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Influence of dentin cavity surface finishing on micro-tensile bond strength of adhesives

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ABSTRACT

The current trend toward minimal-invasive dentistry has introduced innovative techniques for cavity preparation. Chemical vapor deposition (CVD) and laser-irradiation technology have been employed as an alternative to the common use of regular burs in high-speed turbines.

Objectives. The purpose of this study was to assess the influence of alternative techniques for cavity preparation on the bonding effectiveness of different adhesives to dentin, and to evaluate the morphological characteristics of dentin prepared with those techniques.

Methods. One etch&rinse adhesive (OptiBond FL, Kerr) and three self-etch systems (Adper Prompt L-Pop, 3M ESPE; Clearfil SE Bond, Kuraray; Clearfil S3 Bond, Kuraray) were applied on dentin prepared with a regular bur in a turbine, with a CVD bur in a turbine, with a CVD tip in ultrasound and with an Er,Cr:YSGG laser. The micro-tensile bond strength (μTBS) was determined after storage in water for 24 h at 37 °C, and morphological evaluation was performed by means of field-emission-gun scanning electron microscopy (Feg-SEM).

Results. Feg-SEM evaluation revealed different morphological features on the dentin surface after the usage of both the conventional and alternative techniques for cavity preparation, more specifically regarding smear-layer thickness and surface roughness. CVD bur-cut, CVD ultra-sonoabraded and laser-irradiated dentin resulted in lower μTBSs than conventionally bur-cut dentin, irrespective of the adhesive employed.

Significance. The techniques, such as CVD diamond-bur cutting, CVD diamond ultra-sonoabrasion and laser-irradiation, used for cavity preparation may affect the bonding effectiveness of adhesives to dentin, irrespective of their acidity or approach.

1. Introduction

A significant advance in adhesive technology has strongly influenced current concepts in restorative dentistry. Tooth-bonded restorations require only the removal of carious enamel and dentin, basically involving sufficient access to the lesion in order to be able to completely eliminate the diseased tissue, and the subsequent production of a proper bonding surface [1]. Therefore, the surgical approach of "extension for prevention" proposed by Black is no longer

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accepted or justifiable. Alternatively, a concept often referred to as minimal-invasive or minimum-intervention dentistry has been established, emphasizing a more conservative cavity design [2]. In an attempt to fulfill the requirements of this new treatment concept, innovative cavity-preparation techniques are currently available, basing their principles on modern technologies, such as diamond ultra-sonoabrasion and laser-irradiation.

The production of diamond tips for ultrasonic purposes depends on the employment of an innovative technology, originally known as chemical vapor deposition (CVD) [3]. CVD provides high adherence between the slim diamond film and the metal tip [4–6]. Its capability of working at highly inclined angles, not accessible to conventional rotary instruments, guarantees the achievement of a conservative cavity design [7]. On the other hand, an Er,Cr:YSGG laser device was also recently recommended for minimally invasive purposes, mainly because of its precise ablation of enamel and dentin without any side effects [8,9]. Even though the effects of conventional tips for ultra-sonoabrasion and Er:YAG laser-irradiation on dental hard tissues have been fully studied, there have been few studies regarding the use of CVD diamond instruments and Er,Cr:YSGG laser for cavity preparation.

Since both traditional and innovative techniques are based on different procedures for cavity preparation, different grinding patterns and smear-layer features will probably be obtained [9,10]. Considering that the effectiveness of self-etch adhesives is strongly influenced by such variations [11–14], different bonding interactions could be expected between these adhesives and alternatively prepared dentin surfaces. Therefore, further studies are necessary to fully clarify how new techniques for cavity preparation affect the bonding effectiveness of self-etch adhesives to dental hard tissues.

The first purpose of this in vitro study was to evaluate the morphological characteristics of the dentin surface, after being prepared with a CVD diamond bur in a high-speed turbine, a CVD diamond tip in an ultrasound device, a Er,Cr:YSGG laser and a conventional diamond bur in a high-speed turbine. Furthermore, the authors determined the micro-tensile bond strength (μTBS) of one etch&rinse and three self-etch adhesives to dentin prepared with the above-mentioned techniques. The null hypothesis tested was that both conventional and alternative cavity-preparation techniques are equally receptive to bonding procedures.

2. Materials and methods

Sixty-four non-carious human third molars (gathered following informed consent approved by the Commission for Medical Ethics of the Catholic University of Leuven) were stored in 0.5% chloramine solution at 4 °C and used within 1 month after extraction. First, the molars were mounted in gypsum blocks in order to facilitate sample manipulation. All the teeth were randomly divided into 16 groups according to the adhesive system and surface treatment employed. A three-step etch&rinse adhesive, OptiBond FL (Kerr, Orange, CA, USA), a two-step self-etch adhesive, Clearfil SE Bond (Kuraray, Osaka, Japan) and two one-step self-etch adhesives, Clearfil S^3 Bond (Kuraray, Osaka, Japan), and Adper Prompt L-Pop (3M ESPE, Seefeld, Germany), were applied on dentin prepared with a CVD diamond bur (Clorovale, São José dos Campos, Brazil) in a high-speed turbine, a CVD diamond tip (CVDentus, Clorovale, São José dos Campos, Brazil) in an ultrasound device, an Er,Cr:YSGG laser (Waterlase, Biolase Technology, Inc., San Clemente, CA) and a conventional diamond bur (Komet) in a high-speed turbine (control group). Details regarding the selected adhesives, such as manufacturer, composition, application technique and batch number, are listed in Table 1.

2.1. Specimen preparation

Mid-coronal dentin surfaces were obtained by removing the occlusal third of the molar crowns using an Isomet slow-

Table 1 – Chemical composition and application mode of the adhesives tested

Adhesive (manufacturer)	Composition (batch no.)	Application
OptiBond FL (Kerr, Orange, CA, USA)	*Etchant*: 37.5% phosphoric acid, silica thickener (410643); *Primer*: HEMA, GPDM, PAMM, ethanol, water, photo initiator (417174); *Bond*: TEGDMA, UDMA, GPDM, HEMA, Bis-GMA, filler, photo initiator (421941)	Apply the etchant for 15 s; rinse for 15 s; gently air-dry for 5 s; scrub the surface for 15 s with primer; gently air-dry for 5 s; apply a thin coat of bonding agent and light-cure for 30 s
Clearfil SE (Kuraray, Osaka, Japan)	*Primer*: 10-MDP, HEMA, hydrophilic dimethacrylate, photo initiator, water (00480A); *Bond*: 10-MDP, Bis-GMA, HEMA, hydrophilic dimethacrylate, microfiler (00666A)	Apply the primer for 20 s; gently air-blow; apply the bond and light-cure for 10 s
Clearfil 3S (Kuraray, Osaka, Japan)	10-MDP, Bis-GMA, HEMA, hydrophobic dimethacrylate, photo initiator, ethyl alcohol, water, microfiler (00001A)	Apply adhesive and leave it in place for 20 s; dry by blowing high-pressure air for 5 s and light-cure for 10 s
Adper Prompt L-Pop (3M ESPE, Seefeld, Germany)	*Liquid 1*: methacrylated phosphoric esters, Bis-GMA, camphorquinone, stabilizers; *Liquid 2*: water, HEMA, polyalkenoic acid, stabilizers (199474)	Activate blisters; apply adhesive and scrub the surface for 15 s; gently air-dry; apply second coat without rubbing; air-dry to a thin film and light-cure for 10 s

Bis-GMA, Bisphenol-glycidyl methacrylate; GPDM, glycerol phosphate dimethacrylate; HEMA, hidroxyethilmethacrylate; 10-MDP, 10-methacryloyloxydecyl dihydrogen phosphate, PAMM, phthalic acid monoethil methacrylate; TEGDMA, triethilene glycol dimethacrylate; UDMA, urethane dimethacrylate.