Original Article

Effect of Air-Abrasion on Shear Bond Strength of Resin Composite to Dentin: An *In Vitro* Study

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Abstract

This study evaluated the bond strength of composite resin to dentin following different surface pretreatment methods: Air abrasion, acid etching, and a combination of both. Twenty-four extracted human molars were randomly assigned to three groups ($n = 8$). The occlusal dentin surface of each tooth was exposed, creating a standardized smear layer. In Group 1, dentin was conditioned with 37% phosphoric acid for 15 s. Group 2 received air abrasion using 24 µm particles at 40 psi. Group 3 underwent a combination of air abrasion followed by phosphoric acid etching. Composite cylinders, 4 mm in diameter, were bonded to the treated dentin in two increments. Shear bond strength was measured using a universal testing machine at a crosshead speed of 0.5 mm/min. Mean bond strengths and standard deviations (in MPa) were calculated. Data were analyzed using one-way analysis of variance followed by a *post hoc* test. Group 3 demonstrated a statistically significant increase in bond strength compared to Groups 1 and 2 ($P < 0.05$).

Keywords: Air abrasion, Composite resin, Dentin.

Introduction

Modern esthetic dentistry increasingly relies on adhesive techniques to bond composite resins to natural tooth structures. However, achieving predictable adhesion to dentin remains a challenge due to its intrinsic properties – namely, high moisture content and a collagen-rich organic matrix-which can impede adhesive penetration.[1-3] In addition, the smear layer, consisting of residual debris and ground dentin particles produced during cavity preparation, further obstructs effective infiltration of bonding agents. Micro-abrasion of dentin has demonstrated promising results by enhancing surface micro-roughness thus increasing the available bonding area, thereby promoting improved mechanical interlocking and adhesive diffusion.[3-7] This technique may contribute to the formation of stronger and more durable bonds between resin composites and dentin, positioning air abrasion as a valuable adjunct in adhesive dentistry. However, the necessity of subsequent acid etching following air abrasion remains a topic of debate. Leurell *et al*., (1993b) reported superior bond strength in air-abraded dentin compared to acid-etched surfaces. In contrast, Laurell and Hess (1995)[8] concluded that air abrasion alone was sufficient for effective resin tag formation, eliminating the need for additional acid etching. Los *et al.,* (1994) reported superior bond strength in air-abraded dentin compared to acid-etched surfaces. This study is done to evaluate the shear bond strength (SBS) of composite resin with dentin after using air abrasion alone and followed by acid etching.

Materials and Methods

Twenty-four extracted human molars were collected. Flat occlusal surfaces of superficial dentin were exposed by cutting the crown segments by diamond bur. Samples were embedded in acrylic blocks of 18 mm length and 8 mm in diameter. Samples were randomly divided into three groups with eight samples each. Group 1: Dentin surface is treated with air abrasion using constant stream of 27 µm aluminium oxide particles under 40 psi pressure for 10 s, followed by thoroughly rinsing with water spray for 30 s (Figure 1). Group 2: Dentin surface is acid etched with 37% phosphoric

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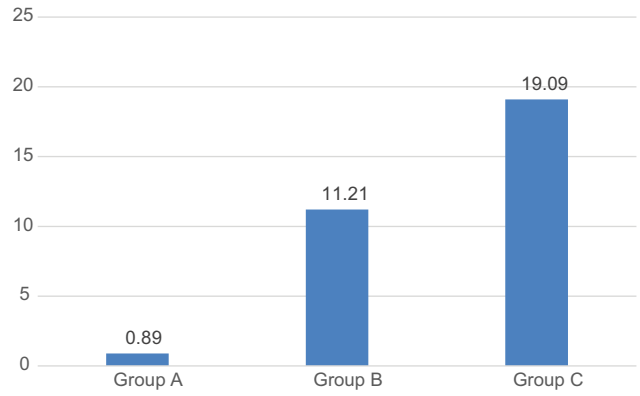
acid for 15 s followed by thorough rinsing with water spray for 30 s. Group 3: Dentin surface treated with air abrasion followed by acid etching. All samples were gently air died and composite cylinders (4 mm × 4 mm) were bonded to dentin surface (Figure 2). SBS was measured using a universal testing machine (Figure 3).

Results

Statistical analysis was done using the Statistical Package for the Social Sciences version 20.0. Comparison of the SBSs of the three groups was made using one-way analysis of variance (Table 1) followed by *post hoc* Tukey's test for intergroup comparison (Table 2). The level of significance was fixed at 0.05. The highest SBS values were obtained for Group 3 followed by Group 2 and Group 1. Group 1 showed the least values (Table 3). There was a statistically significant differences which were seen between all three groups.



Discussion

The adhesion of resin composites to dental hard tissues is a fundamental component of contemporary restorative dentistry. While enamel bonding is relatively predictable due to its highly mineralized and homogenous structure, achieving a durable and reliable bond to dentin continues to pose significant clinical challenges. The inherent properties of dentin – including its higher water content, presence of a collagen-rich organic matrix, complex tubular morphology, and the formation of a smear layer during cavity preparation-impede adhesive infiltration and reduce bonding efficacy.[9] Moreover, the hydrophilic nature of dentin is incompatible with many hydrophobic adhesive monomers, further complicating the bonding process. The long-term success of adhesive restorations depends critically on the stability of the dentin-resin interface. SBS testing serves as a widely accepted method for evaluating the performance and durability of adhesive systems.[5,6] SBS is defined as the maximum shear stress that a bonded interface can withstand before mechanical failure, and it provides insight into the mechanical integrity of the adhesive joint. Among the various surface treatment methods explored to enhance adhesion, air abrasion has emerged as a technique of interest. Originally described by Black in 1945, air abrasion utilizes a focused stream of aluminum oxide particles propelled by compressed air to create micro-roughness on the

Table 1: Mean value of bond strength for each group

Groups	No. of samples	Mean	Standard deviation	*P*-value
Group 1	8	0.8938	0.46785	
Group 2	8	11.2125	0.47037	0.01*
Group 3	8	19.0975	3.02391	

Table 2: *Post hoc* comparison

Groups	Mean difference	Standard error	Significance (*P*)
Group 1			
Group 2	−10.31875*	0.89369	0.000
Group 3	−18.20375*	0.89369	0.000
Group 2			
Group 1	10.31875*	0.89369	0.000
Group 3	−7.88500*	0.89369	0.000
Group 3			
Group 1	18.20375*	0.89369	0.000
Group 2	7.88500*	0.89369	0.000

The results showed that statistically significant difference was noted between the three groups (P=0.001). Statistically significance at $P \leq 0.05$

Table 3: Shear bond strength (MPa) of resin composite to dentin treated with different surface conditioning methods

Sample No.	Group 1: Air abrasion only	Group 2: Acid etching only	Group 3: Air abrasion + acid etching
1	0.3	11.0	20.4
2	1.3	11.4	20.7
3	1.6	11.4	20.1
4	1.0	10.7	19.7
5	0.3	11.7	20.7
6	0.6	10.4	19.7
7	1.0	11.4	20.1
8	1.0	11.7	19.3
Mean±SD	0.89±0.44	11.21±0.42	20.13±0.45

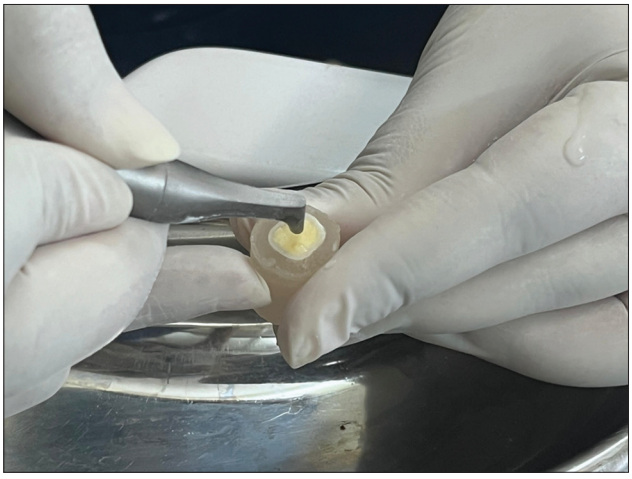


Figure 1: Air abrasion on dentin surface of sample

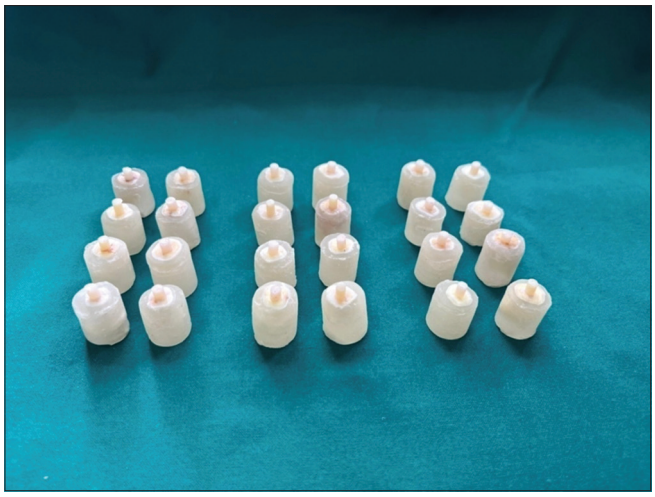


Figure 2: Composite cylinders bonded to dentin surface

Figure 3: Sample mounted on universal testing machine

substrate surface. This micro-retentive topography enhances mechanical interlocking and increases the surface area available for bonding, thereby potentially improving adhesive performance. Previous studies have investigated the effect of air abrasion on bond strength. Bae *et al*., and Valentino and Nathanson concluded that air abrasion alone is not sufficient to achieve optimal bond strength. Instead, they advocated for the subsequent application of phosphoric acid etching following air abrasion to maximize adhesive penetration and bonding effectiveness.[5,6] This approach effectively removes the smear layer and exposes the underlying dentinal tubules, facilitating enhanced resin infiltration and hybrid layer formation. Our findings are consistent with these results. The group that received both air abrasion and subsequent acid etching demonstrated significantly higher SBS compared to other groups. This enhancement in bond strength can be attributed to the synergistic effects of increased surface roughness from air abrasion and improved substrate conditioning from acid etching. Los and Barkmeier similarly reported that the increased surface area created by air abrasion contributes to greater mechanical retention and improved bond strength.[7] In contrast, Roeder *et al*. reported that air abrasion alone does not provide adequate surface treatment for reliable dentin bonding, yielding lower bond strength values compared to conventional acid etching.[9] This observation was corroborated by our study, in which the group treated exclusively with air abrasion exhibited the lowest SBS values. These results reinforce the conclusion that while air abrasion enhances surface roughness, it is not a substitute for acid etching in preparing dentin for adhesive bonding.

Conclusion

Although air abrasion increases surface roughness, it cannot replace acid etching when preparing dentin for adhesive bonding.

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