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ORIGINAL RESEARCH

The Effect of Activation and Acid Etching on Dentinal Shear Bond Strength of Universal Bondings

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Abstract

Background: With the increasing importance of new-generation universal bonds, understanding how to enhance their bond strength to enamel and dentin is crucial. The aim of this study was to investigate the effect of activation on dentine bond strength in universal bonding with two etching and non-etching methods.

Materials and methods: In this experimental laboratory study, 96 intact premolars extracted as part of orthodontic treatment within the last 6 months were selected. The samples were divided into 2Etching and non-Etching groups. Each group was further divided into three subgroups of 16 samples: according to the method used to apply the bonding agent. After bonding, the composite cylinders were connected to the conditioning surface, and then the samples Instron machine. The data were analyzed by two-way analysis of variance and Tukey's post hoc test (α= 0.05).

Results: Among the six studied groups, the highest bond strength was observed in the non-etched group where universal bonding was applied using a sonic device. Conversely, the lowest bond strength was found in the etched group, where universal bonding was applied through rubbing. The mean dentine bond strength using the non-etching method increased significantly compared to the etching method ($p < 0.001$). As for the effect of the activation method on dentine bond strength, the mean bond strength in the etching method did not differ significantly among the three activation methods ($p > 0.05$). However, in the non-etching method, the mean dentine bond strength was strongest in the sonic group, followed by the non-activated group and the rubbing group ($p = 0.05$).

Conclusion: Using a sonic device and avoiding dentin acid etching before bonding can enhance dentine bond strength in universal bonding.

Keywords: Dentin-Bonding Agents; Acid Etching, Dental; Universal bonding

Introduction

One of the most important topics in modern dentistry is tooth-colored restoration. The use of these materials to replace lost dental tissue, enhance the color and appearance of teeth, and improve overall aesthetics has significantly increased. Given the importance of tooth-colored restorations using composite resins, priorities include achieving a color match, greater durability, stronger bonding, lower costs, and simpler procedures. As a result, researching strategies to achieve these objectives is a vital aspect of dentistry (1). Composite bonding provides a sufficient connection to both dentin and enamel, utilizing light cure or dual cure as activation method The introduction of the eighth generation of bonding agents represented a significant advancement in dentistry, as these products can be used for both direct and indirect restorations and are available as a single-step solution (2).

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Dental bonding agents are basically applied to the tooth structure during restorations before the composite material is added. Their effectiveness relies on establishing a strong bond to both enamel and dentin, as well as to the composite itself. Because dentin differs from enamel in its properties—it is living tissue and inherently moist—bonding to dentin presents more challenges. Consequently, extensive efforts have been made to improve dentin bonding agents (3-6).

The Universal Bond is a new generation of restorative bonding that exhibits varying bonding strengths on dentin depending on whether etching or non-etching methods are used. To achieve the highest dentin bond strength, it is essential to identify the most effective universal bonding agent for both bonding activation and non-activation in these two methods. (3, 7, 8) Bonding to enamel is generally reliable from a clinical perspective. However, bonding to dentin is more challenging due to its unique characteristics, such as the presence of dentinal tubules and moisture. Several factors influence bond strength, including the penetration of resin into exposed collagen, the conditioning methods used, the washing and application of bonding resin, solvent evaporation, the extent of bonding polymerization, and the removal of collagen by proteolytic substances (9). Research indicates that using a single layer result in a weak bond, as a thin bonding layer is applied to the tooth's surface. The presence of an oxygen inhibition layer further compromises the polymerized bonding, weakening the bond (10).

Cuevas-Suárez et al. (11) investigated universal bond strength in acid etching mode before universal bonding and concluded that universal bond strength with tooth enamel is improved by using an acid etching strategy. Siqueira et al. (12) found no difference in shear strength and microleakage between the etch and rinse, and self-etch groups.

With the advancements in restorative dentistry, the use of universal bonding agents is increasing to simplify the workflow. These universal bonds can be applied using either an etch-and-wash or self-etch technique. They effectively adhere to enamel, dentin, and various types of restorations. However, given their relative novelty, their widespread application is approached with some caution. Because of the limited research available on universal bonds, this study aims to investigate the impact of activation on the strength of dentin bonds when using two methods: etching and non-etching.

Materials and Methods

In this experimental study, 96 intact premolar teeth were selected from those extracted as part of an orthodontic treatment plan, ensuring that no more than six months had passed since their extraction. Teeth with decay, cracks, fractures, or any anomalies were excluded from the study. The samples were then randomly divided into six groups, each consisting of 16 teeth.

Group 1: Acid Etched, Universal bonding applied to dentine with rubbing

Group 2: Acid Etched, Universal Bonding applied to dentine with sonic device

Group 3: Acid Etched. Universal Bonding Applied to dentine without activation

Group 4: Not acid etched., Universal Bonding Applied to dentine with rubbing Active with

Group 5: Not acid Etched. Universal Bonding Applied to dentine with sonic device

Group 6: Not acid Etched. Universal Bonding Applied to dentine without activation

A cylindrical mold was filled with auto-polymerized acrylic resin (Cold cure acryl methyl methacrylate: Acropars 200, Iran) to mount the samples. The teeth were positioned in the mold up to the cervical zone. To prevent damage from heat generated during the resin hardening process, the samples were placed in a container of distilled water as soon as the resin reached its initial consistency. After this, a cylindrical sample was extracted from the mold. Before dividing the teeth into the desired groups, their surfaces were thoroughly cleaned. The buccal surface of each tooth was then flattened using a disk machine to create a uniform bonding surface and expose the dentin. After applying universal bonds on the dentine surfaces, a transparent plastic tube measuring 1.1 mm in diameter and a2 mm in height was used to place the composites. A plastic mold was filled with composite in color (A2) (3M ESPE FILTEK z250, USA), and the surface of the composite inside the mold was shaped to be convex. This design ensured that when the composite made contact with the tooth surface, it would first spread from the center outward. The plastic tube was then filled and placed on the surface of the prepared sample. A light curing device (Litex 695c, Dentamerica, USA) was applied to cure the composite. The light was directed at five areas—four around the edges and one at the top—for 20 seconds each, summing up to a total of 100 seconds, with an intensity of 1100 microwatts/cm².

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Then, the shear bond strength was checked in the Instron machine (BONGSHIN DBBP-50 Santam, Iran) up to a capacity of 5000 newtons, a minimum of 1, and a maximum of 10 mm/min. The cutting force was applied by a blade with a thickness of 1 mm fixed inside the device, vertically and at a speed of 2 mm/min at the closest possible distance to the joint of the tooth restoration. Fracture force was recorded in Newtons To calculate the micro shear bond strength in megapascals (MPa), this force was divided by the cross-sectional area of the composite cylinder, which was equal to the area of the connection surface (0.95 square mm).

Statistical analyses were performed using the SPSS version 27.0.1(SPSS Inc, IL USA) software. After controlling the normality default using the Kolmogorov-Smirnov test, the obtained data were analyzed by two-way variance analysis and Tukey's post hoc test. Significance level of 0.05 was considered.

Results

Two-way analysis of the variance test showed that both the effect of etching ($P < 0.001$) and the effect of the activation method ($P = 0.03$) on dentine bond strength were significant. So, the mean dentine bond strength in the non-etching etching method was higher than the etching method (Table 1).

Table 1. The mean dentine bond strength in two methods of etching and non-etching in types of universal bonding activation

Universal Bond	Etching	Non-Etching	P value*
	Mean ± SD	Mean ± SD	
with Rubbing	8.9 ± 6.5	11.1 ± 5.7	0.03
Sonic device	10.2 ± 5.2	18.3 ± 6.6	
without Activation	10.1 ± 5.5	14.4 ± 7.9	
P value**	< 0.001		

* The effect of universal bonding type

** The effect of Etching

Regarding the effect of the activation method on dentine bond strength, Tukey's post hoc test indicated that for the etching method, the mean dentine bond strength did not differ significantly between the three methods of activation ($P>0.05$). In contrast, for the non-etching method, the mean dentine bond strength with active sonic bonding was higher than that of the group without bonding activation, and the group without bonding activation had a higher mean bond strength than the group with active rubbing ($P < 0.05$) (Figure 1).

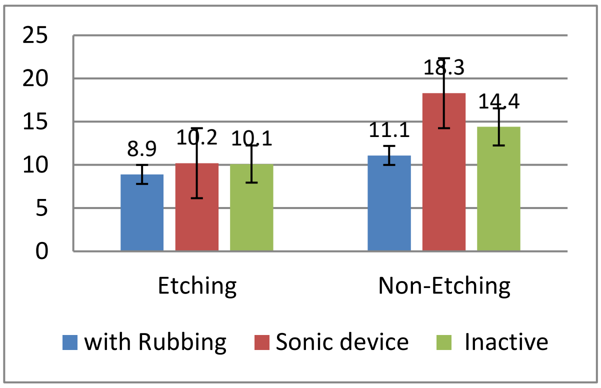

Figure 1. The mean dentine strength in two methods of etching and non-etching in types of universal bonding activation

Discussion

The primary objective of this study was to assess how activation affects the bond strength of dentine when using universal bonding techniques with two different methods: etching and non-etching. The findings indicated that activation enhances the bond strength in universal bonding, aligning with the results of previous studies (11, 13-19).

According to the results of the present study, the increase in strength was evident, especially when using the sonic device. However, using the rubbing method with a microbrush led to a reduction in the bond strength which can be due to insufficient rubbing time on the surface of the dentin or applying excessive force that causes the loss or collapse of exposed collagen fibers on the surface of the dentin or less time during activation. is crucial, as they contribute significantly to bond strength If the collagen fibers collapse due to the aforementioned factors, achieving optimal bond strength becomes impossible

The study of the effect of acid etching on bond strength found that the use of acid etching on dentin has decreased bond strength in universal bonds This reduction occursdue to the collapse of collagen fibers(which are essential for establishing a strong bond in dentin when using universal bonding) exposed by acid etching and rinsing. (20, 21). Universal bond systems were designed expanded to facilitate obtaining a hybrid layer

It is crucial to understand how long this hybrid layer, created with universal bonds, remains stable under the forces of chewing in the mouth. Research shows that universal bonds perform better with a self-etch system

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compared to both the etch system and the etch-and-rinse system (three-step etch and rinse)(22).

Applying an active bond primer or a hydrophilic bond during the two-step etch-and-rinse bonding process can enhance bond strength. This method also aids in evaporating any remaining organic solvent in the bonding material, forming hybrid layers, and preventing microleakage. It is believed that actively applying the bonding compresses the demineralized collagen network, allowing the bonding material to fill it effectively by removing pressure and causing the collagen to expand (23).

The type of composite used can play an important role in the clinical durability of Class V and Class II restorations. Composites experience shrinkage during polymerization, but the amount of shrinkage depends on the mineral content of each composite. Hydrophobic composites have a low Elastic Modulus, also known as Young’s Modulus, allowing them to more effectively relieve the stress generated by polymerization or cuspal deflection.

In contrast, materials with a higher Young's modulus do not release stress by flow and cannot compensate for the stress accumulated during polymerization. These unrelieved stresses can subsequently be transferred to the junction of the composite and cause debonding. However, as the bonding process continues, the hardness of the restorative material may become less critical (24).

Numerous laboratory studies have shown that universal bondings produce a strong initial bond However, all adhesion systems and bonding deteriorate during the artificial aging (16, 17). Despite significant improvements in adhesive systems, the bonding interface continues to be the weakest part of resin restoration (25). Various factors contribute to aging in interface bonding, including biodegradation, thermal cycles, and cycles of mechanical forces.

Rosa et al. (26) pointed out that acid etching has no effect on dentine bond strength in universal bonding, which is in contrast to the results of the present study. This can be due to different type of teeth used performing thermocycle and heating the samples before testing, using different brands of bonding and composites, or bondings with lower acidity than the bonding of the present study.

In their review study, Chen et al. (7) concluded that when using universal bonding agents, it is important to consider whether they are applied in an etch-and-rinse mode or a self-etch mode. Their findings indicate that there is no significant difference in immediate or long-term bond strength between the two methods. This suggests that the self-etch mode can achieve adequate bond strength, making it a logical choice for using universal bonds in applications where long-term bonding performance is crucial.

The study conducted by Torres et al. investigated the influence of acid etching prior to applying universal bonding on bond strength in enamel, dentine, and composite materials. The findings of their research differ from those of the present study. This discrepancy may be attributed to the type of teeth used and the bonding agents employed. In Torres et al.'s study (27), cow anterior teeth were evaluated using Futura Bond (with an acidity level of 2.3) and Scotch Bond (with an acidity level of 2.7). The lower acidity observed at the peak of the universal bond contributes to more effective etching of the smear layer, resulting in improved penetration of the bonding agent into the tubules. Siqueira et al. (12) investigated the shear strength and micro-leakage of various universal bonding agents using etching, rinsing, and self-etch methods on dentin exposed to citric acid or carbonated beverages

They found no difference in dentine bond strength between the etch and rinsed and self-etch groups. However, in the present study, the etch and rinse system decreased the shear strength of universal bonding. The use of citric acid and carbonated drinks on the surface of the dentine causes changes in the appearance of the dentine tubules. The type of teeth studied, and the type of universal bonds used in the two studies differ, affecting the results obtained. The universal bonding agent employed in this study has a pH of 1.2, making it more acidic. This acidity effectively removes the smear layer, which can hinder bonding to tooth dentin

Conclusion

In the non-etching method, the mean dentine bond strength with active sonic bonding was higher than in the group without bonding activation. Additionally, the bond strength in the group without bonding activation was greater than in the group with active rubbing. In contrast, the etching method showed no significant difference in mean dentine bond strength among the three activation methods assessed. Using a sonic device and avoiding the use of dentin etching acid before bonding can enhance dentine bond strength in universal bonding applications

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Conflict of Interests: The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article

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