacities, and innovative placement techniques, today's composites allow simple reproduction of the polychromatic and optical properties of natural dentition.²

Microfilled Composites

Filled with 35% to 50% pre-polymerized 0.02- μm to 0.04- μm silicone dioxide particles, microfilled composites demonstrate high polishability and enamel-like translucency.² Indicated for restoring anterior teeth and cervical abfractions, microfilled composites should not be used in heavy-stress-bearing restorations because they are prone to bulk fracture and marginal chipping.² Microfills demonstrate high compressive strength. However, their higher thermal expansion coefficients, greater water sorption, and polymerization shrinkage, along with lower modules of elasticity, tensile strength, and fracture toughness, make them less than ideal.²

Hybrid Composites

Containing a heterogeneous aggregate of filler particles, hybrid composite resins are typically filled with 70% to 80% 0.04- μm and 1- μm to 5- μm particles.² Although they demonstrate good handling characteristics and initial high polishability, they cannot maintain gloss.² Therefore, manufacturers developed microhybrids with reduced particle sizes of 0.04- μm to 1- μm , making handling and polishing simpler.² The strength of hybrids allows their use in posterior and anterior regions as a universal composite.² Most hybrids are medium viscosity, but low- and high-viscosity materials provide versatility for restorative procedures.²

Nanofilled Composites

Consisting of nanomers (5-nm to 75-nm particles) and nanocluster agglomerate fillers (0.6 μm to 1.4 μm), nanofilled composites are composed of zirconia/silica nanoparticles from 5 nm to 20 nm in size.^{2,4} Fused together at contacts, the porous structure is filled with silane and demonstrates mechanical and physical properties similar to those of hybrid composites.^{2,4} Polishability and gloss retention are un-

surpassed, giving restorations better finish and esthetics.^{2,4} Distribution of particles provides restorations high load potential (79.5%), allowing the material to be used for posterior and anterior indications.⁴ To address the nano-sized particles' inability to reflect, larger filler particles typically were added to improve optical characteristics.⁴

Low-Shrinkage Composites

Because shrinkage stress and the resulting leakage and sensitivity that can develop remain major concerns, manufacturers have developed dental composites that demonstrate lower polymerization shrinkage.⁸ Products incorporating spiro-ortho-carbonate, epoxy-polyol, and siloxane-oxirane monomers are being tested, and some are available.⁴ Most composite manufacturers, however, still concentrate on building their current traditional systems, addressing polymerization shrinkage by adding a Bis-GMA/TEGDMA or Bis-GMA/UEDMA/TEGDMA monomer combination to the organic matrix.⁴

CONCLUSION

Composite resins have evolved to represent artistic alternatives for the direct restorations of anterior and posterior teeth.⁴ Through improvements in formulations, optimization of physical and optical properties, and the development of new placement techniques, today's direct composite resins enable reliable and predictable realization of esthetic outcomes.³ Simultaneously, their proven adhesive capabilities contribute to minimally invasive and tooth-conserving treatment plans.⁴

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