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Evaluation of Shear Bond Strength of Orthodontic Brackets Bonded by Flowable Self Adhesive Resin (Comparative Study)

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ABSTRACT

Aims of the study: To evaluate and compare the shear bond strength of brackets bonded by self-adhesive flowable composite to that of a traditional adhesively bonded composite.

Materials and methods: The orthodontic brackets were bonded to the buccal surfaces of human teeth according to four samples grouping system, Vertise Flow, Vertise Flow fortified with 1% TiO_2, Vertise Flow fortified with $CaCO_3$and Con Tec Dent aurum. The shear bond strength test was performed in a universal test machine with shear rod at a crosshead speed 0.5 mm/min.

Results: Statistical analysis showed a significant higher bond strength with Con Tec adhesive. Fortifying Vertise adhesive with TiO_2, increased shear bond significantly.

Conclusion: Self-adhesive flow able composite is reliable for the use of bracket bonding as an orthodontic adhesive in means of shear bond strength. Self adhesive composite fortified with 1% of weight ratio, Titanium oxide showed better bonding properties with higher shear bond strength.

Key words: Shear bond strength, self adhesive resin, orthodontic brackets.

INTRODUCTION

The Orthodontic treatment involves the use of braces for aligning teeth. Orthodontics consist of brackets that are bonded to the teeth, and arch wires that are threaded through the brackets. The arch wires act as a track and guide each tooth to its proper position[1].

The success of orthodontic treatment greatly depends on ability of adhesive system to resist separating forces directed to bracket - adhesive - enamel junction as well as various factors in the mouth. The Orthodontic adhesive should be capable of keeping the orthodontic bracket to stay bonded to the enamel for the whole duration of treatment and to allow for easy removal of brackets when that is needed without obvious damage to enamel surface and with least discomfort to the patient [2].

Traditionally the process of bonding the orthodontic brackets to the enamel surfaces involves three steps starting from etching and rinsing, followed by sealing and finally the bonding. The introduction of a new system of dental adhesives that supposed to simplify the process of bonding into a one step only procedures look promising in terms of time and effort saving for the orthodontists [3].

Some new bonding systems combine a conditioning and priming agent into a single primer solution for simultaneous use on both enamel and dentine [4]. The combination of conditioning and priming into a single treatment step, results in improvement in cost-effectiveness.

There are conflicting reports of the clinical performance of SEPs (self etch primers) and conventional etch and bond techniques. Asgari et al. [5] and Aljibouri et al. [6] both report good clinical performance with self-etch primer, if not better than with conventional etch and bond than two-stage etch and prime.

MATERIALS AND METHODS:

Teeth Sample Preparation

The sample has been selected from a group of Iraqi Patients who were attending the private clinics, the extraction was for Orthodontic Treatment. (80) Extracted upper first premolars collected, from these only 40 sound teeth were chosen as being of acceptable the criteria of the sample.The age of the patients of the sample ranged from 13-18 years old.

A) Sample Specification

All teeth were examined using magnifying lens (X10). The teeth selected had intact buccal enamel surfaces, they showed no restoration, no caries in buccal enamel surfaces, no enamel cracks caused by extracting forceps, no surface irregularities and had not been treated with hydrogen peroxide (H_2O_2), formalin, alcohol, or other chemical agents after extraction furthermore, malformed teeth were discarded away.The teeth were stored continuously in 0.9% sodium chloride (saline) solution in a sealed box for 1-3 months at 100C, with the saline changed weekly to minimize bacterial growth.

The adhesive materials used for bonding the orthodontic brackets were Vertise Flow, self-adhering flow able composite with OptiBond tecnology (Kerr, Italy), and Con Tec Dentaurum Germany. The Vertise Flow was used once with its original formula, and second after been fortified with two types of silane coated nanofiller: Calcium carbonate, M K Impex Corp. Canada,And Titanium oxide, Skyspring Nanomaterials, Inc. USA. The metal brackets where from discovery® / Assortments , Roth 22, Dentaraum , Germany.

Experimental composite preparations:
A: composite reinforcing with TiO_2:

Preparation of the composite resin specimens:The self adhesive composite SAC (Vertise from kerr) was first preheated in ultrasonic bath at about 40 ^{o}Cfor 10 min. then TiO_2 at 1% weight ratio(digital balance was used to calculate the ratio of the nanoparticles according to the weight of the resin, which were 0.02 and for each 2g tube of the self adhesive composite). The nanoparticles were separately was mixed with the composite resin by hand spatulation on a glass slap in a dark room [7,8].

Once the powder was completely wetted with the resin the composite paste was sheared against a glass surface with Teflon spatula then, the mixture was thoroughly blended by the use of speed mixture device. Then the composite paste was refilled in a dark tight container and placed in ultrasonic bath for 3 hours. This employment of high shear stress has shown to help the nanoparticles to form a stable sol with the composite resin [9].

B: Composite reinforcing with $CaCO_3$:

For the reinforcing with CaCo3, the same procedure was utilized, but instead of using Tio2, CaCO3 was used at (1% and 5% of weight ratio).

Sample preparation for bonding the metal orthodontic brackets:

The orthodontic metal brackets used in this study were first and second premolars brackets, the dimensions of the bracket base surface area were measured by a caliper.The bonding protocol was divided into four groups according to the sample grouping:

Group1: metal brackets bonded with Con Tec orthodontic composite adhesive:The middle third of the buccal surface of each tooth was etched for 30 seconds by 37% phosphoric acid gel, then washed for 30 seconds with water spray, and finally dried for 20 seconds with oil free air stream, the enamel surface look chalky and ready for the bonding, the adhesive was applied to bracket base according to the manufacturers recommendations, the bracket was then placed on the etched enamel surface and seated using a constant force (300 gm) applied by a guideline pin from an articulator (figure: 1) , the excess adhesive was removed by dental explorer then curing by light cure from mesial and distal surfaces for 20 seconds each [10].

Group 2: metal brackets bonded with Vertise Flow self-adhesive composite: The adhesive was applied to the base of the bracket, then the bracket was placed on the unetched tooth surface and seated using constant force (300 gm) applied by a guideline pin from articulator, the excess adhesive was removed by dental explorer then curing by light cure from mesial and distal surfaces for 20 seconds each.

Group 3: metal brackets bonded with Vertise Flow self-adhesive composite fortified with 1% of weight TiO_2.The procedure was the same as for group 2.

Group 4: represents metal brackets bonded with Vertise Flow self-adhesive composite fortified with 1% of weight $CaCO_3$.The procedure was the same as for group 2 and 3.

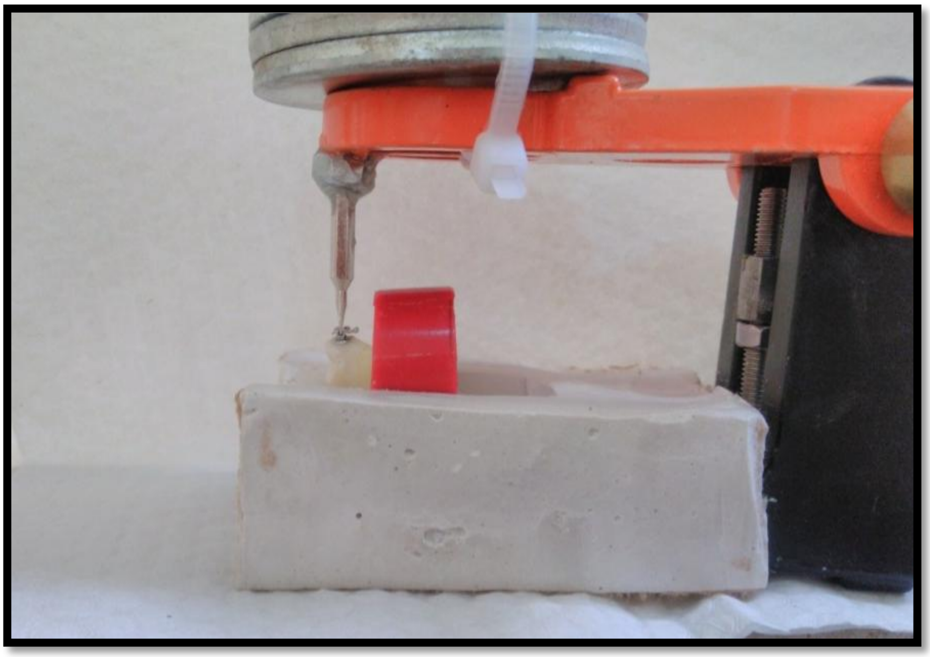

Figure: 1: Fixing the bracket in position by a constant load (300 gm) during bonding.

Evaluation of shear bond strength of metal orthodontic brackets:

The shear bond strength test was performed in a universal test machine at a crosshead speed 0.5 mm/min. The test specimens were placed in a shear device so that a steel rod with one flattened end attached to the crosshead of a Zwick test machine would produce a force falling on the tooth/bracket interface in the occluso/gingival direction, creating a shear stress (figures: 2, and 3). The load necessary to de-bond the bracket was recorded in N and the bond strength was expressed in MPa by dividing the load at which the debonding occurred in N by the surface area of the bracket in square millimeters (mm).

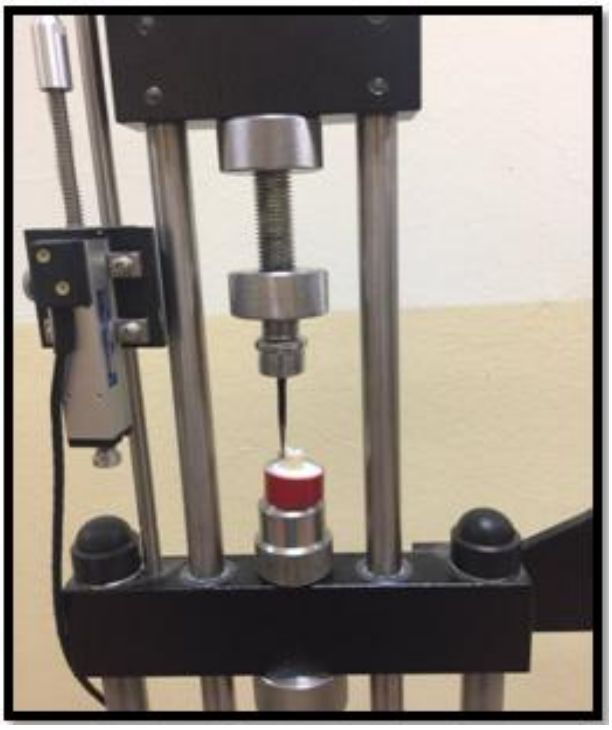

Figure: 2: Sample placed under shear force rode in universal testing machine.

Figure: 3: The position of the shearing bond at tooth bracket interface.

RESULTS

To evaluate the bond strength of the self-adhesive flowable composite, before and after fortifying with both types of nanoparticles (TiO_2 and $CaCO_3$), it was compared with Con Tec LC orthodontic adhesive.

The descriptive data in (Table1) showed that the unmodified kerrself-adhesive composite showed the lowest value of bond strength to thetooth enamel, while reinforcing with nanoparticles increased the bond strength of the self-adhesive err composite.

Table 1: Descriptive analysis of shear bond strength of SAC before and after adding nanoparticles.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Contec	10	15.2250	1.19571	.37812	14.3696	16.0804	13.94	16.72
kerrnon modified	10	7.4070	.58731	.18572	6.9869	7.8271	6.58	8.11
kerr 0.1 TiO_2	10	10.1260	.71894	.22735	9.6117	10.6403	8.98	11.20
kerr 0.1 $CaCO_3$	10	8.1590	.62857	.19877	7.7093	8.6087	6.88	9.05
Total	40	10.2293	3.18801	.50407	9.2097	11.2488	6.58	16.72

Inaddition to that findings, ANOVA test showed that there were significant differences in the shear bond strength among the tested adhesives materials used as shown in Table 2.

Table 2: ANOVA for the shear bond strength of SAC.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	372.192	3	124.064	184.714	.000
Within Groups	24.180	36	.672		
Total	396.372	39			

To locate the real effect of the fortifying of self-adhesive composite with nanoparticles on the shear bond strength, a more sensitive test (Tukey HSD) Table 3was carried out, which revealed that adding 0.1 CaCo4 to the self adhesive materials have no statistical significance on the shear bond strength of the bracket to the enamel surface, which was opposite to adding of TiO_2 particles that highly increased the shear bond strength of the adhesive.

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Table 3: Tukey HSD for SBS groups:

	var	N	Subset for alpha = 0.05		
			1	2	3
TukeyHSD[a]	kerrnon modified	10	7.4070		
	kerr 0.1 CaCo	10	8.1590		
	kerr 0.1 Tio	10		10.1260	
	Contec	10			15.2250
	Sig.		.189	1.000	1.000
Means for groups in homogeneous subsets are displayed.					
a. Uses Harmonic Mean Sample Size = 10.000.					

DISCUSSION

Many researchers have studied adhesion to enamel. Although different modalities have been tested, at present, phosphoric acid etching seems to be the most frequently used method of enamel surface preparation. One of the potential disadvantages of etching with phosphoric acid is that the acid causes demineralization of the most superficial layer [11].The potential use of alternative enamel conditioners has been studied to improve the bonding procedure by minimizing enamel loss and reducing chair time while still maintaining sufficient bond strengths between the brackets and enamel[12].Studies have shown that adhesive systems combining conditioning and priming can be successfully used to bond orthodontic brackets to enamel [13].

The unique characteristic of self adhesive bonding systems in operative dentistry is that they combine conditioning and priming agents into a single acidic primer solution for simultaneous use on both enamel and dentin. Combining conditioning and priming into a single treatment step results in improvement in both time and cost-effectiveness for clinicians as well as for patients. Newer self-adhesive cements have the potential to further simplify the bonding process, that is, by reducing the process of bonding orthodontic brackets to a one-step procedure [14,4].

The result of this study, demonstrated that the self-adhesive flowable composite shear bond strengths for orthodontic brackets although were lower than that of ConTec orthodontic adhesive, but still it were in the acceptable clinical zone for bonding the orthodontic brackets (mean:7.4Mpa), according to [15].

These findings were also in agreement with the work of: [16,17], concluded that self adhesives composite could be considered a reliable and effective alternate to the traditional orthodontic adhesive systems.The statistical analysis of data obtained from shear bond strength of the SAC, before and after the addition of the nanoparticles, revealed that there were a significant differences in the values of SBS of the SAC after the addition of the nanoparticles.The SAC reinforced with both types of the nanoparticles (TiO_2 and $CaCO_3$) showed an increase in the mean SBS values (although for the CaCO3, the increase was not significant) at 1% of weight ratio of the nanoparticles.Any explanation for the change in the SBS values of the SAC, need a deeper look onto the changes in the chemical and mechanical properties of the resultant SAC after the addition of the nanoparticles.

Ataiet al; [18], Tayet al; [19], reached the conclusion that, the lower SBS values for the flowable composites were not because of a weak bond with the enamel, but rather a consequence of their comparatively inferior mechanical properties.At the resin-dentin interface, the adhesive layer has the lowest elastic modulus among the components of the bonded complex, and has been reported to be weaker than the hybrid layer [20, 21].The stresses concentrating on the inherent weakest layer during occlusal loading may cause failure of the resin/dentin bond depending on the level of stress [21].

It is of common belief that an adhesive layer with a medium elastic modulus can resist the stresses and improve intervening stresses from occlusal forces. Therefore, the aim of filler addition to enamel adhesives are to increase the mechanical properties and elastic modulus of adhesive layer, to improve the distribution of the stresses induced by resin composite polymerization shrinkage and occlusal loading, and consequently to increase the dentin bonding strength [22].

The results of the present study showed that the incorporation of nanofiller particles to experimental adhesive system increased the SBS strength to enamel. The highest resin-enamel bond strength was obtained with 1.0 weight percent nanofiller level, and the bond strength gradually decreased with increasing filler content. Some previous studies have also reported the effects of adding filler on bond strength to dentin structure [22-24].The quality of the hybrid layer is an important factor to obtain higher bond strength. The importance of this layer as an elastic buffer between resin composite and dentin was proposed by [25] as the elastic cavity wall concept. According to this concept, it is expected that the filled adhesive layer act as a shock absorber between composite resin and enamel, and result in an increase in bond strength of bonding system to enamel [25, 20, 23, 24] Other studies have indicated that no significant difference exists between filled and unfilled bonding system [26,27].

In a practical application to the previous paragraph suggestion, we tried to use different concentrations of the nanoparticles added to the SAC in an attempt to find the best ratio that will help increase the SBS, the findings were obvious that the increase in SBS will only occur to a certain limit, passing that limit by increasing the ratio of the NP, will result in decrease of the SBS as we found by increasing the NP ratio to 5 % of weight.The incorporation of high fillers ratio (5 %) in the filled adhesive might have diminished its wetting ability when applied to the enamel substrate. Because the pH of the adhesive used is 2.7, its actual depth of interaction at the enamel falls within few hundreds of nanometers, which is sometimes referred to as a ‘nano-interaction’ [28]. This nano-interaction phenomenon will not allow for the incorporation of the nanoparticles within the hybrid layer. On the contrary, they may become agglomerated at the top of hybrid layer, acting as stress raisers and stress concentration areas [29].

The further decrease in bond strength associated with the addition of more nanoparticles could be due to an agglomeration of particles, creating defect points and interfering with the curing process of the adhesive. This pattern of a primary increase in bond strength followed by a further decline has also been seen in other studies [30].

CONCLUSION

Self-adhesive flowable composite is reliable for the use of bracket bonding as an orthodontic adhesive in means of shear bond strength.According to the findings of this study, it can be concluded that self adhesive composite could be considered a better replacement for the traditional etch and rinse procedure in bonding the orthodontic brackets due to its ability to produce an appropriate SBS levels and the ease of application procedure that don’t need multi steps procedures like etching, rinsing and dryness.Self-adhesive composite fortified with 1% of weight ratio, Titanium oxide showed better bonding properties with higher shear bond strength.

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