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Effectiveness of Using Self Etching Primer and Resin Modified Glass Ionomer on Bonding Orthodontic Brackets – an *in Vitro* Study

Skuteczność użycia samotrawiącego systemu wiążącego i szklanojononmeru modyfikowanego żywicą do klejenia zamków ortodontycznych – badanie *in vitro*

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A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation; D – writing the article; E – critical revision of the article; F – final approval of article

Abstract

Background. Many adhesive systems have been investigated as alternatives to conventional bonding methods. Self-etching primers and resin modified glass ionomer cement have been introduced to overcome the disadvantages of acid etching

Objectives. To assess the effect of using either a self etching primer (SEP) or a resin modified glass ionomer (RMGI) on shear bond strength and failure type in comparison with conventional methods (CM).

Material and Methods. Eighty metal brackets were bonded to buccal surfaces of human upper premolars by the same clinician according to 1 of 4 protocols. Group 1, Transbond XT was used with self-etching primer (SEP) Transbond Plus (3M Unitek, Monrovia, Calif). Group 2, resin modified glass ionomer (RMGI) Fuji Ortho LC (GC Crop, Japan). Group 3, light cure resin (LC) Transbond XT (3M Unitek, Monrovia, Calif) were used with 37% phosphoric acid. Group 4, Chemically cure resin (CC) Unite (3M Unitek, Monrovia, Calif) were used with 37% phosphoric acid. The premolars were stored in distilled water for 24 hours at 4°C. Brackets were loaded to failure in Instron machine. Descriptive statistics were calculated. ANOVA, Bonferroni, Kruskal-Wallis tests and Mann-Whitney U were used.

Results. The present study indicated that the SEP provided no significantly higher shear bond (10.01 ± 5.46 MPa) than LC adhesive (8.59 ± 4.07 MPa) while RMGI showed the lowest (5.08 MPa). A comparison of the adhesive remnant index (ARI) scores indicated that there was significantly difference between the groups with less residual adhesive remaining on the teeth with SEP and RMGI.

Conclusions. SEP produced bond strength clinically accepted with less amount of residual adhesive left on the enamel while RMGI produced unacceptable bond strength. SEP can use successfully in bond orthodontic brackets (Dent. Med. Probl. 2016, 53, 1, 50–55).

Key words: shear bond strength, self-etching primer, adhesive remnant index, resin modified glass ionomer.

Słowa kluczowe: wytrzymałość bondu na ścinanie, primer samotrawiący, wskaźnik pozostałej adhezji, szklanojononmer modyfikowany żywicą.

Many theories have been proposed to explain adhesion mechanism between brackets and enamel surface. Chemical and mechanical adhesion are the main types [1]. Conventional bonding methods use phosphoric acid to prepare the enamel surface before bonding, increasing its capability to

the adhesion by creating micro pores on the surface [2–4]. Although this technique increases bond strength, it is a multi stages method [5] and needs stern isolation procedures, as moisture weakens the bond strength [6]. Several studies were made to decrease the disadvantages of using phosphoric

acid by testing alternative acids and adhesive systems.

Resin modified glass ionomer (RMGI) is a hybrid cement [7], which adheres chemically with the tooth surface [8–10]. It was introduced to overcome the high clinical failure rates of conventional glass ionomer [11] and the high susceptibility of the resin to wetness [12–14]. The serious improvements in RMGI bond strength make it appropriate for bonding brackets clinically [10] with the additional property of decreasing enamel decalcification around the brackets by releasing fluoride [15, 16]. There is disagreement about the necessity of enamel preparation before bonding with RMGI. While some studies recommend such preparation [17], Chung et al. [18] mentioned that such a need is still unclear and that wetness does not have a negative effect on the bond strength. So RMGI can be used in wet condition without etching [9, 13, 19–22].

The sixth generation of coupling agents self-etching primer (SEP) has a singular property that it merges the conditioning and priming agents into one solution [2, 23]. This allows for the two steps to take place together [2], giving the primer the possibility to penetrate and reach the whole etched surface [24], thereby achieving good micro-mechanical adhesion [25, 26]. Self etching primer is addressed as no etching, no rinsing and no curing [1], so it has several advantages of simplifying bonding procedures [25], saving time [27, 28], minimizing wetness and saliva contamination opportunities [29], and decreasing enamel demineralization [30–33].

The aim of this study was to assess the effect of using either SEP and RMGI on shear bond strength and failure type in comparison with conventional bonding methods.

Materials and Methods

Eighty human maxillary premolars, extracted newly were used. The buccal surfaces were free of caries, restorations, hypoplastic areas and cracks. The premolars were cleaned from soft tissues, then were stored in 10% formaldehyde for 24 hours to avoid growth of bacteria and then were stored in distilled water at 4°. The sample was randomly divided into equal four groups according to adhesive material. The roots were submerged in chemical cure acrylic matrix with the labial surface parallel to the shear force direction. Eighty stainless steel maxillary premolar brackets with an 0.022 in slot and 10.61 mm² average base surface area (Gemini, 3M Unitek, USA) were bonded by the same clinician.

Before bonding, buccal surfaces were cleaned with a pumice free fluoride for 10 seconds, rinsed with water and dried with compressed air free of oil. The brackets were bonded according to the manufactures instructions as the following:

In SEP group, buccal surfaces was wetted with water, dried incompletely by compressed air. Self-etching primer Transbond Plus® (3M, Unitek, USA) was applied onto the enamel, rubbed for 3–5 seconds and dried by compressed air for 1–2 seconds. Brackets were bonded by Transbond XT® (3M, Unitek, USA) light cured for a total of 20 second from two directions using a visible light-curing unit (Cromalux-E; Mega Physik Dental).

In RMGI group, buccal surface was wetted with water. Fuji Ortho LC® (GC Crop, Japan) was mixed and applied on brackets before placement on the enamel then adhesive was light cured for a overall of 40 seconds from two sides using a visible light-curing unit as in SEP group.

In LC group, buccal surface was etched with 37% phosphoric acid (3M Scotchbond™ Etchant, 3M Dental Products, St Paul, Minnesota, USA) for 20 seconds, rinsed for 10 seconds, and dried for 5 seconds. Transbond XT primer was applied to the etched surface then the brackets was bonded by Transbond XT (3M, Unitek, USA) and light cured as in SEP group.

In CC group, buccal surface was prepared as in LC group. Adhesive primer (3M Unitek) was applied to the etched surface and to the bracket base then brackets were bonded by Unitek (3M, Unitek, USA).

After 5 minutes of bonding, the premolars were stored for 24 hours in distilled water at 4°C. The acrylic matrixes were firmly connected to the Instron Universal Testing Machine (model 6025, Instron, UK) with positioning the blade in such a way that it touched the bracket. Debond occlusogingival shear force was applied at the bracket tooth interface with a cross head speed of 1 mm/minute. The force was recorded in kilograms and converted to Newton then calculated in megapascal as the following: Bond strength MPa = force in Newton/surface area of brackets in mm².

The buccal surfaces were examined after debonding by the same clinician under a light stereomicroscope at 16 magnification. Adhesive remnant index (ARI) [34] was used to determine the amount of adhesive remaining.

Significant differences in shear bond strength were determined using A 1 – way analysis of variance (ANOVA) and Bonferroni test with the level of significance set at ($p < 0.05$). The Kruskal-Wallis test and Mann-Whitney U were used to determine significant differences in the ARI scores between the groups ($p < 0.05$).

Table 1. Descriptive statistics and results of analysis of variance comparing

Groups	N	Mean	SD	Range	P
CC	20	11.32	6.93	2.78–20.33	0.041*
LC	20	8.58	4.07	3.71–18.49	
SEP	20	10.0	5.46	3.7–20.2	
RMGI	20	5.08	2.76	2.31–12.1	

N – sample size; SD – standard deviation; * – significant.

Table 2. Bonferroni test for bilateral comparisons

P value		
1.000	Transbond XT	Unite
1.000	Transbond plus	
0.041*	Fuji Ortho LC	
1.000	Transbond plus	Transbond XT
0.694	Fuji Ortho LC	
0.178	Fuji Ortho LC	Transbond Plus

* – significant.

Results

The highest bond strength values was produced by CC (11.23 ± 6.39 MPa), followed by SEP (10.01 ± 5.46 MPa), whereas RMGI showed the lowest bond strength (5.08 ± 2.76 MPa). ANOVA showed a significant difference between the groups and Bonferroni test showed significant difference between RMGI and CC (Table 1, 2).

Most failure was found at the adhesive enamel interface in RMGI and at the adhesive bracket in CC whereas most failure was in the adhesive in LC and SEP. Significant difference was found between the groups and Mann-Whitney U test showed significant differences between RMGI and CM.

Discussion

Since the introduction of enamel etching in 1955, bonding orthodontics bracket has become the most widely-used method between orthodontists [35]. Self-etching primer SEP has a benefit of

simplifying the bonding procedures with some tolerance to moisture. Resin modified glass ionomer cement (RMGI) has the good properties of both conventional glass ionomer cement and mechanical and physical properties of resin.

In the present study, shear bond strength of brackets bonded with each of SEP and RMGI were evaluated and compared with CM. The results showed that the shear bond strength were (10.01 MPa and 5.08 MPa) for SEP and RMGI in comparison with (11.23 MPa and 8.59 MPa) for CC and LC respectively. No significant difference was found between SEP and CM. This findings may be attributed to the identical etch type [2] although SEP etch type is more superficial but merging etchant and the primer together increases adhesion by primer penetration to whole etched surface [2, 36]. In contrast, a significant difference was found between RMGI and CC and this may be attributed to the difference in adhesion mechanism which is micromechanical in CC resulting from acid etching in addition to the complete polymerization of the resin [36], while its chemical in RMGI resulting from the ion interplay between polymer acid and enamel calcium [8, 37, 38].

Reynolds [39] mentioned that bond strength between 6–8 MPa is sufficient to achieve successful orthodontic bonding. In this study, the bond strength achieved by SEP and CM showed the shear bond higher than this limit, while RMGI did not achieve the minimum.

The shear bond strength produced by SEP coincides with the preceding studies. Dorminey et al. [24] and Sfondrin et al. [40] have found no significant differences in shear bond between

Table 3. Frequency distribution and the result of the Kruskal-Wallis test of ARI

	ARI ^a				x ²	P value
	0	1	2	3		
Unite	0	3	0	7	12.901	0.005*
Transbond XT	0	3	3	4		
Transbond Plus	1	4	2	3		
Fuji Ortho LC	5	4	0	1		

^aARI – 0, no adhesive left on enamel; 1, less than half of adhesive left; 2, more than half of adhesive left; 3, all of adhesive left with a distinct impression of the bracket mesh; * – significant.

Table 4. Result of Mann-Whitney U test

		U value	P value
Unite	Transbond XT	39.5	0.376
	Transbond plus	31.5	0.125
	Fuji Ortho LC	12.5	0.003*
Transbond XT	Transbond plus	39.0	0.381
	Fuji Ortho LC	14.0	0.005*
Transbond Plus	Fuji Ortho LC	23.0	0.032*

* – significant.

Transbond Plus (11.9 MPa, 8.57 MPa) and Transbond XT (11.3 MPa, 8.27 MPa) respectively. Rogelio et al. [29] and Turk et al. [41] have not found significant differences between Transbond Plus and Transbond XT, but they recorded higher shear bond strength for SEP (16.6 MPa, 16.82 MPa respectively) and LC (19 MPa, 19.11 MPa respectively) than we have in our study. Coups et al. [42] have recorded a significant difference between RMGI (5.86 MPa) and CM. In contrast, Buyukyllmaz et al. [26] have found significantly higher bond strength with Transbond Plus (16 MPa) than with Transbond XT (13 MPa). Rieko et al. [43] have studied shear bond strength of SEP and RMGI and have recorded significantly lower bond strength with the Megabond SEP® (8.8 MPa) than with Kurasper F® (12 MPa). The difference with our study may be attributed to the difference in the materials used. On the other hand, shear bond for Fuji Ortho LC (8.6 MPa) was higher than in our study with no significant difference in comparison with LC, and that may be attributed to enamel etching with polyacrylic acid before bonding. Chung et al. [18] have studied shear bond strength of RMGI in different condition and has found no significant difference between CC (10.52 MPa) and Fuji Ortho LC in wet condition without etching (2.96 MPa) and reported an increase in bond strength (5.31 MPa) after enamel etching. The low bond for RMGI

without etching in comparison with our study may be attributed to saliva wetting the enamel surface.

Adhesive remnant index scores have shown that the failure type was in the adhesive in both of SEP and LC with less adhesive remaining on the enamel surfaces that were treated with SEP, whereas most failure was found at the adhesive bracket in CC, and in the enamel adhesive interface in RMGI. Significant differences were found between RMGI and the other groups and that may be attributed to the difference in mechanism adhesion. The largest amount of the remaining resin on the teeth in CC may be attributed to the complete polymerization of the resin [3]. Although this failure type is the most secure [44], it needs more time to clean the teeth. In contrast, incomplete polymerization resin in LC as a result of a decrease in light penetration to the bracket base [46], may be partly responsible for the failure type [45]. On the other hand, the difference in etchant concentration and chemical formulation in addition to the difference in etching and priming occurrence way [2] may explain the least remaining resin with SEP in comparison with CM. While the strong adhesion between RMGI and the bracket base compared with its adhesion with the enamel may explain its failure type [10]. These results coincide with preceding studies [18, 36, 40], whereas Turk et al. [41] have recorded significant difference in failure type between SEP and LC. Buyukyllmaz et al. [26] have found failure at adhesive bracket interface for SEP, while Millett et al. [7], Komori and Ishikawa [20] have recorded failure in the adhesive and at adhesive bracket for RMGI and that may be attributed to using etching before bonding.

Transbond plus SEP produced clinically acceptable bond strength, with a smaller amount of residual resin remaining on the enamel after debonding. This failure type needs less time to clean the teeth after debonding. Fuji Ortho LC (RMGI) has not achieved the minimum limit for successful clinical bond, so SEP has the potential to successfully bond orthodontic brackets.

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