

INFLUENCE OF REUSED DENTAL BURS ON BOND STRENGTH TO DENTIN

ABSTRACT

AIM: this study evaluated the bond strength of an adhesive system to human dentin prepared with reused diamond burs. **MATERIAL AND METHODS:** five molars (G1) were prepared in a standardized way with five diamond burs. Flat deep dentin surfaces were etched, received adhesive and received composite build-ups. The same burs were cleaned and reused on another five teeth groups (G2 until G8). After 24-hours storage and thermocycling, 50 dentin-resin sticks per group were obtained and subjected to microtensile bond strength test (μ TBS). **RESULTS:** analysis of variance (ANOVA) and Tukey test were applied to identify differences between groups ($p < 0.05$). The reuse of a diamond bur for more than two preparations resulted in significantly lower μ TBS values ($G1 = G2 > G3 = G4 = G5 = G6 = G7 = G8$). **CONCLUSION:** Reuse of diamond burs interfered on adhesion between dentin and resin.

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KEYWORDS

Dental burs. Dentin. Bond strength.

INTRODUCTION

Regarding the improvements of adhesion on dental substrates, the retention of most restorations are relied on hybridization concept. The dentin substrate is partially demineralized, infiltrated by resin monomers and after its polymerization a hybrid layer is composed.¹ Nevertheless, dentin adhesion remains more difficult, less predictable and is influenced by several factors including cutting.² During tooth preparation dentin surface is covered by smear layer (mixture of enamel, dentin, cement, blood, saliva and microorganisms) that occludes dentin tubules orifices.³ This layer presents weak adhesion to underlying dentin substrate and act as “diffusion barriers”, then it must be removed or modified in order to obtain a good hybridization.⁴

Tooth preparations for direct or indirect restorations are usually conducted with diamond burs because their greater abrasion resistance and lower heat generation.⁵ These rotatory instruments were empirically introduced in dentistry in the late 19th century and have undergone improvements. Dental burs are basically composed of multiple layers of diamond chips (natural and synthetic) attached to a metal rod. Different grit sizes are available but medium-grit (average particle size of 90-120µm) is most commonly used in prosthetic preparations.^{6,7}

The American Dental Association, the Centers for Disease Control and Prevention and other organizations clearly state that all dental instruments that penetrate or come into contact with dental tissues must be sterilized after each use to minimize cross-contamination risks. Cleaning and sterilization procedures of diamond bur are time-consuming then it should be disposable or “single-patient-use”.⁵ However in most dental offices diamond burs are reused. Additionally, manufacturers do not clearly indicate the bur durability so its discard is personal and subjective.

After tooth preparation, diamond bur surface is modified and if is used for another dental wear the smear layer may present distinct characteristics. Some studies showed that smear layer thickness resulted by different abrasives and dentin topography after its removal affect bond strength to adhesive systems and resin cements.^{8,9,10,11,12,13,14,15,16,17,18} Therefore, is important to evaluate the effects of repeated use of diamond burs on the formation of hybrid layers with different bonding potentials. This *in vitro* study investigates the influence of diamond bur reuse on bond strength between coronal deep dentin and an etch&rinse adhesive.

MATERIAL AND METHODS

A total of 40 extracted noncarious permanent human molars with similar dimensions, gathered following informed consent approved by the Ethics Committee on Human Research of the Federal University of Santa Catarina (#2310), after debridement were stored in distilled water up to six months until they were used.

In order to obtain specimens for microtensile test it was necessary to fill pulp chambers. Root portions were removed with a low-speed saw (Isomet 100, Buehler, Lake Buff, IL, USA). After their cleaning and emptying, each chamber was etched with phosphoric acid 37% (37 Condac, FGM Dental Products, Joinville, SC, Brazil) for 15 seconds, thoroughly rinsed and dried with cotton pellet. A simplified adhesive system (Adper™ Single Bond 2, 3M ESPE, St. Paul, MN, USA) was applied strictly following the manufacturer's guidelines (Table 1). Chambers were incrementally filled with composite resin (Filtek Z350, color OA3, 3M ESPE, St. Paul, MN, USA) and cured for 40 seconds with a LED unit (Litex 696 LED Curing Light CORDLESS, INC. Dentamerica., City of Industry, CA, USA) with a output of 1.000mW/cm².

Five teeth were randomly selected to compose Group 1 (G1). And received a circumferential mark 4mm below cusp in order to limit wear in approximately 65% of coronal volume (simulating a full crown volume reduction). Teeth were vertically aligned in individual polymeric tubes and embedded with silicone impression material to within 2mm of cemento-enamel junction. Each G1 tooth received a standardized wear with a new cylindrical medium-grit conventional diamond bur (#4102, KG Sorensen, Barueri, SP, Brazil), mounted on high-speed water-

cooled handpiece (605C Extra torque, Kavo, Joinville, SC, Brazil) and perpendicular positioned to dental long axis. All preparations were performed by the same operator with similar pressure and the bur was moved along the occlusal surface (buccolingual guidance) toward cervical direction. Wear was disrupted when the circumferential mark was reached, then a flattened deep coronal dentin surface was obtained. In addition, time spent in each preparation was registered. Afterward each flat dentin surface was etched with phosphoric acid 37% for 15 seconds, rinsed and dried with cotton pellet. An etch&rins adhesive system (Adper Scotchbond Multi-Purpose, 3M ESPE, St. Paul, MN, USA) was applied according manufacturer's instructions (Table 1). A composite build-up was then made using a single resin composite (Filtek Z350, shade A1, 3M ESPE, St. Paul, MN, USA) which was applied in two increments with a height of approximately 2mm and cured for 40 seconds with a LED unit. G1 teeth were stored in 37°C distilled water to simulate the oral temperature and moisture.

The five diamond burs used on G1 teeth preparations were mechanically cleaned by hand scrubbing (20 times with wire brush) in running water to remove debris and ultrasonically cleaned for 5 minutes. Burs were sterilized in an autoclave machine (Autoclave Automatic Horizontal Model AC365, Ortosintese Industria e Comercio Ltda., SP, Sao Paulo) with a temperature of 128°C. The same five burs were reused for identical preparations on another five teeth (G2). Cutting, bonding and restoration procedures were performed as same manner as G1. Diamond burs continued to be cleaned, sterilized and reused in another five teeth sets then creating six more groups (G3, G4, G5, G6, G7 and G8). After 24-hour water storage, all teeth

were subjected to water baths set to 5°C and 55°C for 500 cycles, with dwell time of 30 seconds.

Table 1. Adhesives composition and indications for use.

Adhesive	Composition	Instructions for Use
Adper Single Bond 2	Bis-GMA, HEMA, dimethacrylates, ethanol, water, photoinitiator system, methacrylate functional copolymer of polyacrylic and polyitaconic acids.	Apply 2-3 consecutive coats of adhesive for 15 seconds with gentle agitation using a fully saturated applicator. Gently air thin for 5 seconds to evaporate solvent and light-cure for 10 seconds.
Scotchbond Multi-Purpose	<i>Primer:</i> water, HEMA, polycarboxylic acid. <i>Bond:</i> Bis-GMA, HEMA, camphorquinone, EDMAB, DHEPT.	Apply the primer for 30 seconds, dry gently for 5 seconds. Apply the bond and light-cure for 20 seconds.

Resin-dentin specimens were sectioned using a water-cooled diamond saw (Isomet 1000, Buehler, Lake Bluff, IL, USA) in both the x and y directions to obtain ten rectangular sticks (cross-sectional area of $0.9 \pm 0.2 \text{ mm}^2$) selected from the central part of each tooth. Fifty sticks were randomly selected per group. The 400 sticks had their bonding interface measured by means of a digital caliper (model 727, Starrett, Itu, SP, Brazil) with 0.01mm accuracy. Non-trimmed sticks had the extremities individually fixed on Geraldini's device using cyanoacrylate glue and tested in tension at a crosshead speed of 0.5 millimeters/minute using a universal testing machine (Instron, model 4444, Instron Corp., Canton, MA, USA). The μTBS values were calculated in MPa considering maximum load (in N) at the time of fracture and bonding area (in mm^2).

The failure modes were evaluated using a magnifying glass with 4x magnification and classified as "interfacial", "cohesive" (dentin or composite) or "pre-testing". Only "interfacial" fractured specimens were included at the statistical analysis. The means and standard deviations were calculated for each group. And data were evaluated

by one-way ANOVA and Tukey's multiple comparisons test at a significance level of $\alpha=0.05$ using SPSS 17.0 (IBM, Chicago, IL, USA).

RESULTS

The μTBS means of the eight groups are shown in Figure 1 and ranged from 16.07 to 27.17 MPa. The analysis of variance test showed significant difference between groups ($p < 0.05$). Tukey post-hoc test revealed that G1 and G2 presented significant high μTBS values than the other groups (Table 2).

It was observed that time required for preparation increased according to the diamond bur reuse, indicating a greater difficulty for tooth cutting. A time increase of approximately 11% (or 20 seconds) was recorded between G1 and G8.

DISCUSSION

Thermocycling was realized prior bond strength measurement in order to simulate

thermal changes that usually occur in the oral environment. This process induces stresses on adhesive interface enhancing composite water sorption and hydrolytic degradation of hybrid layer.¹⁹ Some studies use a larger number of cycles and classified 10.000 cycles as a year in oral function. Therefore, 500 thermal cycles used in this study following ISO protocol

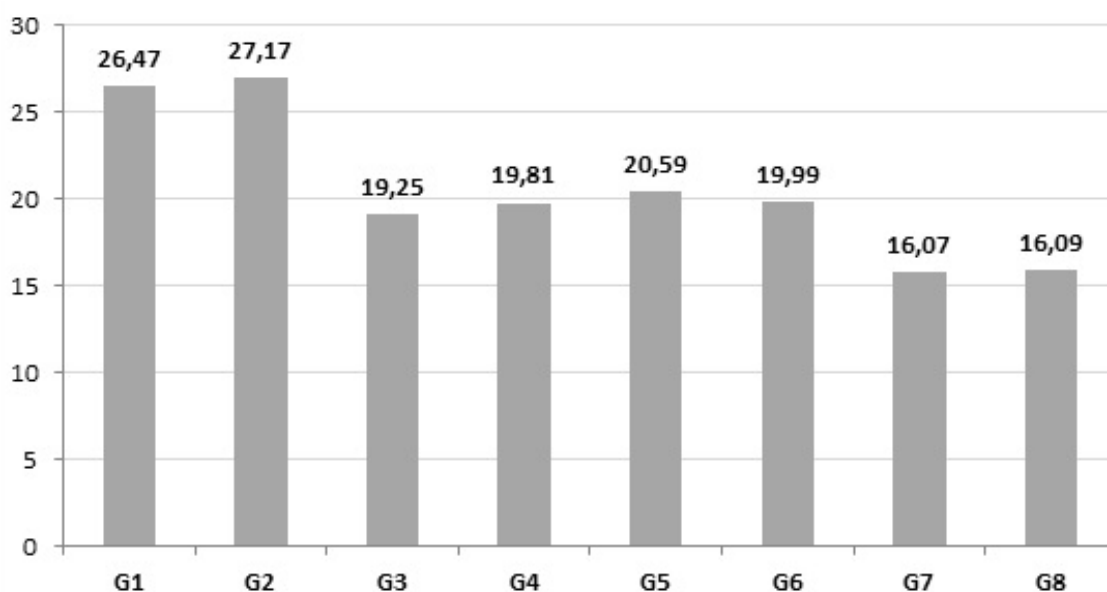
correspond to approximately 20 days of aging.²⁰ Due to lack of standardization and consensus in the literature about thermocycling protocols, is not possible to affirm if this artificial aging method influenced bond strength values.²¹

Table 2. μ TBS and Failure Analysis.

Groups	Microtensile Bond Strength		Failure Analysis		
	Mean μ TBS (MPa)	ptf/n*	Interfacial	Cohesive in Dentin	Cohesive in Resin
G1	26.47 \pm 8.07 ^a	4/50	44	-	2
G2	27.17 \pm 9.80 ^a	2/50	45	1	2
G3	19.25 \pm 7.55 ^b	1/50	47	2	-
G4	19.81 \pm 7.84 ^b	2/50	45	1	2
G5	20.59 \pm 8.27 ^b	4/50	45	1	-
G6	19.99 \pm 7.19 ^b	3/50	44	2	1
G7	16.07 \pm 6.20 ^b	4/50	46	-	-
G8	16.09 \pm 5.92 ^b	2/50	40	7	1

*ptf = pre-testing failures, n = number of specimens, values with the same superscript are not statistically significantly different.

Figure 1. μ TBS means values (MPa) of eight experimental groups.



Most *in vitro* studies that evaluate the bond strength uses SiC papers #600 to prepare dentin substrate which enables a standardized smear layer because it reduces the influence of operator. Indeed, these studies do not indicate clinical relevance of this approach because it is not clinically feasible.²² In this research, smear layer was created using diamond burs as in the clinical procedures. Dentin surface roughness, smear layer thickness and density are dependent of the instrument applied for cutting. Diamond bur is currently most widely used than tungsten carbide burs and medium-grain (91µm-126µm) grit is recommended for gross tooth reduction.²

A full anterior or posterior crown preparation promotes 63% to 72% coronal volume reduction.^{23,24} Approximately the same cutting volume was conducted in each tooth to represent one diamond bur use. Dentin bond strength measurement is relevant because this substrate is most available for adhesive luting in this preparation design.

According to literature the lowest and highest microtensile bond strength values between Adper Scotchbond Multi-Purpose and dentin are 12.7 and 56.3MPa, depending of substrate condition (sound, carious or sclerotic) and aging protocol (none, water storage or thermocycling).² Values registered in our research (15.09 – 27.17Mpa) are within this range. And it is noteworthy that these low values are due to deep coronal dentin. The

relative area of dentin occupied by tubules decreases as they diverge from the pulp. These tubules are involved directly on hybridization quality and consequently determine the bond strength. Moreover, dentin moisture might dilute or precipitate bonding agent, thus reducing bond strength.²⁵

Dentin topography after smear layer removal reflects the irregularities produced by cutting and a more irregular surface result in an increased surface area. It is possible to estimate that roughness influences adhesion.²² According to our results, higher dentin bond strength values were obtained after first and second diamond bur use (G1 and G2), suggesting that superficial roughness produced is more favorable for hybridization than G3 to G8. Other methodologies including SEM must complement this study to investigate smear layer characteristics.

Considering that there are no studies investigating diamond bur reuse influence on dentin bond strength any direct comparison can be realized. An *in vitro* study revealed that repeated use of diamond burs may result in an increase on microleakage of composite resin restorations for both etch&rinse or self-etch adhesives.²⁶ Another similar *in vitro* research evaluated Class V restorations and suggested that reusing disposable burs can affect the leakage behavior. The use of diamond bur for more than three preparations increased marginal leakage and SEM images showed

diamond wear and debris accumulation deposited on the new preparations.²⁷ This may influenced dentin bond strength as occurred in our research.

Improvements on adhesives allowed dentists to provide adhesive restorations to patients. Possibly, the diamond bur condition when executing a tooth preparation is the most neglected factor by dentists due absence of parameter for it disposal, because criteria are still personal and subjective. Scientific research must search for a diamond bur disposal parameter, therefore dentists would have enough information to standardize the use of these instruments.

CONCLUSION

Diamond bur reuse for cutting tooth structure influences bond strength between deep coronal dentin and an etch&rinse adhesive system. When diamond bur was used more than twice to wear a substrate volume compatible with a full crown preparation the bond strength was significantly lower.

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