Bond Strength, Microleakage and Induced Strain of Two Self-Adhesive Flowable Composites

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Dedication

I would like to dedicate this work to my wonderful parents, to whom I owe everything and the true reason behind my success.

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List of Abbreviations

Bis-GMA: Bisphenol A glycidyl methacrylate.

UDMA: Urethane dimethacrylate.

TEGDMA: Triethylene glycol dimethacrylate.

GPDM: Glycerol phosphate dimethacrylate.

4-MET: 4-methacryloxy-ethyl trimellitate.

4-META: 4-methacryloxy-ethyl trimellitate anhydrite.

NPG-GMA: N-phenylglycine glycidyl methacrylate.

MMA-TBB: Methylmethacrylate tri-n-butyl borane.

HEMA: Hydroxyethylmethacrylate.

MDP: Methacryloyloxydecyl dihydrogen phosphate.

PAA: Polyalkenoic acid.

SEM: Scanning electron microscope.

TEM: Transmission electron microscope.

XPS: X-ray photon electron microscopy.

SBS: Shear bond strength.

TBS: Tensile bond strength.

MPa: Megapascal

Introduction

Resin composites are used in variety of applications in dentistry, including its use as a restorative filling material, cavity liners, pit and fissure sealants, core build-up material, inlays, onlays, crowns, provisional restorations, cements for single or multiple tooth prostheses and orthodontic devices, endodontic sealers, and root canal posts. It is likely that the use of these materials will continue to grow both in frequency and application due to their versatility. The rapidity by which the materials have evolved suggests a constantly changing state of the art starting from the Bis-GMA based resin composite in the mid 1960's up to self-adhesive flowable composites in 2010(1).

Dental composite comprises an organic polymer matrix, inorganic filler particles (silica, zirconium oxide, barium glass), coupling agent, and the initiator-accelerator system. The resin forms the matrix of the composite material. The individual filler particles are bonded to the resin matrix after being treated with organo-functional silane coupling agent to obtain chemical adhesion (1-3).

Flowable composites are typically produced with a lower viscosity by reducing the filler content of the mixture, or by adding other modifying agents, such as surfactants, which enhance the fluidity while avoiding a large reduction in filler content that would significantly reduce the mechanical properties and increase shrinkage (4).

Currently, all resin-based restoratives require a surface pretreatment of enamel and dentin using either an etch-and-rinse adhesive or self-etch adhesive system. This multi-step application technique is lengthy, rather complex and often very technique sensitive (5-8). Different from etch-and-rinse adhesives, self-etching ones do not require a separate etching step as they contain acidic monomer that simultaneously condition and prime the dental substrate. Consequently, this approach has been claimed to be more user-friendly (shorter application time, less steps) and less technique-sensitive (no wet-bonding, simple drying), thereby resulting in a reliable clinical performance (9 -11).

Simplification of the clinical application steps needed to bond a composite restoration is highly desirable. This would not only reduce clinical treatment time, but also technique sensitivity (12). A new category of flowable composite restoratives that do not require any pretreatment of the substrate according to the manufacturer's instructions was recently introduced; its self-adhesiveness is supposedly based upon the use of acidic monomers that demineralize and infiltrate the tooth substrate, resulting in micro-mechanical retention, potentially enhanced by additional chemical interaction (1,12).

An inherent disadvantage of dental composite restorative materials is that they shrink during polymerization (13). Restorative techniques that reduce the level of stress caused by resin composite polymerization shrinkage have been suggested. To create a stress-absorbing layer, the placement of a cavity liner or base of low-viscosity/low-elastic modulus materials such as resin modified glass ionomers, filled adhesives, and flowable composites has been suggested. This layer increases the strain capacity (13) and reduces the stresses at the adhesive interface (14-16).

Accordingly, this study will be carried out to evaluate two self-adhesive flowable composites in comparison to a conventional one regarding the bond strength to enamel and dentin, the tooth-restoration interface and mode of failure when the materials are applied according to the manufacturer's instructions, when used with an etch-and-rinse adhesive system and when used with a self-etch adhesive system. The study will also investigate microleakage and the induced strain during polymerization.

Review of Literature

1. Resin composite

1.1. Composition of resin Composites

Dental resin composites can be distinguished by differences in formulations tailored to their particular requirements as restoratives, sealants, cements and provisional materials as well. These materials are similar in that they are all composed of a polymeric matrix, typically a dimethacrylate, reinforcing fillers; typically made from radiopaque glass, a silane coupling agent for binding the fillers to the matrix, and chemicals that promote or modulate the polymerization reaction (1).

The most common matrix monomers are aromatic dimethacrylates. The double bonds at each end of these molecules undergo addition polymerization by free-radical initiation. Although these monomers can provide optimum optical, mechanical, and clinical properties, they are rather viscous and have to be blended with low molecular- weight diluent monomers so that a clinically workable consistency may be obtained upon incorporation of the fillers. More recently low-shrinkage composites have been introduced that contain, for example, monomers with epoxy (also known as oxirane) functional groups at the ends. The polymerization of these monomers is initiated by cations. Other commercial resin composites utilize various monomers and filler technology to reduce polymerization shrinkage and consequently the shrinkage stresses (2).

The dispersed inorganic filler particles may consist of one or more inorganic materials such as finely ground quartz or glass, sol-gel derived ceramics, microfine silica, or more recently nanoparticles. Fillers make up a major portion by volume or weight of the composite. The function of fillers is to reinforce the resin matrix, provide the appropriate degree of translucency, and control the volume shrinkage of the composite during polymerization. A helpful method of classifying dental composites is by the particle size, shape, and the particle-size distribution of the fillers (2).

The vast majority of monomers used for the resin matrix are dimethacrylate compounds. Two monomers that have been commonly used are bisphenol A glycidyl methacrylate (Bis-GMA) and urethane dimethacrylate (UDMA). Both contain reactive carbon double bonds at each end that can undergo addition polymerization initiated by free-radical initiators. The use of aromatic groups affords a good match of refractive index with the radiopaque glasses and thus provides better overall optical properties of the composites. Few products use both Bis-GMA and UDMA monomers. The viscosity of the monomers, especially Bis-GMA, is rather high and diluents must be added, so a clinical consistency can be reached when the resin mixture is compounded with the fillers. Low molecular-weight compounds with difunctional carbon double bonds, for example, triethylene glycol dimethacrylate (TEGDMA), are added by the manufacturer to reduce and control the viscosity of the composite (2).

The coupling agent, an organosilane (often referred to as silane), is applied to the inorganic particles to surface-treat the fillers before being mixed with the unreacted monomer mixture. Silanes are called coupling agents, because they form a bond between the inorganic and organic phases of the composite. One end of the molecule contains functional groups (such as methoxy), which hydrolyze and react with