Polymer-Based Direct Filling Materials

Carmem S. Pfeifer, DDS, PhD

KEYWORDS

• Dental composites • Polymerization • Clinical longevity • Caries

KEY POINTS

- Review of the literature on conventional materials and current drawbacks, including wear and polymerization stress.
- Summary of claims and properties of newer materials, and their relationship (or lack thereof) with the increase in clinical longevity in dental composite restorations.
- Evidence from the last 10 years on novel materials and techniques, such as bulk fill and self-adhesive composites.
- Analysis of clinical trials available using most current materials and techniques.
- Brief outlook to the future and latest research on materials intended to better withstand the environmental and bacterial challenges in the oral cavity.

INTRODUCTION

Since their introduction to the market more than 60 years ago, modern resin composite restorative materials have undergone substantial development and improvement. Even larger posterior restorations now show good clinical performance when built with current materials.[1–3] More and more, amalgams are falling out of favor for such applications for a number of different reasons, but are composite materials truly a complete substitute? Most of the developments throughout the history of composites have concentrated on the inorganic filler portion, and the advent of microhybrid and nanohybrid formulations has made it possible to obtain highly esthetic and wear-resistant restorations recommended for use as universal restoratives.

More recently, especially in the last 15 years or so, the technological advances have focused on the organic matrix, with a heavy emphasis on producing low shrinkage and low stress materials. The rationale is that polymerization shrinkage and the consequent stress that develops at the tooth–restoration interface produces gaps that, in turn, make the restoration more prone to recurrent decay.[4] This premise has been challenged in the past few years, especially because materials that have been shown

Division of Biomaterials and Biomechanics, Department of Restorative Dentistry, Oregon Health & Science University, 2730 Southwest Moody Avenue, Room 6N036, Portland, OR 97201, USA
E-mail address: pfeiferc@ohsu.edu

Dent Clin N Am 61 (2017) 733–750
http://dx.doi.org/10.1016/j.cden.2017.06.002
dental.theclinics.com

to present low shrinkage and stress in in vitro testing were not able to outperform so-called conventional materials in clinical trials.[5,6] More recent advances include bulk fill composites and materials claiming to be self-adhesive to the tooth, with the main goal of simplifying the technique-sensitive restorative procedure to avoid inherent operative errors. As it stands, composite restorations present an average lifespan of about 10 years or less, with the main reasons for failure being secondary caries and fracture.[7–11] Therefore, even with the tremendous advances made in the recent past, there remains room for improvement.

This article examines the scientific evidence available in the last 10 years to provide insight into novel techniques and materials available to the clinician. From the more than 3000 papers published on dental composites and related techniques in that period, this review focuses on novel materials or restorative protocols developed, and on how those have influenced clinical practice. The term "conventional composite" in this article refers to composite materials with regular consistency (not flowable or packable) and whose placement protocol recommends increments no thicker than 2 mm, preceded by the application of an adhesive system.

THE EVOLUTION OF FILLER SYSTEMS

Current commercially available composite materials can be classified according to their filler type (**Table 1**). Excellent, in-depth reviews focusing specifically on the filler technology can be found in the literature,[12–14] and a summary is provided here. Microfill composites contain colloidal silica particles with average size of 50 nm. To enhance filler loading levels, monomers are highly filled with colloidal silica and polymerized by heat. These prepolymerized composites are then ground to a relatively fine powder on order of 50 μm in size, and then redispersed in the final composite for a total filler content (including prepolymers) of about 70 wt%, according to the manufacturers (available from: http://www.ivoclarvivadent.com/en/products/restorative-materials/composites/heliomolar). These materials present excellent polishability,[15] but do not perform well in more mechanically challenging situations, so their main indication is for highly esthetic areas, and relatively small class III and class V restorations.[16] To try to overcome these challenges and expand the indications of esthetic direct restorations, the materials evolved into hybrids and midifills having glass fillers with variable sizes in combination with the 50-nm colloidal silica. This aimed to improve filler loading and, therefore, mechanical properties, while maintaining reasonable esthetic characteristics.[17] In fact, generally, midifills and hybrids have ranked among the materials with the greatest fracture toughness, flexural strength, and elastic modulus,[18] which makes them very good choices for midsize to larger posterior restorations.[19] However, loss of surface gloss and wear of the restorations remain a clinical concern, even within a relatively short time after restoration placement,[20–22] and especially in larger posterior preparations. Wear and esthetics were the main driving forces for the development of even smaller sized filler technologies, in an attempt to combine smooth, esthetic surfaces with longer lasting restorations, capable of withstanding occlusal challenges.

Microhybrid composites were then developed. Together with nanohybrid materials, they comprise the most abundant categories of composite currently on the market. These materials have also been extensively characterized in the literature, both in in vitro and in clinical studies.[23–28] They are considered to be universal composites, recommended for use in anterior and posterior restorations. In vitro studies comparing the mechanical properties of microhybrid and nanohybrid composites with those of