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Ethanol-wet bonding technique: Clinical *versus* laboratory findings

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ABSTRACT

Objectives. This study evaluated the microtensile bond strength (μTBS) and nanoleakage (NL) of dentin bonded interfaces produced with ethanol-wet and water-wet bonding protocols under clinical and laboratory conditions.

Methods. The sample was composed of forty primary second molars in advanced exfoliation process. Occlusal cavities were prepared leaving a flat dentin surface on the pulpal floor. In half of the teeth, the water-wet protocol was followed using a three-step etch-and-rinse adhesive. In the other half, dentin was dehydrated with ascending ethanol solutions (50%, 70%, 80%, 95% and 3 × 100%), 15 s each for the ethanol-bonding protocol. An experimental hydrophobic primer was used, followed by the neat adhesive application. Resin build-ups were prepared, stored for 24 h, sectioned into sticks and tested in tensile mode (0.5 mm/min). NL was performed for all groups. The μTBS and NL data were submitted to two-way ANOVA and Kruskall–Wallis tests, respectively ($\alpha = 0.05$).

Results. Under clinical conditions, the highest μTBS was observed for the water-wet bonding while under the laboratory setting, the highest μTBS was obtained for the ethanol-wet bonding. Increased NL was observed in the water-wet bonding groups irrespective of the bonding condition.

Significance. The immediate benefits of the ethanol-bonding observed in the laboratory setting was not confirmed when the same protocol was performed *in vivo*. However, as reduced nanoleakage was seen in adhesive interfaces produced with the ethanol-wet bonding technique, suggests that the hybrid layer may be more resistant to degradation.

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1. Introduction

Early generations of dental adhesives were relatively hydrophobic, and dry substrates were required for bonding. However, drying acid-etched dentin causes collapse of the collagen meshwork that prevented resin infiltration. As a consequence, the resulting dentin bond strengths were very low [1]. Modifications of adhesive formulations, by the inclusion of more hydrophilic monomers and acidic resin monomers, made adhesive solutions more compatible with moist dentin, which, in turn, yielded significant improvements in the immediate bonding effectiveness of most adhesive systems [2,3].

The potential problems associated with incorporation of hydrophilic formulations are well known [1]. Increased water sorption [4–6] rapid deterioration of mechanical properties of the adhesive layer [4,7] as well as increased permeability of the adhesive interface [8,9] that jeopardize the longevity of resin–dentin bonds after short- and long-term periods under *in vivo* and *in vitro* investigations [10–17].

In an attempt to solve these problems, some studies attempted to make acid-etched dentin more hydrophobic [18–20]. The strategy involved the replacement of water within the demineralized collagen matrix with ascending concentrations of ethanol, allowing the latter to penetrate the collagen matrix without causing additional shrinkage of the interfibrillar spaces, in the so-called ethanol-wet bonding technique [20].

Although dentin bonding with hydrophobic resins using the ethanol-wet bonding technique has shown encouraging results in terms of resin–dentin bond stability [18,21,22] the protocol is time consuming and technique-sensitive [23]. Additionally, a complete replacement of water by ethanol may not be feasible under clinical conditions due to the constant presence of an outward physiological dentinal fluid coming up from the dental pulp. Although the ethanol-wet bonding technique was conceived to be a bonding philosophy rather than a bonding technique, due to its clinical difficulties, the understanding of the behavior of this technique in a clinical setting may complement what has been reported in laboratory studies and it may be a major contribution to the adhesive dentistry. So far, to the extent of the authors' knowledge no study has attempted to investigate the ethanol-wet bonding protocol in an *in vivo* setting. Therefore, the aim of the present study was to compare the resin–dentin bond strength and nanoleakage of dentin-bonded interfaces produced with ethanol- and water-wet bonding protocols under clinical and laboratory conditions. The following null hypotheses were tested: (1) there are no differences in the resin–dentin bond strength and nanoleakage produced by an etch-and-rinse adhesive system bonded with the ethanol-wet and water-wet protocols; (2) there are no differences in the resin–dentin bond strength and nanoleakage produced by an etch-and-rinse adhesive system bonded under clinical or laboratory conditions.

2. Materials and methods

2.1. *Specimen preparation for the clinical and laboratory experiments*

The present investigation was approved by the local Ethics Committee under protocol number 24/2009. For the clinical experiment, clinical and radiographic examination of approximately 100 patients ranging from 10 to 12 years old were performed in order to find 20 patients to take part in this study. These patients were required to have an incipient caries lesion in the primary second molar (up to the upper 1/3 of the dentin in the interproximal radiograph) and be in need of restorative treatment in the same hemi-arch, so that patients would necessarily receive anesthesia and rubber dam isolation. All teeth selected were at an advanced stage of physiological root resorption and mobility, indicating advanced physiological exfoliation process. The fact that these teeth have been used as source of stem cells was evidence of their pulp vitality [24,25].

For the laboratory evaluation, 20 recently exfoliated primary second molars free of caries or having an incipient caries lesion were used. Teeth were stored in saline solution at 4 °C for up to 3 months before the *in vitro* experiment.

2.2. *Tooth preparation and restorative procedures*

In each tooth, one standardized occlusal cavity was prepared under local anesthesia without vasoconstrictor (3% mepivacaine solution, Mepisv, Nova DFL, Rio de Janeiro, RJ, Brazil) and rubber dam isolation, using a cylindrical diamond bur (#1092, KG Sorensen, São Paulo, Brazil) under water-cooling. Each diamond bur was used in four preparations and then discarded. The cavities were prepared in order to achieve: 1 – the largest possible dimensions, which averaged 7 mm wide, 6 mm long and 2 mm deep; 2 – completely flat cavity floor dentin; 3 – complete enamel cavo-surface margins. The specimens were randomly divided into two groups, according to the bonding technique: water-wet ($n = 10$ teeth) and ethanol-wet bonding techniques ($n = 10$ teeth). Due to the cavity dimensions, the bonding was performed in deep dentin.

For the water-wet bonding technique, preparations were total-etched with 35% phosphoric acid gel for 15 s, followed by water rinsing (15 s). Two coats of the Scotchbond Multi-Purpose primer (Adper Scotchbond Multi-Purpose Plus – 3M ESPE, St. Paul, MN, batch number # 0804002271; Table 1) were applied to visibly moist demineralized dentin according to the manufacturer's directions. After briefly air-drying for 10 s, Scotchbond Multi-Purpose Adhesive was applied and light cured for 10 s.

After acid-etching, dentin in the ethanol-wet bonding group was treated with a series of increasing ethanol concentrations: 50%, 70%, 80%, 95% and three 100% ethanol applications for 15 s each following a chemical dehydration protocol [22]. Dehydration procedures were meticulously performed to ensure that the dentin surface was always