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A Comparison of The Effect of Adding Nano-Silver Particles to The Primer and The Composite Adhesive on Shear Bond Strength of Metallic Brackets

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ABSTRACT

To investigate the shear bond strength of orthodontic brackets on incorporating Nano-Silver particles in either the composite adhesive or the orthodontic primer. Material and Methods: Forty-five extracted premolar teeth were divided into three groups; Group 1: conventional adhesive system (control group). Group 2: adhesive system with primer containing Nano-Silver particles. Group 3: adhesive system with composite adhesive containing Nano-Silver particles. Bonding of the brackets was done according to the manufacturer's instructions. Shear bond strengths and failure mode were measured for all groups and the data were statistically analyzed. No significant difference was found between group 1 (3.97±1.26 MPa) and group 3 (3.77±1.19 MPa), while the shear bond strength for group 2 (2.11±0.43 MPa) was significantly less. The incorporation of Nano-silver particles in the composite adhesive didn't affect the shear bond strength of orthodontic brackets. However, its incorporation in the orthodontic primer resulted in the decrease of the shear bond strength.

Key words: Nano-silver particles, shear bond strength, Metal brackets, orthodontic primer, adhesive.

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INTRODUCTION

Composite resin is considered one of the most widely used adhesives for bonding orthodontic brackets; due to its ease of application and high flow-ability that allow maximum penetration into the etched enamel [1]. But the main drawback for using composite resin in bonding orthodontic brackets was its inability to protect the tooth surface from demineralization. This results from the accumulation of plaque around the margins of the brackets especially in the presence of archwires, multiple loops, and elastic bands which present a difficulty for the patient in maintaining proper oral hygiene [2], [3], [4].

Many attempts have been made to solve this problem which included the incorporation of fluoride inside the adhesives [5]. Using mouth rinses with antimicrobial agents or coating the brackets with remineralizing agents were common attempts as well.:. Unfortunately, the effect of these methods may last only for a few weeks, and may affect the bond strength of the adhesive [6].

The improvement in the field of nanotechnology allowed for the production of Nano-particles; which has proven to have superior antibacterial activity [7]. Various Nano-particles were used in the field of orthodontics such as, titanium oxide, zinc oxide, gold and Nano-Silver particles [8], [9].

Nano-Silver particles when investigated exhibited superior bactericidal activity against oral streptococci [10]. It attaches to the bacterial cell membrane, affects its permeability and modifies the cell potential [11]. Many authors confirmed the hypothesis that Nano-Silver particles are non-toxic [12]. For all these reasons, Nano-Silver particles are considered as a promising agent in the field of Orthodontics.

When Nano-Silver particles are incorporated into composite resin this results in a reduction in the growth of gram +ve and –ve bacteria [13], and an increase in the inhibition zone of Staphylococcus, streptococcus mutans and E coli [14]. Nano-particles also help in decreasing the surface roughness of orthodontic adhesives, which subsequently affect the bacterial adhesion [15]. Nano particles can be added to the orthodontic primer as well; this allows the silver ions to be in direct touch with the enamel surface and thus maximize its effect [16].

Accordingly, the aim of this study was to investigate the shear bond strength of orthodontic brackets on incorporating Nano-Silver particles in either the composite adhesive or the orthodontic primer.

MATERIALS AND METHODS

Materials:

- 1% Silver Nanoparticles (Sigma Aldrich, St. Louis, MO).
- 0.018inch slot standard Roth premolar brackets (Rx, 3M Gemini metal brackets)
- 35% phosphoric acid gel (Transbond XT Etching Gel System)
- Non-fluoride Rely-a-bond no mix adhesive (Reliance Orthodontic Products, Itasca, III)

Methods:

Addition of Silver Nanoparticles into the composite resin

Transbond™ XT Light Cure composite resin adhesive was mixed with 1% silver nanoparticles in a dark room by a high-speed mixer, (SIMENS, DAC, 150FVZK, Germany, 3500 RPM), for 5 min.

Addition of Silver Nanoparticles into the primer

1% silver nanoparticles were added to every 1mm of the primer using a graduated pipette and thorough mixing was performed.

Samples preparation

Forty-five premolar teeth extracted for orthodontic purpose were used in this study. They all had intact labial surfaces with the absence of any caries or restoration. Polishing of the enamel surfaces was done using pumice and water, and then all the specimens were embedded in self-polymerizing acrylic resin. The samples were randomly divided into three groups using Random.org software. Group 1: conventional adhesive system (control group). Group 2: adhesive system with primer containing silver nanoparticles. Group 3: adhesive system with composite adhesive containing Nano-Silver particles.

The enamel surfaces were etched with a 35% phosphoric acid gel for 30 s, rinsed with a water syringe for 60 s and dried with oil and moisture-free air until a frosty white appearance appeared on the enamel surface. 0.018inch slot standard Roth premolar brackets were bonded to the enamel surfaces of each predetermined group under constant firm pressure. Removal of the excess adhesive was done using a hand scaler. The adhesive was then light cured (3M Unitek, Monrovia, CA) 10 s for each side of the bracket with a total of 40 s for each specimen.

Shear bond strength was measured using the universal testing machine ((Model LRX-plus; Lloyd Instruments Ltd., Fareham, UK), the force was applied using a chisel shape blade with a 0.6 mm thick edge. An occluso-gingival force with a crosshead speed of 0.5 mm/ min was applied to the specimens until failure occurred. After the debonding process, the specimens were examined using USB digital-microscope (Scope Capture Digital Microscope, Guangdong, China) with a 10X magnification to determine the adhesive remnant index (ARI) as introduced by Artun and Bergland [19]. Then the images were captured and transferred to an IBM personal computer equipped with the Image-tool software (Image J 1.43U, National Institute of Health, USA) to determine the bracket failure interface.

The failure mode was analyzed and any adhesive remaining after debonding was scored according to the modified adhesive remnant index (ARI ;Olsen et al., 1997) [17].

Data were presented as means and standard deviation (SD) values. One Way-ANOVA was used to study the effect of different tested groups followed by Tukey's post-hoc test for pair-wise comparison between the means when ANOVA test was significant. A non-parametric one-way ANOVA (Kruskal–Wallis) test followed by paired group comparisons using Mann–Whitney U tests at a 5% significance level were used to analyze the mode of failure.

Statistical analysis was performed using IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA) Statistics Version 24 for Windows.

RESULTS

Shear bond Strength (MPa) results:

The mean and standard deviations (SD) of the Shear Bond Strength (MPa) for the different tested groups were presented in Table (1) and Figure (1). On comparing group 2 (2.11±0.43 MPa) to groups 1(3.97±1.26 MPa) and 3 (3.77±1.19 MPa) the shear bond strength was significantly less at p≤0.001.

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Table 1: Mean Shear bond Strengths (MPa) for the different tested groups

	Tested Groups						p-value
	Control		Nano-silver Primer		Nano-silver Composite		
	Mean	SD	Mean	SD	Mean	SD	
Shear bond Strength (MPa)	3.97[a]	1.26	2.11[b]	0.43	3.77[a]	1.19	≤0.001*

Means with the same letter within each row are not significantly different at p=0.05.
**= Significant*

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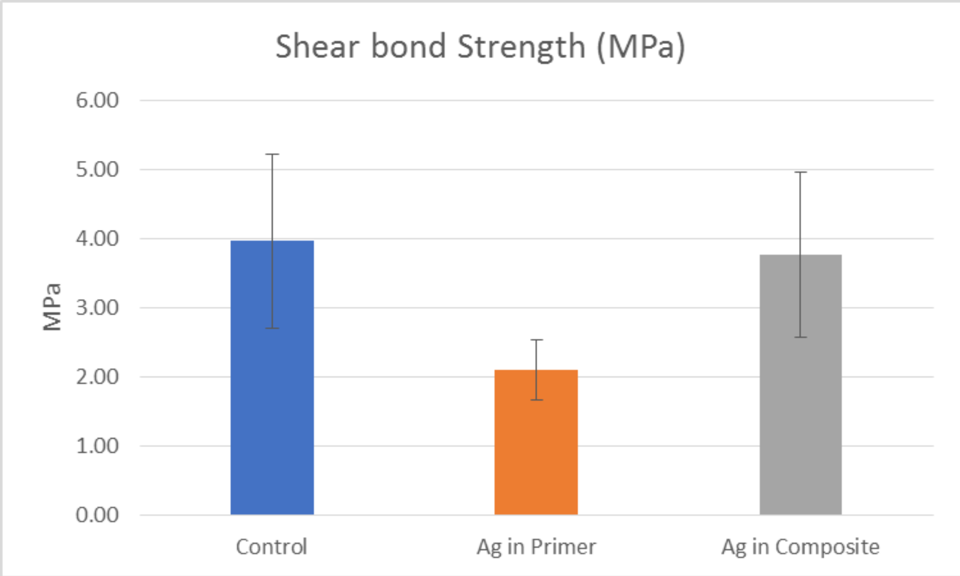

Figure 1: The Shear bond Strengths (MPa) of the tested groups

Mode of failure:

Calculating the mode of failure revealed an insignificant difference between the three groups (Table 2, Figure 2). The ARI scores recorded were 1,3,4 which indicated that some of the adhesive was left on the tooth surface.

Table 2: Frequency and Mode of failure percentage for the tested groups

		Tested Groups						p-value
		Control		Ag in Primer		Ag in Composite		
		N	%	N	%	N	%	
Mode of failure	Score 1	0	0.0%	1	6.7%	0	0.0%	0.673 NS
	Score 2	0	0.0%	0	0.0%	0	0.0%	
	Score 3	9	60.0%	8	53.3%	10	66.7%	
	Score 4	6	40.0%	6	40.0%	5	33.3%	
	Score 5	0	0.0%	0	0.0%	0	0.0%	

Means with the same letter within each row are not significantly different at p=0.05.
**= Significant*

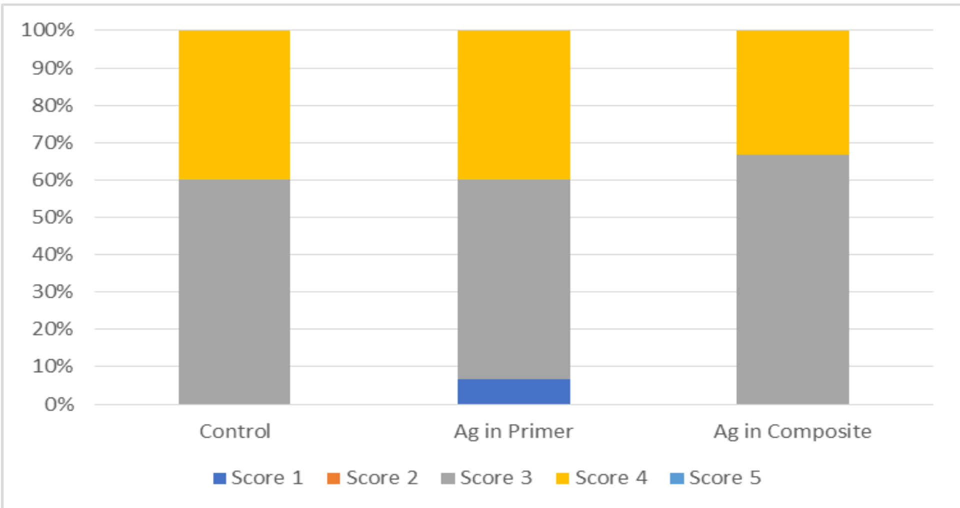

Figure 2: The mean Mode of failure for the tested groups

DISCUSSION

Adhesion of the bacteria on the tooth surface is the main cause of enamel demineralization around orthodontic appliances. It was reported previously that orthodontic adhesives retain more bacteria than bracket materials [18]. Accordingly, controlling the bacterial microflora is a vital factor for the success of orthodontic treatment [19].

Silver particles have been widely used in restorative dentistry as an antibacterial agent [20]and its antibacterial effect was confirmed in previous studies [21], [22]. It helps in the conversion of inactive oxygen into an active one; which causes structural damage to the bacterial cell. It binds to disulfide or sulfhydryl groups present in the cell wall proteins [23], [24] and binds to the DNA in the nucleus causing cell death. Supplying the sliver particles in a Nano size enhances its antimicrobial properties and bacterial deactivation. The Nano size improves of the physical, chemical and optical properties of these particles [25], [26], [27].

The Transbond™ XT adhesive system was Chosen in this study because it is a popular gold standard adhesive used in the orthodontic field [16]. The concentration of 1% Nano-Silver particles was used in this study to obtain the best antimicrobial effect [28], [29].

The proper amount and uniform distribution of Nano-particles in the adhesive system is an important factor for providing better adhesion of the composite resin to hard tooth structure [15]. Adding Nano- silver particles into the composite resin after dissolving it in a specific solvent by stirring was a common method used in many researches [30], [31], [32]. Mixing Nano-Silver particles with composite resin by a spatula for 30 min was another method used by Kasraei and Azarsina in 2012 [33], it was done in a dark room to prevent initial curing of the composite resin. The use of an electronic mixer was the best way to ensure the homogenous distribution of Nano-Silver particles into the resin particles and subsequently increase the mechanical strength of the material [34], [35]. Therefore, the electronic mixer was the method of choice in this study.

From the results, there was no significant difference between the control group and the Nano-silver containing composite adhesive group; regarding the shear bond strength. This was in accordance with Miresmaeili et al [15] who used 1% Nano-Silver particles, and Ahn et al [36], however the latter used a combination of 5 nm of Nano-Silver particles with Nano-silica in the composite adhesive.

There was a significance reduction in the shear bond strength of Nano-silver containing primer group which might be attributed to the agglomeration of Nano-silver particles inside the primer; owing to the increase flow-ability of the primer, which created a weak point that prevented the curing of the adhesive, and hence decreased the bond strength [31].

On the other hand, Akhavan A. et al. in 2013 [16] stated that the addition of 1% Nano-silver into the primer lead to an increase in the bond strength of the adhesive while increasing the concentration to 5% decreased the bond strength. Furthermore, Blöcher S. et al in 2015 [6] found that the addition of small concentrations of Nano-Silver particles, (0.11%, 0,18%, 0.33%), into the orthodontic primer did not affect either the shear bond strength or the ARI scores.

Evaluation of the ARI scores following debonding of the orthodontic brackets is important for the verification of the amount of composite left on the enamel surfaces. The results showed that there was no significant difference between the control and the experimental groups regarding the mode of failure. Most fractures happened at the bracket/composite interface with different amounts of material left on the enamel surface (ARI scores = 1, 3, and 4). The increased amount of composite left on the tooth surface was reported to have the privilege of decreasing the possibility of enamel fracture [37].

CONCLUSION

The incorporation of Nano-silver particles in the composite adhesive didn't affect the shear bond strength of orthodontic brackets. However, its incorporation in the orthodontic primer resulted in the decrease of the shear bond strength.

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