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Research Article

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In Vitro Comparison of Shear Bond Strength (SBS) of Orthodontic Brackets Bonded with 4 Adhesive Materials and Debonded at Different Time Intervals

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Abstract

***Aim**: This study compared the SBS of orthodontic brackets that were bonded on buccal enamel of premolars either with composite resins or with RMGI after 2 and 24 hours and after 4 weeks.*

***Methods**: 220 premolars extracted due to orthodontic reasons were divided in four groups: In 2 groups brackets were bonded with composite resins: GC connect and Transbond XT-3M, and in 2 groups with RMGI: GC FUJI LC Capsule and GC Automix. Each group was divided to 3 different time intervals: 2H, 24H and 4 weeks. At each time interval the brackets were tested using a constant load of 2.5 N and the shear bond strength recorded as stress at maximal load was recorded in MPa.*

***Results**: Our study shows that the RMGI glue GC LC Capsule had the highest shear bond strength after 2H (11.6 MPa) and after 24H (8.5 MPa) with significance of P<0.001*

***Conclusions**: As shown also in previous studies GC Fuji LC Capsule should be considered as a safe material for bracket bonding and caries protection during orthodontic treatment, due to fluoride release around the bracket.*

Keywords: Orthodontics, Bonding materials, Glass-ionomer cements, Composite cements

1. Introduction

In the recent years the orthodontic treatment has become very popular, a German study shows that one third of the adolescents aged 11-14 will receive orthodontic treatment [1]. According to the AAPD the term adolescent defines youth between the ages of 10-18, those individuals have significant caries activity, low fluoride intake and poor oral hygiene [2]. It is well known that placing an intraoral orthodontic appliance raises the caries risk [3]. Hence as clinicians we should seek for a substance that will provide good adhesion for our appliances but also a good caries defense. A material which might provide good adhesion and caries defense would be RMGIC. RMGIC contains the same components as conventional GIC (basic glass powder, water, polyacid) but also includes monomers [4]. Nevertheless, previous studies show that RMGI has lower shear bond strengths than composite resin [5]. The aim of this study was to compare the shear bond strength of 2 RMGI versus 2 Composite resins in vitro.

2. Materials and Methods

2.1 Four Bonding Materials Were Tested

1. RMGI (resin modified glass ionomer) bonding systems: a. GC Fuji Ortho LC Capsules (GC Co. Tokyo, Japan, LOT 1909051), a light cured resin reinforced- glass-ionomers in capsules, b. GC Fuji Ortho LC Paste Pak Automix (GC Co. Tokyo, Japan, Lot 1702091), a light cured resin reinforced glass-ionomer.

2. Composite resins bonding systems: a. Transbond XT (3M Unitek, Monrovia CA, LOT N979427), a light cure composite adhesive paste, b. GC Ortho Connect (GC Europe N.V., Leuven, Belgium, LOT: WA42196), a light cured composite adhesive paste.

220 extracted premolars were cleaned and stored in Biotene artificial saliva solution (GSK Consumer Healthcare, Waterford, Ireland, LOT 5147110). All teeth were mounted in self cure epoxy resin and kept in the artificial saliva solution in order to prevent dehydration.

2.2 On the Buccal Surface of Each Tooth a Mini Tween Bracket Slott 22 (Ormoco) Was Placed Using the Four Bonding Systems According to Manufacturer Instructions

1. GC Fuji ORTHO LC Capsule (GC LC capsule)- all teeth were brushed clean for 10 sec without pumice, GC ortho conditioner

was applied for 20 seconds, rinsed with water, the capsules were activated and placed for 10 sec in to the mixer (400 RMP). The bonding material was extruded from the capsule, placed on the bracket and the bracket was placed on the tooth and light cured - occlusal, mesial, distal and gingival for 10 sec each side.

2. GC Fuji ORTHO LC Automix (GC LC Automix), GC Ortho Gel conditioner was applied for 10 sec, rinsed, and the bonding material was dispensed from the cartridge on the bracket and the bracket was attached to the tooth and light cured for 20 second mesially and distally.

3. Transbond XT (Com 3M) – light cure adhesive. 37% phosphoric acid etch was applied for 30 sec on the buccal surface and rinsed with water for 10 sec. Application of Transbond Primer on the tooth according to manufacture instructions, application of adhesive on the bracket and the bracket attached to the tooth and light cure for 3 sec at each side.

4. GC-connect (GC conn). The teeth were brush cleaned for 10 sec without pumice and rinsed, 37% phosphoric acid etch was applied for 30 sec on the buccal surface and rinsed for 10 sec. No bond agent was placed. GC ortho connect paste was placed on the bracket and the bracket attached to the tooth and light cured for 10 sec mesially and distally.

The teeth were divided in to 3 groups for analysis and kept moist in the artificial saliva solution till the analysis. The shear bond strength (SBS) was checked after 2 hours, 24 hours and 4 weeks.

2.3 SBS Test

An occluso-gingival load was applied to produce a shear force at the bracket-tooth interface using a universal testing machine (LR10K plus, LLOYD Instruments, an AMETEK Inc, 8600 Somerset Dtrive, Largo, FI). This was accomplished with the flattened end of a steel rod attached to the crosshead of the testing machine. The bond strengths were measured at a crosshead speed of 5 mm per minute, with a preload of 2.5 N. The load applied at the time of fracture was recorded in kilograms and converted into MegaPascals (Mpa).

The shear force recorded in Newtons as load at maximum and in Mpa as Stress at Maximum load. Our results compared the values of stress at maximum load.

All results were recorded with the Nyxegen Plus materials testing software.

2.4 Statistical Analysis

The data was transferred to a computer and the statistical analyses were performed using Student´s T-test using SAS20. Descriptive statistics including means, standard deviations, range, were calculated for the SBS analysis. Significance of the differences between bonding groups at different periods were determined at $P < 0.05$.

3. Results

The mean SBS values and SD (in MPa) for the four bonding materials groups at all time periods are shown in Figure 1.

The highest value of 10.5 MPa was measured in the GC LC Capsule and the lowest value was measured in the GC LC Automix and the differences between the GC LC Capsule and all other materials were significant ($P<0.05$).

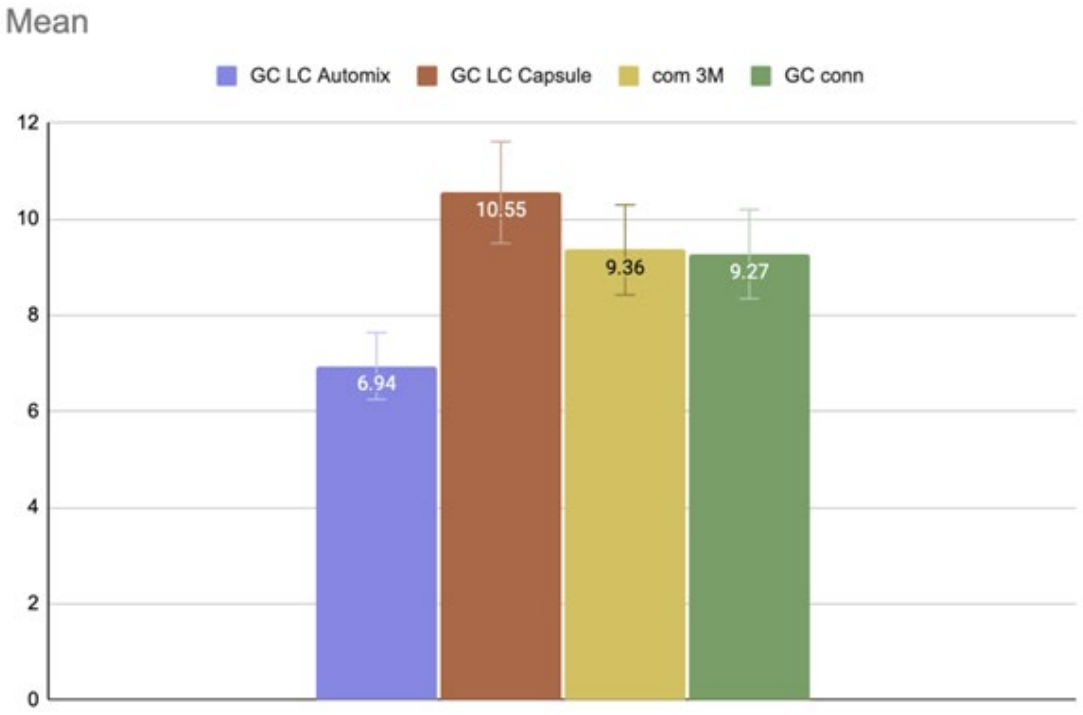

Figure 1: Mean Mpa values for four bonding materials

All four groups were divided according to the debonding timeline, 2H, 24H and 4 weeks and the SBS values are described in Table 1.

Time	Glue	N	Mean	Std. Deviation	Minimum	Maximum	Sig.
2H	com 3M	18	9.3164	4.37290	2.04	19.30	.000
	GC LC Capsule	18	11.6138	3.98929	5.75	20.69	
	GC LC Automix	18	4.2200	2.25822	1.90	9.50	
	GC conn	18	10.6170	5.26532	4.35	17.10	
24H	com 3M	18	8.1737	2.36593	3.50	12.80	.001
	GC LC Capsule	18	8.5611	2.49025	5.20	14.40	
	GC LC Automix	18	5.6335	2.19399	2.84	10.90	
	GC conn	18	6.9100	1.93704	3.80	9.90	
Month	com 3M	19	11.9318	11.12066	2.40	55.70	.800
	GC LC Capsule	19	10.1716	4.28482	3.05	20.30	
	GC LC Automix	19	8.8069	13.33103	1.12	57.30	
	GC conn	19	10.3911	4.12872	5.57	16.60	

Table 1: Mean and SD of four bonding materials according to debonding time periods

The mean SBS values after 2H were the highest for GC Fuji ORTHO LC Capsule - 11.61 MPa and the lowest for GC Fuji ORTHO LC Automix 4.22. The values for both composite based adhesive groups were 9.3-10.6 MPA. The differences between GC LC capsules and all other materials were significant statistically.

After 24H we noticed a slight decline in the SBS for all groups beside GC Fuji ORTHO LC Automix which increased to 5.6. The differences between the highest results (GC LC capsule and com 3M) to the other two were significant statistically.

After one month there was an improvement in the SBS in all 4 groups ranging from 11.9 -10.4 in the composite resin group and 10.7-8.8 in the RMGIC groups, and the differences between all types were not significant.

4. Discussion

Previous studies suggested that a suitable SBS for orthodontic brackets should be between 5.9-7.8 MPa [6]. Our study shows that GC LC Capsule has suitable values for bonding brackets, range of 8-10 MPa. Bonding strength should not be higher than 11.3 Mpa, in order to avoid enamel cracks [7]. Our study showed that after 4 weeks the SBS was 12 MPa for composite resin and from 8-11 for RMGI.

Regarding debonding and enamel loss, previous studies showed that using polyacrylic acid (GC conditioner) before bonding reduces the amount of enamel loss comparing with conventional phosphoric acid [8].

In our study we didn't record any enamel fractures during the debonding procedure although some values were higher than 9.7 Mpa, the value from which enamel fracture can occur [9].

Beside enamel loss an important factor during debonding is the ARI- Adhesive Remnant Index which was developed by Artun and Bergland in 1984 (1- Absence of adhesive material on the tooth surface, 3- Presence of all the adhesive material on the tooth surface) [10].

A study conducted by Piccoli, et al. showed a high ARI score for brackets that were placed with RMGI. It seems that glass ionomer shears a chemical bond both to the base of the bracket and to the enamel, and it improves with time [10].

Composite bonds to enamel through demineralization of the prismless enamel layer and interrod microporos (using 37% phosphoric acid which statistically increasing the bond strength) and then micromechanical interlocking achieved by the monomer [11].

Demineralization of enamel occurs at the time of bonding, due to acid exposure, and afterwards during orthodontic treatment due to habits such as lack of oral hygiene, nutrition and sugar consumption [12].

Using a material which is fluoride releasing and fluoride re-

chargeable would be beneficial for all patients but especially for the patients who are at high risk of caries, adolescent and patients with special needs [13].

Bonding with RMGIC leads to significantly less WSL formation when compared to di-acrylate orthodontic cements even without the use of fluoride treatments [14]. Bonding brackets with glass-ionomer based cements, in comparison with composite based cement, will reduce or prevent white spot lesions development (WSL) [15].

Therefore using Sodium Fluoride and Tooth Mousse/MI+ paste would be beneficial mainly when the brackets are bonded with composite resins [16].

Regarding the time intervals, our study shows different values than suggested in the literature. According to previous studies the SBS is increased after 24H. Debonding of brackets can occur as soon as the bracket is positioned due to stress produced by mastication or contraction of adhesive cement [17].

After 4 weeks, all four groups show higher SBS compared to the values at 2 hours. Regarding the RMGI this could be contributed to the fact that the acid- base reaction of the glass-ionomer continues after the initial setting [18].

The different values might be due difference in the storage medium. Other studies have storage their samples in 37C water, our samples were storage in Biotene- an artificial saliva mouthwash which contains: Water, Glycerin, Xylitol, Sorbitol.

5. Conclusion

As shown in this study the SBS of adhesive material for bracket bonding based on RMGI will provide a suitable adhesion for orthodontic appliances with combination of caries protection due to fluoride release.

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