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Influence of a hydrophobic resin coating on the immediate and 6-month dentin bonding of three universal adhesives

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ABSTRACT

Objective. To test the influence of a hydrophobic resin coating (HC) on the immediate (24h) and 6-month (6m) microtensile dentin bond strengths (μTBS) and nanoleakage (NL) of three universal adhesives applied in self-etch (SE) or in etch-and-rinse (ER) mode.

Methods. Sixty caries-free extracted third molars were assigned to 12 experimental groups resulting from the combination of the factors "adhesive system" (Scotchbond Universal Adhesive [SBU], 3M ESPE; All-Bond Universal [ABU], Bisco Inc.; and G-Bond Plus [GBP], GC Corporation); "adhesive strategy" (SE or ER); "hydrophobic resin coating" [HC] (with or without Heliobond, Ivoclar Vivadent); and "storage time" (24h or 6m). Specimens were prepared for μTBS testing – (24h) half of the beams were immediately tested under tension; and (6m) the other half was stored in distilled water (37 °C) for 6m prior to testing. For each tooth, two beams were randomly selected for NL evaluation for both evaluation times. Data were analyzed for each adhesive system using three-way ANOVA and Tukey's *post-hoc* test ($\alpha = 0.05$).

Results. μTBS: (24h): In SE mode, HC resulted in statistically greater mean μTBS for all adhesives. (6m): When HC was not used the mean μTBS for SBU/ER, ABU/ER, GBP/ER and SBU/SE decreased significantly.

NL: (24h): SBU/ER, ABU/ER and GBP/SE resulted in a significant reduction in NL when HC was applied. (6m): No significant reduction was observed for SBU/ER or for SBU/SE regardless of the use of HC.

Significance. The application of a hydrophobic resin coating improved the 24h and the 6m performances of all three adhesives systems in SE mode.

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1. Introduction

The new simplified universal adhesives can be used as 2-step etch-and-rinse [ER] or as 1-step self-etch [SE] adhesives. This dual strategy is accomplished by using 1-step SE adhesives associated or not with previous phosphoric acid (PA) etching, which gives dentists a more versatile and attractive adhesive system that can also be used in selective etching mode [1–3].

PA etching, the first step in the ER strategy, removes the smear layer and demineralizes a few micrometers of the dentin surface [4]. After the removal of hydroxyapatite from the interfibrillar spaces, resin monomers infiltrate those spaces and impregnate collagen fibrils, leading to the formation of a thick hybrid layer of collagen and resin within the dentin substrate [5]. Dentin hybridization in simplified ER adhesives is a sensitive technique due to the potential for discrepancy between the etching depth and the effective adhesive impregnation of the exposed collagen fibril network [6,7]. SE adhesives, however, do no require preliminary PA etching, as dentin demineralization and priming may occur simultaneously [8]. The simultaneous etching and infiltration of SE adhesives into dentin does occur for all SE adhesives [9,10].

The idea of using the same adhesive solution for either adhesive strategy is not new. In fact, the application of PA with earlier versions of SE adhesives has resulted in debatable results [11–13], which may be a consequence of specific adhesive composition and technical application of the same adhesive under ER and SE strategies [14,15].

The inclusion of hydrophilic monomers in the composition of simplified adhesives has increased substantially within recent years with the objective of making these adhesives compatible with the inherently wet dentin substrate. The degradation potential of resin–dentin interfaces formed with hydrophilic simplified adhesives has been shown to enhance due to residual solvents and water entrapped in the polymer. In fact, water droplets are formed in 1-step SE adhesives as a result of water absorption from dentin through osmosis [16]. Water entrapment may hinder the formation of cross-linked polymers. This may occur via water-filled, nanometer-sized voids formed as a result of a decrease in the degree of conversion of the adhesive. A low degree of conversion affects the stability of the resin–dentin interface due to the elution on unreacted monomers and consequent formation of a porous hybrid layer [17,18].

One-step SE adhesives result in a thinner adhesive layer, being more susceptible to polymerization inhibition by oxygen [19]. The suboptimal polymerization is a drawback related to the use of universal adhesives as 1-step SE adhesives. A clinical alternative is the application of an additional layer of a hydrophobic resin coating (HC) over the polymerized simplified adhesive [20]. This extra resin coat aims at increasing the thickness and uniformity of the adhesive layer, as well as reducing the fluid flow across the adhesive interface [21]. Excellent *in vitro* and clinical results have been reported after placement of a HC over 1-step SE adhesives [22,23].

Additionally, promising results in terms of bond strength, nanoleakage, and degree of conversion inside the hybrid layer, have been recently reported for universal adhesives [24]. However, to the extent of our knowledge, studies on the longevity of this technique have not been carried out.

The aim of this study was to evaluate the immediate (24h) and 6-month (6m) microtensile bond strength (μTBS) and nanoleakage (NL) of universal adhesive systems used in the ER and SE approaches with or without an additional HC. The null hypotheses tested were that the use of an additional HC would not improve: (1) the immediate and 6-month bond strengths of universal adhesives used as ER or SE and; (2) the immediate and 6-month nanoleakage of resin–dentin interfaces formed with universal adhesives used as ER or SE.

2. Material and methods

Sixty caries-free extracted human third molars were disinfected in 0.5% chloramine, stored in distilled water and used within 6 months after extraction. The teeth were collected after obtaining the patients' informed consent under a protocol approved by the local Ethics Committee Review Board. A flat occlusal dentin surface was exposed in all teeth after wet-grinding the occlusal enamel with # 180 grit SiC paper. The exposed dentin surfaces were further polished with wet # 600-grit silicon-carbide paper for 60 s to standardize the smear layer [25].

2.1. *Experimental design and specimen preparation*

The teeth were randomly assigned to 12 experimental conditions resulting from the combination of the factors "adhesive system" (Scotchbond Universal Adhesive [SBU, 3M ESPE, St. Paul, MN, USA – also known as Single Bond Universal in some countries], All-Bond Universal [ABU, Bisco Inc, Schaumburg, IL, USA], and G-Bond Plus [GBP, GC Corporation Tokyo, Japan – also known as G-ænial Bond]) (Table 1); "adhesive strategy" (ER or SE); "hydrophobic resin coating" [HC] (with or without, Heliobond, Ivoclar Vivadent, Schaan, Liechtenstein); and "storage time" (24h or 6m).

The adhesive systems were applied according to the respective manufacturers' instructions (Table 1), except for GBP, for which the manufacturer does not recommend dentin etching with phosphoric acid. Furthermore, the respective manufacturers do not recommend the application of HC (Table 1). Composite resin crowns were built with a nanofilled composite resin (Filtek Z350 XT, 3M ESPE, St. Paul, MN, USA; also named Filtek Supreme XTE or Filtek Supreme Plus) in two increments of 2 mm each. Each increment was light-cured for 40 s using a LED light-curing unit set at 1200 mW/cm^2 (Radii-cal, SDI Limited, Bayswater, Victoria, Australia).

After storage in distilled water for 24h at 37 °C, the specimens were sectioned longitudinally in mesio-distal and buccal-lingual directions across the bonded interface with a slow-speed diamond saw (Isomet, Buehler Ltd., Lake Bluff, IL, USA) to obtain resin–dentin beams with a cross sectional area of approximately 0.8 mm^2 measured with a digital caliper (Digimatic Caliper, Mitutoyo, Tokyo, Japan). Half of the beams from each tooth were used in the immediate time (24h) for the μTBS test, except two specimens that were randomly selected for measurement of NL. The other half were stored in distilled