Shear Bond Strength of a Self-adhering Flowable Composite and a Flowable Base Composite to Mineral Trioxide Aggregate, Calcium-enriched Mixture Cement, and Biodentine

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Abstract

Introduction: The purpose of this study was to investigate the shear bond strength (SBS) of a self-adhering flowable composite (Vertise Flow; Kerr, Orange, CA) and a flowable composite (X-tra base; Voco GmbH, Cuxhaven, Germany) to mineral trioxide aggregate (MTA), Biodentine (Septodent, Saint-Maur-des-Fosses Cedex, France), and calcium-enriched mixture (CEM; Yektazist Dandan, Tehran, Iran). **Methods:** Sixty cylindric acrylic blocks with a hole (3 mm in diameter and 1.5 mm in height) were prepared. The acrylic blocks were filled with MTA, Biodentine, and CEM (n = 20) and accordingly allocated into 3 groups. The specimens were stored for 72 hours at 37°C and 100% humidity. Then, each group was divided into 2 subgroups according to the composite resin type used (n = 10). Vertise Flow and X-tra base were applied over MTA, Biodentine, and CEM and then polymerized. SBS was tested in a universal testing machine with a crosshead speed of 1 mm/min. Data were analyzed using 2-way analysis of variance and the Tukey test. **Results:** The Vertise Flow–CEM and X-tra base–MTA groups showed significantly higher SBS values than the group made of Vertise flow–Biodentine ($P < .05$). There were no statistically significant differences among the other groups ($P > .05$). **Conclusions:** MTA and CEM exhibited higher SBS than Biodentine; therefore, they could be preferred under flowable composites. *(J Endod 2015;41:1691–1695)*

Key Words

Biodentine, flowable composite, mineral trioxide aggregate, shear strength

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If the pulp is exposed, the long-term success and preservation of the vitality are endangered. Therefore, the treatment protocol of deep carious lesions is a complicated task for the dental clinician (1, 2), and the treatment modalities must aim to preserve the pulp vitality to achieve the formation of a dentin bridge (3). Previously, calcium hydroxide was used in such treatments but has not been widely accepted because of unpredictable results such as not adhering to dentin and dissolving over time and dentin bridges adjacent to the material containing multiple tunnel defects (4). Thus, novel dental biomaterials are being used instead of calcium hydroxide (5–7). Mineral trioxide aggregate (MTA), which consists of a mixture of tricalcium aluminate, dicalcium silicate, tricalcium silicate, tetracalcium aluminoferrite, and bismuth oxide, was first applied in dentistry in 1993 (8). MTA has attracted considerable attention because of its desired properties such as low solubility (9), ability to set in a wet environment, setting in the presence of blood, prevention of bacterial leakage, and biocompatibility (10, 11). However, it has some disadvantages, such as difficult handling and long setting times (12). A variety of new calcium silicate–based materials have been developed recently to overcome the shortcomings of MTA. One of these materials is Biodentine (Septodent, Saint-Maur-des-Fosses Cedex, France), which contains tricalcium silicate, calcium carbonate, and zirconium oxide. The liquid consists of calcium chloride and a water-reducing agent. Biodentine has good sealing ability, high compressive strength, a short setting time, (13, 14) biocompatibility, bioactivity, and remineralization properties (15). Thus, it is recommended as a dentin substitute for resin composite restorations and represents an endodontic repair material. Biodentine has a shorter setting time and higher viscosity than MTA (16). Calcium-enriched mixture (CEM; Yektazist Dandan, Tehran, Iran) is a new material that contains various calcium combinations, including oxide sulfate, phosphate, carbonate, silicate, hydroxide, and chloride compounds. When compared with MTA, CEM has a shorter setting time, lower viscosity, and smaller film thickness (17, 18).

Flowable resin composites were introduced in the late 1990s with a wide range of applications. They have 2 desirable clinical handling properties: fluid injectability and nonstickiness (19). They are recommended for the restoration of small-sized cavities and cavity lining (20). Recently, new self-adhering flowable resin composites (SACs) have been developed that combine an all-in-one bonding system and a flowable composite. These systems eliminate the need for an additional adhesive application. Incorporation of the bonding agent into a flowable composite holds great potential with respect to saving treatment chair time and minimizing handling errors. These new SACs are even more useful when a patient may be uncooperative during the treatment. They have been proposed as an adhesive-free restorative material indicated for the restoration of small class I cavities, class V cavities, and noncarious cervical lesions as well as for lining in class I and II restorations (21).

The bond strength between restorative and pulp capping materials is important for the quality of the filling and the success of restorations (22). Moreover, proper bonding of composite resins to pulp capping biomaterials produces the adhesive joint, which is capable of spreading stress relatively evenly over the entire region of the bond (23). To date, numerous studies have been performed on the bond strength of MTA to composite resins with different adhesive systems (22, 24–27), and a limited number of studies have been performed on the bond strength of CEM (24, 25) and Biodentine (16, 28) to composite resins. However, the bond strength of new self-adhering flowable composites and conventional flowable composites to MTA, CEM, and Biodentine has not been investigated until now. Therefore, the aim of this study was to evaluate the shear bond strength (SBS) of a self-adhesive flowable composite (Vertise Flow; Kerr, Orange, CA) and a flowable composite (X-tra base; Voco GmbH, Cuxhaven, Germany) to MTA, Biodentine, and CEM. The tested hypothesis was that the SBS of Vertise Flow and X-tra base to MTA, CEM, and Biodentine would not vary.

Materials and Methods

Two commercial flowable composites and 3 pulp capping materials were used in this study. The materials used are listed in Table 1. Sixty cylindric acrylic blocks with a hole (3 mm in diameter and 1.5 mm in height) were prepared. MTA, CEM, and Biodentine were mixed according to the manufacturers' instructions, and then the holes were filled with these materials using a spatula and covered with a wet cotton pellet. The specimens were stored for 72 hours at 37°C and 100% humidity. The acrylic blocks were randomly allocated into 3 groups according to their filling with MTA, Biodentine, and CEM ($n = 20$). All prepared surfaces were polished with 400-grit paper for 60 seconds to create a standard layer. Then, each group was divided into 2 subgroups according to the composite resin type used ($n = 10$). Vertise Flow and X-tra base were applied over MTA, Biodentine, and CEM by means of a plastic cylinder with a height and diameter each of 2 mm. The surface area was placed over the previously prepared surfaces, and Vertise Flow and X-tra base were placed into the rings and light cured with a light-emitting diode (Elipar Freelight 3; 3M ESPE, Seefeld, Germany), according to the manufacturer's recommendations, from the side of the cylinder. The samples were stored in a humid environment for 24 hours at 37°C, and SBS was tested for failure using a knife-edge blade in a universal testing machine (Shimadzu, Model AGS-X 5 kN; Shimadzu Corporation, Kyoto, Japan) with a crosshead speed of 1 mm/min. Simulation of the study design is presented in Figure 1. The load at failure was recorded in newtons, and the bond strength was calculated in megapascals by dividing the load at failure by the adhesive surface area (mm^2). Failure modes were evaluated by a single operator under a stereomicroscope (Nikon type 102; Nikon, Tokyo, Japan) at 40× magnification and categorized into 1 of 3 types: adhesive: 100% adhesive failure between the pulp capping material and the composite resin; cohesive: 100% cohesive failure within the pulp capping

TABLE 1. Chemical Composition and Application Procedure of the Tested Materials

Material (batch)	Composition	Mode/steps of application
MTA Angelus, Londrina, PR, Brazil (24929)	Tricalcium silicate, bismuth oxide, dicalcium silicate, tricalcium aluminate, calcium sulfate dehydrate or gypsum	Mixed powder/liquid ratio: 1/3
Biodentine Septodent, Saint-Maur-des-Fosses Cedex, France (B08889)	*Powder:* tricalcium silicate, dicalcium silicate, calcium carbonate and oxide, iron oxide, and zirconium oxide *Liquid:* calcium chloride and hydrosoluble polymer	Five doses liquid and powder supplied for 30 seconds with a mixed amalgamator
CEM Yektazist Dandan, Tehran, Iran (C100501)	Portland cement (tricalcium silicate, dicalcium silicate, tricalcium aluminate, tetracalcium aluminoferrite) and bismuth oxide	Mix the powder with the liquid for 15–30 seconds
Vertise Flow Kerr, Orange, CA (2894473)	Self-adhesive restorative, dynamic application *Resin:* GPDMA, HEMA, BisGMA, catalysts *Fillers:* prepolymers, silanated Ba-glass, SiO_2, YF3	Dispense a thin layer (<0.5 mm) on a forcefully dried surface; use a provided applicator with a brushing motion for 15–20 seconds; light cure for 20 seconds; syringe additional material in increments of <2 mm and light cure each increment for 20 seconds.
X-tra base Voco GmbH, Cuxhaven, Germany (1223555)	*Resin:* BisGMA, BisEMA, UDMA, and Procrylat *Filler system:* zirconia/silica with a particle size range of 0.01–3.5 μm (average 0.6 μm) Ytterbium trifluoride particle size range of 0.1–5 μm Filler loading is 64.5% by weight (42.5% by volume)	Apply the X-tra base directly into the cavity and polymerized.
Futurabond DC Voco GmbH, Cuxhaven, Germany (1222233)	Organic acids, Bis-GMA, HEMA, TMPTMA, BHT, ethanol, fluorides, CQ, amine, catalysts	Mix 1 drop of liquid 1 and 1 drop of liquid 2 on mixing palette. Apply a moderately thin layer of the adhesive to the enamel/dentine with a suitable applicator and allow it to act for 20 seconds. Dry the adhesive layer for at least 5 seconds. Polymerize with blue light for 10 seconds.

4-MET, trimelitic acid methacrylate; BHT, butylated hydroxytoluene; BisEMA, ethoxylated bisphenol-A dimethacrylate; BisGMA, bisphenol glycidyl dimethacrylate; CQ, camphoroquinone; GPDMA, glycerolprosphoric acid dimethacrylate; HEMA, hydroxyethyl methacrylate; SiO_2, silicon oxide; TEGDMA, triethylene glycol dimethacrylate; TMPTMA, trimethylolpropane trimethacrylate; YF3, ytterbium tri-fluoride.