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Faculdade de Medicina da Universidade de Coimbra

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Effect of ultrasound tooth preparation in micro-tensile bond strength using different adhesive strategies

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Coimbra, Julho 2019

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Dumbo

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Summary

Abstract

Introduction: Intracoronal or extracoronal tooth preparations are conventionally performed with diamond burs. However, these instruments have some limitations, thus new devices have been suggested, such as ultrasonic instruments. This new technology seems advantageous throughout the available literature regarding tooth surface morphology, yet its influence on bonding procedures still needs further research. The aim of this study was to evaluate and compare two different tooth preparation techniques (CVD diamond ultrasound tips vs conventional diamond burs) regarding the dentin adhesion obtained with two different strategies (self-etch vs etch-and-rinse) by means of micro-tensile bond strength testing (μTBS).

Materials and Methods: A total of 16 intact permanent molars were collected and divided into two halves by a diamond disk. Then they were distributed into four groups, according to the preparation method and adhesive system used. Afterwards, one half of each tooth was prepared with the CVD tip and the other with a diamond bur. A single operator carried out all tooth preparations, as well as all restoration procedures. Then, the teeth were sectioned to obtain uniform sticks that were then submitted to micro-tensile testing (μTBS) using a universal testing machine. Data statistical analysis was performed using Shapiro-Wilk and Leven test. The influence of both variables was analyzed using Two-way ANOVA.

Results: There were no statistically significant differences between the means of micro-tensile bond strength concerning the adhesive system ($F(1,24) = 1.004$, $p = 0.326$), nor regarding the type of cut ($F(1,24) = 2,505$, $p = 0.127$), neither in what concerns to the interaction between both factors ($F(1,24) = 0.040$, $p = 0.840$).

Conclusions: Both adhesive strategies presented similar μTBS values and therefore might be equally effective regardless the preparation technique. Concerning the preparation method, ultrasound groups showed the highest values of micro-tensile bond strength independently of the adhesive strategy, although not statistically significant. Further studies in this line of research are needed with standardized experimental protocols to establish clear relations between the evaluated parameters.

Key-words: Dental Cavity Preparation, CVD, Ultrasonics, Smear Layer, Dental Bonding, Tensile Strength.

Resumo

Introdução: Preparações dentárias intracoronárias ou extracoronárias são convencionalmente realizadas com brocas diamantadas. No entanto, esses instrumentos possuem algumas limitações, daí novos dispositivos terem sido propostos, tal como instrumentos ultrassónicos. Esta nova tecnologia parece ser vantajosa, à luz da literatura atual, no que concerne à morfologia da superfície dentária, embora a sua influência nos procedimentos adesivos ainda precise de mais estudos. O objetivo deste estudo foi avaliar e comparar duas técnicas distintas de preparação dentária (pontas diamantadas CVD vs brocas diamantadas convencionais), quanto à adesão dentinária obtida com duas estratégias distintas (autocondicionamento vs condicionamento total), por meio de um teste de resistência adesiva por microtração (μTBS).

Materiais e métodos: Um total de 16 molares permanentes intactos foram recolhidos e divididos em duas metades com um disco de diamante. Em seguida, foram distribuídos em quatro grupos, de acordo com o método de preparação e o sistema adesivo utilizado. Depois, uma metade foi preparada com a ponta CVD e a outra com uma broca diamantada. Um único operador realizou todas as preparações dentárias e todos os procedimentos restauradores. Em seguida, os dentes foram seccionados para obtenção de bastonetes uniformes que foram então submetidos ao teste de microtração (μTBS), utilizando uma máquina de testes universal. A análise estatística dos valores obtidos foi realizada pelos testes Shapiro-Wilk e Leven. A influência de ambas as variáveis foi analisada utilizando Two-way ANOVA.

Resultados: Não houve diferenças estatisticamente significativas entre os valores médios de força de adesão no que toca ao sistema adesivo ($F(1,24) = 1,004$, $p = 0,326$), nem quanto ao tipo de corte ($F(1,24) = 2,505$, $p = 0,127$), nem no que diz respeito à interação entre os dois fatores ($F(1,24) = 0,040$, $p = 0,840$).

Conclusão: Ambas as estratégias adesivas apresentaram valores similares de μTBS, portanto podem ser igualmente eficazes independentemente da técnica de preparação. Em relação ao método de preparação, os grupos em que foram utilizados instrumentos ultrassónicos apresentaram os maiores valores de força de adesão, independentemente da estratégia adesiva, embora sem significância estatística. É imprescindível a realização de mais estudos, com aplicação de metodologias standard, para clarificar as relações entre as variáveis testadas.

Palavras-chave: Preparo da Cavidade Dentária, CVD, Ultrassom, Camada de Esfregaço, Colagem Dentária, Resistência à Tração.

Introduction

Intracoronal or extracoronal tooth preparations are conventionally performed with rotatory instruments, usually diamond burs produced by plating small industrial or mineral diamond particles on stainless steel shanks by a galvanic process. [1, 2]

Although widely spread, these instruments present some limitations due to the heterogeneity of the grain shape and size within the same bur, the difficulty of automation in the fabrication process, the short lifetime and the possibility of decreasing their cutting effectiveness as a result of repeated sterilization cycles or grain detachment on use, causing an irregular diamond particle loss, ultimately leading to the production of irregular and unpredictable preparation surfaces in terms of roughness and finishing. [1-4]. Moreover, stemming this multifactorial wear, this type of bur can lead to contamination of the dental surface by Ni^{2+} ions. [1, 3]

In an attempt to overcome these limitations, new devices for dental preparation and finishing have been suggested. The most preeminent are ultrasonic instruments produced by the chemical vapor deposition (CVD) of diamond around a molybdenum stem. [5-8] These tips are highly resistant to wear and demonstrate efficient cutting ability and longevity. [5, 6, 9] CVD ultrasonic instruments are also capable of working at highly inclined angles, not accessible to conventional rotary instruments, allowing for conservative cavity preparations. [3, 9-12] Additionally, these ultrasonic instruments are atraumatic to soft tissues (gingiva and dental pulp) due to their oscillating action and also to adjacent teeth because of the selective active cutting surfaces. [2, 5, 12-14] The use of molybdenum stems facilitates a fabrication process in which direct CVD diamond layers are centripetally deposited over the metal stem with high adhesion characteristics, creating an homogenous, thick and dense diamond cutting instrument that can be adapted to the handpiece of an ultrasonic device. [2, 5, 7, 8, 11, 12, 15] The continuous diamond film without a metallic binder between crystals not only prevents the accumulation of metal ions on the tooth, but also allows the instrument to maintain a constant cutting ability with the creation of consistent preparation surfaces. [5]

Although CVD diamond instruments seem advantageous throughout the available literature regarding tooth surface morphology, there is few information about what happens when used with adhesive procedures. Regarding microleakage, some authors report similar [5] or higher performance [3] when compared to substrates prepared with conventional diamond burs. A decrease in smear layer deposit on the dental surface when CVD tips are used for cavity preparation is also well described in the literature, with very limited conclusions on the clinical effect of this finding. [3, 6-8]

Smear layer is a surface accumulation of debris formed after the preparation of enamel and dentin with an amorphous and irregular appearance. [14] This deposit is composed by an inorganic (hydroxyapatite) and an organic (bacteria, proteins, and remnants of odontoblastic processes within dentinal tubules) part.[6] Some of the factors responsible for modifying the smear layer characteristics are the type of instruments used [10, 15, 16], the pressure applied by the operator, the use and nature of cooling and the size and shape of cavity preparation. [6] The quality of the formed smear layer is important because of its influence in bond strength. [6, 10, 11, 17]

Adhesion can also be influenced by the type of bonding system used: etch-and-rinse or self-etching. [17, 18]

With etch-and-rinse systems, a pretreatment of enamel and dentin with acid etching is mandatory [18], which leads to a complete smear layer removal and subsequent exposure of the underlying dentin and collagen matrix. [6, 10] This is followed by a priming step and adhesive resin application resulting in a three-step procedure. Simplified two-step etch-and-rinse adhesives combine the primer and adhesive resin in the same bottle. [18]

Self-etch systems operate by the capacity of their non-rinse acidic monomers to simultaneously condition and prime dentin [6, 10, 17, 18]. This strategy created a permeable smear layer that is not removed but rather integrated. [6, 10]

Aiming to evaluate bond strength in different situations, micro-tensile assays are currently the gold-standard technique to measure the quantity of tensile stress between composite resin, adhesive system and substrate, providing evidence on the effectiveness of the techniques used. [6]

The aim of the present in vitro study is to evaluate and compare two different tooth preparation techniques (CVD diamond ultrasound tips vs conventional diamond burs) regarding the dentin adhesion obtained with two different strategies (self-etch vs etch-and-rinse) by means of micro-tensile bond strength testing (μTBS).

The tested null hypothesis states there are no statistically significant differences between distinct preparation techniques and adhesive procedures.

Materials and Methods

1- Sample size calculation

The sample size calculation was performed using G*Power 3.1 software, adopting the two possibilities of effect size described in the paper entitled “Influence of ultrasound and diamond burs treatments on bond strength” by Conde, A. et al [19]

Three possible levels of significance were considered, α = 0.01, α = 0.05 or α = 0.10. Three different power levels were also considered, 0.80 (1-β = 0.80), 0.90 and 0.95.

A t-student test of bilateral independent samples and an allocation ratio between groups of 1: 1 was also used to calculate the sample size.

The following tables show the results obtained in the different studied scenarios.

Table 1 – Sample size calculation

Etched dentin: 45.31±8.16 e 34.04±9.29 – effect size = 1.29

	1-β=0.80	1-β=0.90	1-β=0.95
α=0.01	16+16=32	20+20=40	24+24=48
α=0.05	11+11=22	14+14=28	17+17=34
α=0.10	9+9=18	12+12=24	14+14=28

Non-etched dentin: 15.17±3.71 e 9.86±3.89 – effect size = 1.40

	1-β=0.80	1-β=0.90	1-β=0.95
α=0.01	14+14=28	17+17=34	20+20=40
α=0.05	10+10=20	12+12=24	15+15=30
α=0.10	8+8=16	10+10=20	12+12=24

We opted for the less conservative scenario, in which 8 elements are needed in each group.

2- Specimen selection and preparation

Human molars extracted for orthodontic or periodontal reasons were collected immediately after extraction and stored in a saline solution until transportation the laboratory. Sixteen (16) intact permanent molars from 16- to 40-year-old individuals, clinically and radiologically presenting no carious lesions, restorations, endodontic pathology, cracks or other abnormal features were selected for the experimental procedures.

Each selected tooth was inspected, cleaned from debris using periondontal scalers and polished in order to remove any calculus or adherent organic material.

Upon arrival to the laboratory, teeth were transferred to a 0,5% chloramine T (chlT) medium and stored for a period of six weeks prior to the experimental procedure at 5ºC.

Each tooth was positioned in a polytetrafluorethylene tube filled with a self-polymerizing acrylic resin (ProBase® Cold – LOT V29238/ Exp 2020-07, Ivoclar Vivadent, Lichenstein), until the full length of the root was embedded in the resin, this obtaining cylinders in order to facilitate subsequent sectioning procedures.

The occlusal surface was sectioned perpendicularly to the long axis of the tooth using a precision cut-off machine (Accutom-5, Struers, USA), with integrated cooling system.

Each tooth was then divided in two halves by means of a thin and shallow groove performed with a diamond disk (Kerr, Orange, CA, USA)

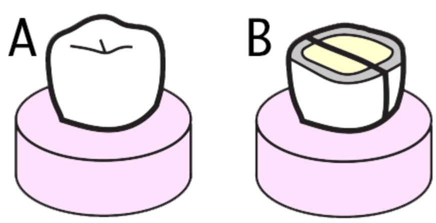

Fig. 1 – Schematic illustrating the division of each tooth in two halves
A – Initial sample; B – Divided sample

3- Group distribution

Four experimental groups were divided by a computer algorithm (www.randomizer.org; Urbaniak, G. C., & Plous, S. (2013); Research Randomizer, Version 4.0), accordingly to surface treatment and adhesive system.

Group 1: OptiBond FL and CVD
Group 2: OptiBond FL and Diamond Bur
Group 3: Clearfil SE Bond and CVD
Group 4: Clearfil SE Bond and Diamond Bur

4- Experimental protocol

A single operator carried out all tooth preparations, as well as all restoration procedures.

Every tooth was assigned two different preparation methods, randomly allocated to each half identified with a letter (A or B), according to the preparation method performed: one of the sections was prepared with a medium-grit diamond bur (Diaswiss®, Nyon, Swiss) in a water-cooled high-speed turbine (Pana-Max2®, NSK, Madrid, Spain) and the other using an ultrasonic tip with chemical vapour deposition diamond coating (CR1U, CVDentus, SP, Brazil) adapted to a piezoelectric ultrasound device (DentSurg PRO®, CVDentus, SP, Brazil) operating according to the parameters recommended by the manufacturer (CVDentus®): 25 to 31 kHz of frequency; 10 W of electric output power; 120ml/min of water flow rate; 70% of its maximum power.

After surface preparation, teeth were randomly divided. Each tooth was given a number used as a reference to sort the different groups with the aid of a randomization software, according to the adhesive strategy used: self-etch – Clearfil SE Bond (Kuraray, Osaka, Japan) and total-etch – OptiBond FL (Kerr, Orange, CA, USA).

Subsequently, the adhesive procedures were performed to the prepared dentin surfaces in a controlled environment (23ºC; 50 ± 3%RH), with the following methodology:

OptiBond™ FL: 37% phosphoric acid was applied to the dentin surface for 15 seconds and rinsed with water for an equal amount of time until etchant has been completely removed; excess water was absorbed with absorbing paper tips. Primer was actively scrubbed using a microbrush for 15 seconds and then gently air dried for approximately 5 seconds. Adhesive resin was applied and air stream was used to remove the excesses until a shiny and static layer was obtained. Light curing (Bluephase Style 20i®, Ivoclar Vivadent, Lichenstein) was performed for 20 seconds,

Clearfil™ SE Bond: primer was applied using a microbrush for 20 seconds, gently air dried to evaporate the solvent; the adhesive resin was applied and air was used to remove the excesses until a shiny and static layer was obtained, followed by 20 seconds of light curing (Bluephase Style 20i®, Ivoclar Vivadent, Lichenstein).

Table 2 – Adhesive systems studied, manufacturers, lot and expiration date, chemical composition

Adhesive System (Manufacturer)	Clearfil™ SE Bond (Kuraray Medical, Tokyo, Japan)	Optibond™ FL (Kerr, Orange, CA, USA)
Lot/Exp	000017 2020-07-31	6899820 2020-03-31
Composition	Primer: 10-MDP, HEMA, dl-camphorquinone, hydrophilic aliphatic dimethacrylate, N,N-Diethanol-p-toluidine, water. Bond: 10-MDP, BisGMA, HEMA, dl-camphorquinone, colloidal silica, N,N-Diethanol-p-toluidine, hydrophobic aliphatic dimethacrylate	Primer: HEMA, GPDM, PAMM, ethanol, camphorquinone, water. Bond: BisGMA, HEMA, GPDM, camphorquinone, glycerol, barium aluminoborosilicate, silicon dioxide dimethacrylate resins

CSE – Clearfil™ SE Bond; OFL – Optibond™ FL; MDP - 10-Methacryloyloxydecyl dihydrogen phosphate; HEMA – 2-hydroxyethyl methacrylate; BisGMA – bisphenol A diglycidylmethacrylate; GPDM – glycerol phosphate dimethacrylate; PAMM – phthalic acid monomethacrylate

In this Split-tooth design, the two halves were separated in the restoration procedure by using a metal matrix (Hawe™, Kerr, Orange, CA, USA) stabilized by applying a rubber dam liquid (myCustom resin™, Polydentia SA, Mezzovico-Vira, Switzerlabnd).

Each area was restored with 2-mm thick increments of Clearfil Majesty ES-2 (Kuraray, Osaka, Japan), obtaining a 6mm high cylinder on the exposed surface.

Photopolymerization was achieved by using a LED light-curing unit at 1,200 mW/cm2 ± 10% (Bluephase Style 20i®, Ivoclar Vivadent, Lichenstein).

After restoration procedures were finished in both tooth areas, the separating metal matrix was removed.

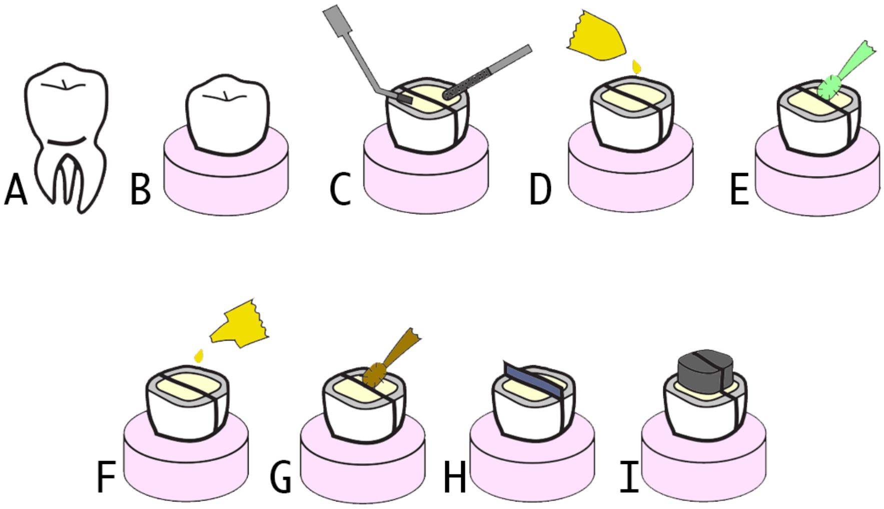

Fig. 2 – Schematic illustrating the successive steps of tooth mounting and bonding with Clearfil SE Bond.

A – Initial sample; B – Mounted sample; C – Preparation with CVD tip and Diamond bur; D – Primer application; E – Active application; F – Bond application; G – Active application; H – Separation of the halves with a metal matrix; I – Restorative procedure

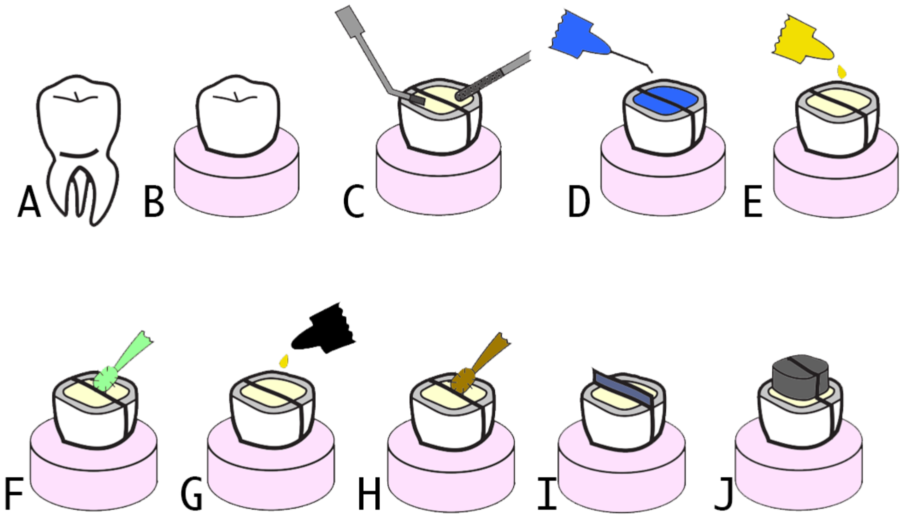

Fig. 3 – Schematic illustrating the successive steps of tooth mounting and bonding with OptiBond FL.

A – Initial sample; B – Mounted sample; C – Preparation with CVD tip and Diamond bur; D – Acid etching application; E – Primer application; F – Active application; G – Bond application; H – Active application; I – Separation of the halves with a metal matrix; J– Restorative procedure.

5 - Tooth preparation for testing

The specimens were stored in a 100% humidity environment and sent to the School of dentistry, Federal University of Amazonas, Brazil where micro-tensile bond strength was to be tested.

Each tooth was cross-sectioned perpendicularly to the adhesive interface in a precision water cooled cut-off machine with a low-speed cutting saw (Accutom-5, Struers, USA), and a speed of 1000 rpm at 0.100 mm/s in order to produce sticks of dentin-composite resin with an approximate sectional square area of 0.8 mm2. After the first cut in x-axis direction, the free residual space between the slices was filled with light body silicone (Virtual®, Ivoclair Vivadent, Schaan, Liechtenstein). Having finished the y-axis direction cut, the roots were sectioned approximately 2 mm bellow the cementoenamel junction. Resulting dentin-composite sticks were analyzed under a stereo-microscope (Leica EZ4 HD, Switzerland) and all samples with defects were excluded.

Each stick was then measured with a thickness gauge (Mitutoyo Digital Caliper, Japan) and the adhesive interface area was calculated.

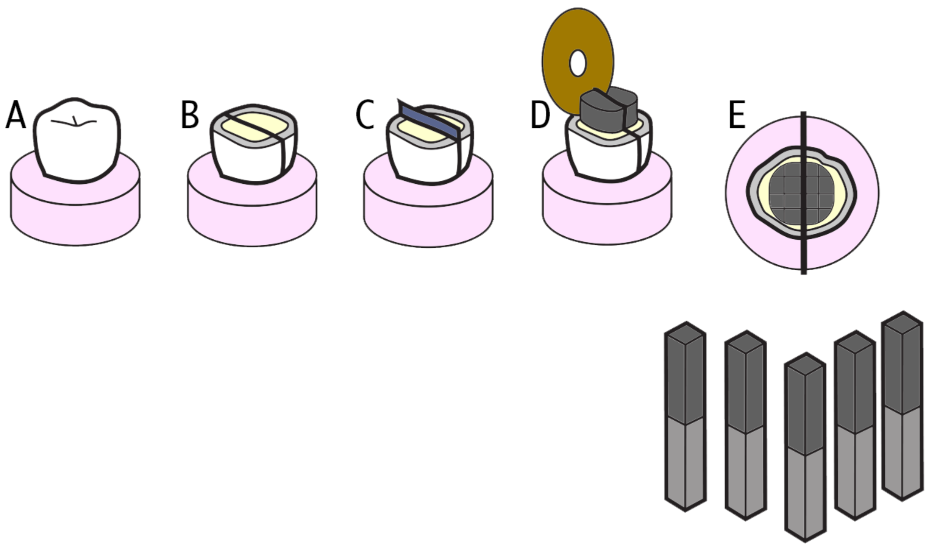

Fig. 4 – Split-tooth design: each tooth half served as a separate experimental group involving a different preparation procedure protocol; one different adhesive treatment was applied per tooth.

A- Initial sample; B – Divided sample; C – Separation of the halves with a metal matrix;
D – Cross-section of the sample; E - Dentin-composite sticks.

6 - Micro-tensile Bond Strength (μ TBS) Testing

Each stick was bonded to a micro-tensile sample holder with cyanoacrylate rubber enhanced superglue gel (CE10 Flex, Ce Chem Limited, UK – lot 3865, expiration date 2019-07) and fixed to the micro-tensile device (Od04-Plus; Odeme Dental Research, Luzerna, Brasil).

Specimens were fractured using a universal testing machine in tensile mode (Emic DL2000, Emic, São José dos Pinhais, SP, Brasil, 100N loading cell) with a pre-load force of 0.5N and loading rate of 0.5 mm/min. The maximum load at failure was recorded in Newton (N).

7- Statistical analysis

The description of the results within each group was performed using the mean, standard deviation, maximum and minimum values for the 4 evaluated groups, which were considered independent. Box-plots were also constructed aiming to show the obtained micro-tensile bond strength values of the 4 tested groups.

The normality of data distribution testing was carried out using the Shapiro-Wilk test and the homoscedasticity using the Levene test. Two-way ANOVA was used to analyze how micro-tension is influenced by the adhesive system and by the instrument used.

Statistical analysis was performed using the commercially available IBM SPSS v.24 software and the significance level was 5%. The outcomes regarding shear bond strength were expressed in MPa.

Results

Table 3 – Mean, standard deviation, maximum and minimum values of micro-tensile bond strength [20] of the tested groups.

Group	1 OFL + US	2 OFL + DB	3 CSE + US	4 CSE + DB
N	6	6	8	8
Mean	38.83	34.65	36.41	31.03
Standard deviation	9.81	10.59	6.19	5.21
Minimum Maximum	22.34 50.18	22.61 48.34	26.47 44.82	24.57 40.58

CSE – Clearfil™ SE Bond; OFL – Optibond™ FL; US – Ultrassound; DB – Diamond bur

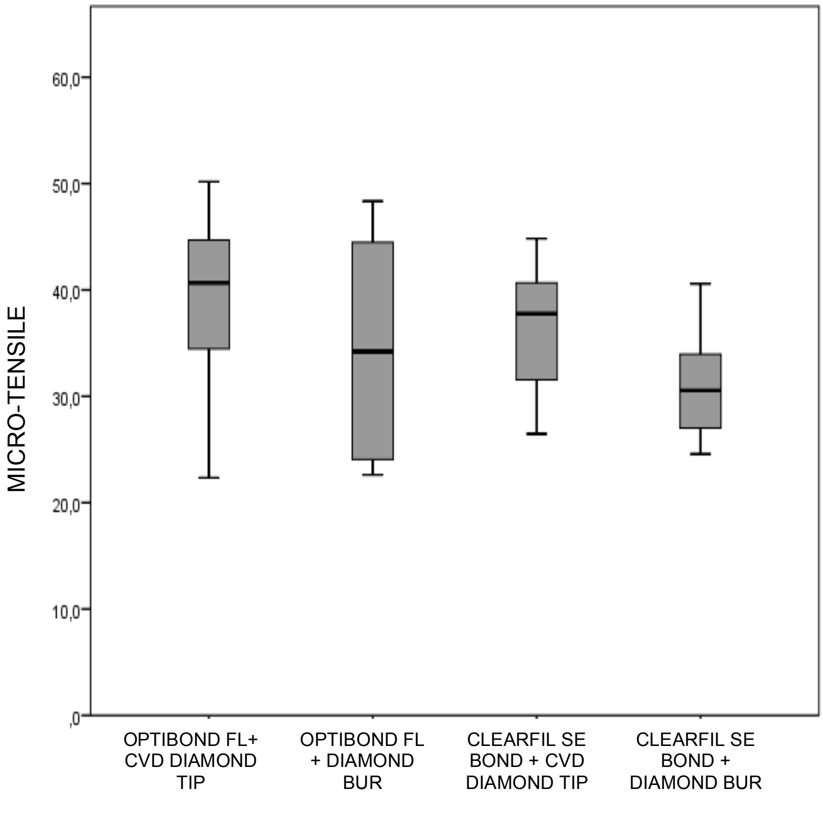

Figure 5 – Box-plot showing micro-tensile bond strength [20] values distribution in the tested groups.

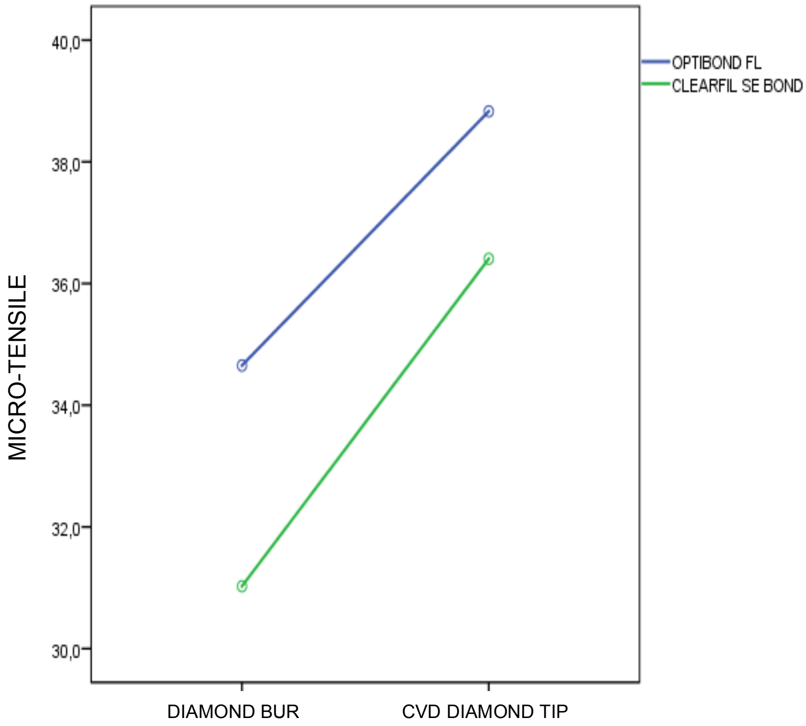

Figure 6 – Line graph showing the mean values of micro-tensile bond strength [20], according to the factors tested: adhesive system and preparation instrument.

There are no statistically significant differences between the means of micro-tensile bond strength concerning the adhesive system (F (1,24) = 1.004, p = 0.326), nor regarding the type of cut (F (1,24) = 2,505, p = 0.127), neither in what concerns to the interaction between both factors (F (1,24) = 0.040, p = 0.840).

Discussion

Recent developments in cutting instruments have changed the conventional techniques applied to the removal of decay or cavity preparation. [2, 5] The new concepts of adhesive dentistry lead to advancements on instruments, due to the necessity of doing minimal invasive preparations and taking advantages of new bonding procedures. [5-8]

The main mechanism of bonding to tooth substrates is based on the exchange process between removal of the minerals from the dental hard tissues and resin monomers that become interlocked in the porosities created. [21]

Dentin is the bulk tissue of the tooth and has an important role in clinical outcomes of adhesive restorations. Bonding to this substrate has been considered more difficult and less predictable than to enamel. [22] Dentin's characteristics, such as hydrophilicity, hamper the infiltration of hydrophobic resin monomers, which is considered one of the major challenges to adhesive procedures. [21, 22]

Adhesive systems are often depicted by a generations classification according to chronological appearance in the market. However, the most informing and meaningfull characterization is based on their mechanism of adhesion to dentin.[22] In this sence, there are 2 main groups:

1) "Total-etch" system which implicates complete removal of smear layer [23] and superficial demineralization of dentin and enamel

2) "Self-etch" system that dissolves the smear layer and incorporates its dissolved particles into the adhesive interface [21, 22]

Regarding total-etch approaches, the first mechanism of micromechanical retention is the hybridization of the dentin surface. Aiming to improve adhesion strength, it is important to maintain a wet surface, without excessive water pooling, for the infiltration of resin monomers into the prepared dentin without the collapse of the collagen matrix which occurs when dentin is overdried. The clinical impossibility of knowing when dentin is nor too wet, nor too dry renders this technique very sensitive on dentin, although it is considered the most predictable adhesion process for enamel.[24]

On the other hand, self-etch adhesive systems have the capability of incorporating and/or partially demineralizing smear layer at the adhesive interface.

The presence of certain acidic primers, such as 10-MDP and also the mineral component of dentin, provide additional chemical retention with this mechanism. [22] As this strategy involves no acid conditioning followed by rinsing and drying, the uncertainty of how wet the surface should be is clinically inexistent and therefore it is by far the less sensitive and more predictable technique for dentin adhesion. [24]

In the study of Cardoso et al., regarding ultrassound preparations, OptiBond FL presented the highest bond strength value among all the adhesives studied. [3] On the contrary, Kawaguchi et al. demonstrated that in ultrassound prepared teeth, the self-etching strategy presented higher bond resistance. [6]

Ultrasounds appeared as a reasonable choice for performing minimal invasive preparations and taking advantage of new bonding procedures. The chemical-vapor deposition (CVD) technology allows diamond deposition with coalescent granulation in various formats and substrates, as well as the obtention of diamond tips with a high adherence of diamond as a single stone on a metallic stem, resulting in an excellent performance with free of contamination and homogenous preparations. [2, 5]

Borges et al. evaluated the wear of different tips with scanning electron microscopy. Conventional diamond tips presented diamond grains aggregated by a nickel matrix, whereas in CVD diamond tips there was a completely consolidated CVD diamond film, without evidence of salient grains. [1] These findings are in agreement with the results of Cardoso et al., as well as Trava-Airoldi et al. [3, 25]

Some authors report that preparations with ultrasonic tips lead to the removal of the smear layer [3, 19] and an increase in bond strength. [19] This occurrence is related to the cleaning capability of the cavitation phenomenon [3, 19, 26] that occurs when ultrasound vibrations with more than 20 kHz are produced in liquids. [3] In fact, this vibration during cavity preparation promotes an overpressure releasing a large amount of energy. [3, 19, 26] Consequently, the production of a turbulent flow of liquid into the cavity contributes to the removal of the smear layer. [3, 19]

Oliveira et al. reported differences between surfaces prepared with CVD and diamond tips. Dentin surfaces prepared with diamond tips presented deep grooves and dentinal tubules covered by large amounts of uniform smear-layer. On preparations with CVD diamond tips, cavities showed a wavy smear layer with almost completely obliteration of dentinal tubules. [7] Likewise, Silva et al. obtained the same results. However, in what concerns to CVD preparations, there were some tubules partially opened and less amount of smear-layer [11] On the other hand, Youssef et al. obtained the most regular smooth surface with CVD diamond burs, whereas conventional diamond bur preparations presented an irregular surface with different particle sizes. In both surfaces there was smear-layer upon the dentin surface and the dentinal tubules were occluded. [16]

Conde et al. assessed the bond strength between different adhesive systems and dentin prepared with ultrasonic tips. Preparations with ultrasonic tips presented statistically significant higher bond strength values when compared to a surface treatment with conventional diamond burs, also when using different adhesive strategies. [19] On the other hand, Cardoso et al. reported lower values of bond strength in CVD diamond instrument preparations, when comparing with surfaces prepared by conventional diamond burs. [3]

Cerqueira et al. observed that preparations with diamond burs presented a thicker and more irregular smear-layer, whereas ultrasonic diamond burs originated a denser smear-layer. [14]

Horne et al. proved that finishing margins with CVD tips leads to less smear-layer on the surface. However, the dentinal tubules were visible and in regular patterns, with some cracks on their apertures. [13]

The purpose of the present in vitro study was to evaluate the influence CVD diamond ultrasonic tips and conventional diamond burs may have in adhesion to tooth substrates using two different adhesive strategies, as the literature about this topic is scarce and not consensual. Also, an insight on this subject would present undoubted clinical relevance.

As referred, bonding to dentin is actually a challenge in dentistry [21]. In this study, the mean values of bond strength obtained for both adhesive systems tested were similar.

In the present study, the mean values obtained for Clearfil SE Bond was of [36.41±6.19] MPa (group 3) and [31,03±5.21] MPa (group 4). OptiBond FL verified bond strength values of [38,83±9.81] MPa (group 1) and [34.65±10.59] MPa (group 2).

Previous studies, showed mean values of adhesion to dentin with Clearfil SE Bond of [22.8±3.6] MPa (27) and other of [37.51±19.04] MPa (28). In what concerns to OptiBond FL the presented values on literature are of [37.51±19.04] MPa (27) and [45.59±17.35] MPa(20). Thus, the obtained values of this study are in accordance with the literature.

While diamond tips are commonly used in daily practice on cavity preparation or removal of decay, ultrasonic tips are a new method that permits a conservative approach. (3, 5, 7, 8) Hence, it is important to assess the influence of this process in bonding procedures.

In the present study, preparations with CVD diamond ultrasonic tips (groups 1 and 3) showed the highest micro-tensile bond strength values, but nonetheless without statistically significant differences with the other groups (p=0.127).

One factor that could have contributed to these results was the choice of µTBS. Nowadays, the micro-tensile bond strength test (µTBS) is described as the best surrogate measure of dental composite restoration retention. (29) This test is versatile, enables more inventive study set-ups as multiple specimens can be obtained from one tooth and allows better-controlled substrate variables. (30) Conde et al. (19) obtained the same result, whereas Cardoso et al. (3) found that conventional diamond burs present higher bond strengths values.

In what concerns to bonding systems, OptiBond FL (group 1) showed the highest mean micro-tensile bond strength, but with no statistically significant difference (p=0.326).

According to Cardoso et al, that reported the same result regarding adhesive strategy, preparations with diamond burs produce a thick and dense smear layer, thus the interaction between the self-etch adhesive and the basal intact dentin may have been probably hindered. Thus, this finding may explain the slightly and non statistically significant lower bonding values of Clearfil SE as compared to OptiBond FL, when bonded to bur-cut dentin. (3) Similarly, Silva et al. reported lower bond strengths with Clearfil SE Bond, in surface treatment with diamond or CVD tips. (11)

Contrarily, Kawaguchi et al. related higher bond strengths with self-etching adhesive system. (6) This fact could have derived from dentin smear-layer characteristics, such as thickness and quality, which may have a strong influence on the ability of mild self-etching adhesive systems to demineralize and readily penetrate the tooth substrate. [3, 6]

The interaction between the bonding procedure and the type of instrument did not record differences (p=0.840).

The null hypothesis, H0: “There are no statistically significant differences between distinct preparation techniques and adhesive procedures” is accepted, by the findings of this study.

Conclusions

Within the limitations of the present *in vitro* study, our findings suggest:

- Both OptiBond FL and Clearfil SE Bond present similar μTBS values and therefore might be equally effective regardless the preparation technique, hence the clinical decision must rely on other aspects such as the technique's predictability and clinical reproducibility in which Clearfil SE Bond has the winning hand as no dentin acid etching is required, eliminating the uncertainty of how wet is the surface after rinsing and drying.

- Concerning the preparation method, ultrasound groups showed the highest values of micro-tensile bond strength independently of the adhesive strategy, as well as an improved consistency in the obtained μTBS values comparing to when OptiBond FL was used, although not statistically significant.

Further studies in this line of research are needed with standardized experimental protocols to establish clear relations between the evaluated parameters.

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