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Effect of dimethyl sulfoxide wet-bonding technique on hybrid layer quality and dentin bond strength

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ABSTRACT

Objectives. This study examined the effect of a dimethyl sulfoxide (DMSO) wet bonding technique on the resin infiltration depths at the bonded interface and dentin bond strength of different adhesive systems.

Methods. Flat dentin surfaces of 48 human third molars were treated with 50% DMSO (experimental groups) or with distilled water (controls) before bonding using an etch-and-rinse (SBMP: Scotchbond Multi-Purpose, 3M ESPE) or a self-etch (Clearfil: Clearfil SE Bond, Kuraray) adhesive system. The restored crown segments ($n = 12$/group) were stored in distilled water (24 h) and sectioned for interfacial analysis of exposed collagen using Masson's Trichrome staining and for microtensile bond strength testing. The extent of exposed collagen was measured using light microscopy and a histometric analysis software. Failure modes were examined by SEM. Data was analyzed by two-way ANOVA followed by Tukey Test ($\alpha = 0.05$).

Results. The interaction of bonding protocol and adhesive system had significant effects on the extension of exposed collagen matrix ($p < 0.0001$) and bond strength ($p = 0.0091$). DMSO-wet bonding significantly reduced the extent of exposed collagen matrix for SBMP and Clearfil ($p < 0.05$). Significant increase in dentin bond strength was observed on DMSO-treated specimens bonded with SBMP ($p < 0.05$), while no differences were observed for Clearfil ($p > 0.05$).

Significance. DMSO-wet bonding was effective to improve the quality of resin–dentin bonds of the tested etch-and-rinse adhesives by reducing the extent of exposed collagen matrix at the base of the resin–dentin biopolymer. The improved penetration of adhesive monomers

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is reflected as an increase in the immediate bond strength when the DMSO-wet bonding technique is used with a water-based etch-and-rinse adhesive.

1. Introduction

Modern dental restorations rely on the adhesives providing adequate bonds between the tooth and the restorative composite. Several approaches to enhance the bond strength of adhesive system to dentin have been studied in the past decade [1–4]. Even though they have produced promising *in vitro* results, some concepts defy the principles of user friendliness and technique simplification. Clinically feasible acceptable methods to enhance dentin adhesion improving the collagen–resin biopolymer are still needed.

Current bonding systems to dentin rely on effective adhesive penetration into dentin substrate to form the hybrid layer [3,5] and on chemical interactions between residual hydroxyapatite and specific functional monomers found mainly in self-etch adhesives [6–8]. The resultant micro-mechanical interlocking formed after dentin hybridization is a prerequisite to achieve adequate dentin bonding [3,8]. Ideally, such resin–dentin interfusion zone should form a continuous and stable tooth-restoration interconnection. However, this objective is not achieved by contemporary adhesives [4,9,10].

Dimethyl sulfoxide (DMSO; $(CH_3)_2SO$) is a polar aprotic solvent that dissolves both polar and non-polar compounds. It is a polyfunctional molecule with a highly polar S=O group and two hydrophobic CH_3 groups. DMSO is fully miscible in solvents and most adhesive monomers [11] used in adhesive dentistry. Moreover, DMSO has the ability to dissociate the highly cross-linked collagen into a sparser network of apparent fibrils [12] also in dentin matrix [13], most likely by the suppression of hydrogen bond-mediated attractive forces within the collagen [14]. This allows DMSO to efficiently penetrate biological surfaces, which makes it perhaps the best currently known penetration enhancer for medical purposes [15].

In a recent study, a considerably low concentration of DMSO was shown to reduce dentin bond strength loss after aging [13]. Considering DMSO properties, higher concentrations might have a positive effect on dentin bonding. Since adhesive resins cannot completely infiltrate collagen matrices in demineralized dentin [16], and since monomer diffusion into the dentin substrate is critical to proper dentin bonding [3,4,8,16], the aim of this study was to investigate the effect of high DMSO concentration on dentin bonding. The hypothesis set were that dentin pretreatment with DMSO would: (i) reduce the amount of exposed collagen matrix at the base of the hybrid layer and (ii) increase immediate dentin bond strength values of commercially available adhesive systems.

2. Materials and methods

2.1. Tooth preparation

Forty-eight recently extracted non-carious human third molars were obtained after patient informed consent under a protocol approved by the Ethical Committee of the Piracicaba Dental School, University of Campinas, Brazil (protocol 017/2013). Teeth were cleaned, ultrasonicated in water for 5 min for cleaning, disinfected for 1 week in 0.5% chloramine-T solution at 4 °C, and stored in distilled water at 4 °C for up to 1 month before use. A flat coronal dentin surface was obtained by sectioning off the occlusal surface (Isomet 1000 Precision Saw, Buehler, Lake Bluff, IL, USA). The surface roughness was standardized with 600-grit silicon carbide paper (BuehlerMet, Buehler) for 1 min under water cooling.

2.2. Dentin bonding

The teeth were randomly assigned to four groups ($n = 12$) according to the adhesive/bonding technique: (i) three-step etch-and-rinse adhesive (Adper Scotchbond Multi-Purpose, 3M ESPE, St. Paul, MN, USA) (SBMP); (ii) DMSO-wet bonding with SBMP; (iii) two-step self-etch adhesive (Clearfil SE Bond, Kuraray, Osaka, Japan) (Clearfil); and (iv) DMSO-wet bonding with Clearfil. DMSO-wet bonding consisted of light-pressure circular scrubbing movements of a 50 μL of water-based 50% (v/v) DMSO (dimethyl sulfoxide, Sigma–Aldrich, St. Louis, MO, USA) (pH 8.2) for 60 s, using a disposable cavity brush. For SBMP, DMSO was applied after dentin etching; for Clearfil, DMSO was applied onto smear layer-covered dentin. Control groups consisted of distilled water application for 60 s instead of DMSO. Table 1 displays mode of application, components and manufacturers of the adhesives. Both adhesive systems were applied actively [17]. Adhesive procedures were carried out in a controlled environment with a temperature of 24 °C and a relative humidity of 60%. Resin composite build-ups (Z250, shade A2, 3M ESPE) were built on top of the bonded dentin surfaces in four 1-mm increments that were individually light-cured for 20 s. Light curing of all resin materials was performed using an LED device (Bluephase 20i, Ivoclare Vivadent, Schaan, Liechtenstein). All procedures were carried out by a single operator.

2.3. Specimen preparation

After storage in distilled water at 37 °C for 24 h, the restored segments were sectioned (Isomet 1000 Precision Saw, Buehler) occluso-gingivally into four slabs measuring approximately 0.9 mm. One composite-dentin slab was randomly reserved for morphologic analysis of the adhesive interface with an