Editorial

What causes Durability Reduction in Tooth-colored Resin Restorations?

Despite its common use, the dental resins still have a lower durability when compared to amalgam restorations and indirect restorations.

Success in adhesive dentistry involves long lasting restorations; however, the resin-dentine interface degradation appears as the biggest obstacle to achieve this goal. Independent of the adhesive strategy used for bonding to tooth substrates (self-etch or etch-and-rinse adhesive systems) degradation of the hybrid layer can be observed. It should be emphasized that the lower durability of restorations results from degradation of the bonded interfaces formed by the adhesive systems (Hashimoto, 2010), being more apparent when dentin is the major bonding substrate involved.

According to the strategic plan on tooth-colored resin restorations (NIDCR, 2009-2013), its durability is approximately 6 years. Considering that the dentist spends about 50 to 70% of their clinical time only for replacing this composite resin restorations (Ericson et al, 2007), this yields an annual cost (US only) of approximately $5 billion (Jokstad et al, 2001).

What causes this reduction in the durability of tooth-colored resin restorations?

The reduction in the durability of adhesive restorations is directly related with the balance between the resinous components of the adhesive system and components from organic substrate which can lead to dental degradation of adhesive interface. This degradation occurs in two ways: Either by hydrolysis of the resin components or by hydrolysis of the collagen matrix. Being the main causes, the incomplete infiltration of resin monomers, the hydrolytic degradation of adhesive system polymer by water sorption, and the breakdown of collagen fibrils by MMP and cathepsin-cysteine.

The increased concentration of hydrophilic monomers (e.g. HEMA) in both self-etch or etch-and-rinse adhesive systems leave the adhesive film permeable to water. This water may arise from pulpal pressure of dentinal tubules (Bresch et al, 2008) or remnants of water molecules that do not evaporated with the solvent (alcohol or acetone).

Aside from the presence of water at the base of hybrid layer, the interfibrillar spaces of collagen in apatite-depleted dentin also contain hydrated negatively charged proteoglycans that form a hydrogel (Scott and Thomlinson, 1998). If these hydrogels remain hydrated in interfibrillar spaces, they may be responsible for 'molecular sieving' of larger hydrophobic dimethacrylates (like BisGMA—bisphenol A—glycidyl methacrylate), allowing only smaller hydrophilic molecules (like HEMA—2-hydroxyethyl methacrylate) to permeate upon the bottom of the hybrid layers.

Hydrophilic resin monomers (like HEMA) are vulnerable to hydrolysis, due to the presence of ester linkages (Ferracane, 2006). Hydrolysis of monomer methacrylates ester bonds can be caused either by the increase in acidity of monomer components in self-etch adhesive systems (Aida et al, 2009) or by salivary esterases (Shokati et al, 2010) that can break covalent bonds between the methacrylate polymers by the addition of water molecules to the ester bonds. Thus, the plasticization and nano-phase separation of polymers decreases the dynamic mechanical properties of the polymerized adhesives (Park et al, 2010) and increases their susceptibility to esterase-catalyzed hydrolysis (Kostoryz et al, 2009).

Mineralized dentin contains matrix metalloproteinases (MMPs), such as MMP-2, 3, 8, and 9 (Birkedal-Hansen et al, 1993). Due to dentin mineralization process, the MMPs are retained in the collagen extracellular matrix as inactive proenzymes in a latent state (Tjäderhane et al, 1998). However, MMPs can be activated if, for some reason, the demineralized dentin is exposed to acid, such as monomers of etch-and-rinse (Mazzoni et al, 2006) and self-etch adhesive systems (Nishitani et al, 2006a). When activated, the MMPs act in the degradation of collagen, elastin and extracellular matrix components (Birkedal-Hansen et al, 1993). Thus, apatite-depleted, resin-sparse collagen fibrils within the hybrid layers become susceptible to degradation, compromising the longevity of resin-dentin bonds (Breschi et al, 2008; Hashimoto, 2010).

Another extracellular enzyme present in dentin is the cysteine cathepsins. They have recently been reported to be present in intact dentin (Tersariol et al, 2010) and more abundantly (approximately 10-fold) in carious dentin (Nascimento and Tjäderhane, unpublished observations). They are derived from the dental pulp via the dentinal fluid (Tersariol et al, 2010) and, similar to MMPs, may be activated in mildly acidic environments, produced by both etch-and-rinse and self-etch adhesive systems.

Adhesive technology has evolved rapidly since it was introduced more than 60 years ago. The main challenge for dental adhesives is to provide an equally effective bond to two hard tissues of different nature. The contemporary dentin adhesive is not as durable as we had assumed. The complete replacement of free and loosely bound water within the apatite-depleted collagen fibrils within the hybrid layers and the inactivation of collagenolytic enzymes appear to be the main objectives to improve durability of tooth-colored resin restorations.

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Sérgio Brossi Botta DDS, MSc, PhD
Department of Restorative Dentistry
Assistant Professor, Camilo Castelo Branco University
São Paulo, Brazil