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Bond strength of self-adhesive resin cements to tooth structure

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KEYWORDS

Self-adhesive;
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Cement

Abstract *Objectives:* The aim of this study was to evaluate the strength of the bond between newly introduced self-adhesive resin cements and tooth structures (i.e., enamel and dentin).

Methods: Three self-adhesive cements (SmartCem2, RelyX Unicem, seT SDI) were tested. Cylindrical-shaped cement specimens (diameter, 3 mm; height, 3 mm) were bonded to enamel and dentin. Test specimens were incubated at 37 °C for 24 h. The shear bond strength (SBS) was tested in a Zwick Roll testing machine. Results were analyzed by one-way ANOVA and *t*-test. Statistically significant differences were defined at the $\alpha = 0.05$ level. Bond failures were categorized as adhesive, cohesive, or mixed.

Results: The SBS values ranged from 3.76 to 6.81 MPa for cements bonded to enamel and from 4.48 to 5.94 MPa for cements bonded to dentin ($p > 0.05$ between surfaces). There were no statistically significant differences between the SBS values to enamel versus dentin for any given cement type. All cements exhibited adhesive failure at the resin/tooth interface.

Conclusions: Regardless of their clinical simplicity, the self-adhesive resin cements examined in this study exhibit limited bond performance to tooth structures; therefore, these cements must be used with caution.

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1. Introduction

Cementation is a critical step in ensuring the longevity of indirect restorations. Indeed, in certain clinical situations (e.g., when using ceramic or composite indirect restorations), adhesive cements must be used. Various dental luting agents are available to clinicians, each with its own particularities and indications; thus, choosing which cement to use may be difficult. Resin cements possess superior mechanical

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properties, as they are relatively insoluble, can withstand the stresses of the oral environment, provide excellent retention, and are capable of maintaining the integrity of the tooth and restoration (Rosenstiel et al., 1998). However, resin cements require multiple sensitive clinical steps. For this reason, self-adhesive cements were recently introduced, aimed at simplifying the luting procedure.

Manufacturers of self-adhesive resin cements advocate that these cements require neither conditioning of the tooth nor surface treatment of the restoration (Abo Hamar et al., 2005; Behr et al., 2004). These cements are moisture-tolerant and capable of fluoride release in a manner similar to glass ionomer cements (Gerth et al., 2006). However, one study reported that the dentin surface should ideally be treated before applying a self-adhesive system, to improve the dentin/alloy bond strength (El-Guindy et al., 2010). Moreover, etching the enamel with phosphoric acid, either alone (De Munck et al., 2004; Duarte et al., 2008; Hikita et al., 2007) or followed by a bonding agent (Lin et al., 2010), can significantly improve the bond strength of the self-adhesive cement to the tooth structure. RelyX Unicem (3M ESPE, Seefeld, Germany) was the first self-adhesive resin cement to be launched on the market and, therefore, is the most thoroughly studied of these cements (Behr et al., 2004; Duarte et al., 2008; Hikita et al., 2007). This product was intended to combine the ease of use of glass ionomer cements with the adhesive properties of resin cements, without the complexity of the procedure.

The bonding properties of resin cements are related to the chemical composition. The organic matrix of the cement, consisting of multifunctional phosphoric acid methacrylates, is proposed to be capable of simultaneously demineralizing and infiltrating the tooth surface (Yoshida et al., 2000). The phosphoric (Gerth et al., 2006; Radovic et al., 2008) and carboxylic groups of polyalkenoic acid form ionic bonds with hydroxyapatite, thereby ensuring a second means of retention (Fukuda et al., 2003; Gerth et al., 2006; Radovic et al., 2008). However, studies have shown that RelyX Unicem has a limited demineralization capacity and interacts only superficially with the tooth structure (Aguiar et al., 2013; Al-Assaf et al., 2007; Duarte et al., 2008; Monticelli et al., 2008). Compared to conventional luting systems, RelyX Unicem showed equivalent or lower bond strength values in bonding to dentin or enamel, respectively (Behr et al., 2004; Chai et al., 2008; Duarte et al., 2008; Flury et al., 2010; Hikita et al., 2007; Poitevin et al., 2013). Nevertheless, RelyX Unicem exhibited superior strength in bonding to restorative materials compared to glass ionomer cement (Capa et al., 2009; Piwowarczyk et al., 2004).

Most of the currently available data for self-adhesive cements are based on *in vitro* investigations, with very few studies of clinical performance. One short-term clinical study revealed that the performance of self-adhesive cements is comparable to that of zinc phosphate cement (Behr et al., 2009). Therefore, the purpose of this study was to evaluate the shear bond strength (SBS) values of self-adhesive resin cements to enamel and dentin tooth structures. The null hypothesis was that there is no significant difference in SBS among the different types of self-adhesive resin cements.

2. Methods

The tested self-adhesive cements were RelyX Unicem, SmartCem2 (Caulk-Dentsply, Milford, DE), and seT SDI (SDI Limited, Victoria, Australia), as shown in Table 1.

2.1. Tooth preparation

Freshly extracted posterior teeth were collected and inspected for existing caries, lesions, and fillings. Only sound teeth were used in this study. Teeth were kept in saline water for later use. A diamond disk (Diamant GmbH, D&Z, Berlin, Germany) was used to cut the teeth (bucco-lingual section) and to expose the dentin and enamel. Surfaces were polished with 600-grit sandpaper for 5 s. Polished tooth sections were embedded in brass mold holders, which had been specifically designed for conducting shear testing.

Resin cements were mixed in accordance with the manufacturers' recommendations. Custom-made Teflon disks (internal diameter, 3 mm; external diameter, 14.4 mm; thickness, 3 mm) were fixed over the tooth surface, and the cement was injected inside the Teflon mold. All cements were light-cured for 40 s with a QTH light-curing unit (Optilux501, SDS Kerr, Danbury, USA), which was operated in standard mode. The light-curing unit emitted 760 mW/cm^2 irradiance, as measured by the incorporated radiometer that had been calibrated against a flat-response power meter. Once curing was completed, the molds were removed, and specimens were incubated in a wet environment at 37 ± 1 °C for 24 h before testing.

Table 1 Materials used in this study.

Luting agent	Delivery system	Batch number	Composition
RelyX Unicem (3M ESPE, Seefeld, Germany)	Capsules	384237	Methacrylated phosphoric esters, dimethacrylates, acetate, glass fillers, silica, calcium hydroxide, stabilizers, co-initiators, pigments Filled to approximately 72% by weight
SmartCem2 (Caulk-Dentsply, Milford, DE, USA)	Paste/paste dual syringe auto mixing	0808013	Urethane dimethacrylate (UDMA), di and tri methacrylate resin, 4-methacryloxyethyl trimellitate anhydride (4-META), phosphoric acid modified acrylate resin, barium boron fluoroaluminosilicate glass, initiators, accelerators, UV stabilizers Filled to approximately 69% by weight
seT SDI (SDI Limited, Victoria, Australia)	Capsules	S0904282	Methacrylate phosphoric esters, Urethane dimethacrylate (UDMA), Strontium fluoroaluminosilicate glass, silica camphorquinone stabilizer, co-initiators, pigments Filled to approximately 67.5%