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Shear Bond Strength of Resin Modified Glass Ionomer Cement Using Different Enamel Conditions

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الخلاصة

الأهداف: لتحسين قوة شد الالتصاق للاسمنت الزجاجي الراتنجي المحور للحواصر التقويمية باستخدام عدة أنواع من التحضيرات لسطح المينة. **المواد والطرق:** مجموعة مكونة من مئة ضرس حديث القلع تعرضت لمرحلتين علاجيتين: الأولى تتضمن تقسيم الأسنان إلى خمس مجاميع كل مجموعة مكونة من 20 ضرس كالأتي: الأولى عولجت باستخدام 37%حامض الفسفوريك، الثانية استخدمت الطريقة الحديثة لمعالجة المينة بجزيئات الألمنيوم اوكسايد بحجم 50 ماكرون، الثالثة استخدمت المنظف الهوائي بجزيئات الصوديوم بايكاربونيت 45 ماكرون، الرابعة استخدمت دسك للصقل نوع الخشن لمدة 10 ثواني، الخامسة أبقيت المينة على حالها بدون معالجة. الثانية تضمنت تقسيم كل مجموعة إلى مجموعتين ثانويتين كل واحدة تضم 10 أسنان، المجموعة الثانوية الأولى عولجت تحت ظرف رطب أي يعرض سطح السن إلى ماء الإسالة الاعتيادي والمجموعة الثانوية الثانية بقيت جافة. وبعد الحضانة لمدة 24 ساعة وبدرجة حرارة 37 سيليزية في ماء مقطر قوة الشد للحواصر التقويمية تم قياسها باستخدام آلة الفحص العلمية مع مقطع الرأس بسرعة 10 ملم لكل دقيقة. **النتائج:** تشير النتائج أن أعلى قوة شد توصلت إليها المجموعة التي عولجت باستخدام 37% حامض الفسفوريك تحت الظرف الرطب والأقل هي للمجموعة التي تركت بدون علاج للمينة وتحت الظرف الجاف. أما بالنسبة لاستخدام تحليل مان ويتني فاظهر اختلاف معنوي بين السطح الرطب والجاف بشكل عام مع احتمال عالي لفشل الالتصاق للسطح الجاف عن الرطب. **الاستنتاج:** ظرف المينة المناسب لشد الالتصاق مع وضعية فشل الالتصاق لوحظ كونها للسطح الرطب للمجموعة الخامسة. لكننا نستطيع أن نستنتج أن أفضل ظرف للمينة لربما هو المينة المعالجة بالديسك الخشن مع الرطوبة.

ABSTRACT

Aims: In an effort to improve the shear bond strength of resin modified glass ionomer cement on orthodontic brackets, various enamel conditioning have been evaluated for use with this cement. **Materials and methods:** A total of 100 freshly extracted human premolars were subjected to two steps of treatment. The first step of treatment involve dividing the teeth into 5 groups each of 20 teeth: (I) treated with 20 second acid etching with 37% phosphoric acid; (II), treated with micro–etching using 50 µ aluminum oxide; (III), treated with air polisher using 45 µ sodium bicarbonate; (IV), treated with coarse finishing disk for 10 second; (V), left the enamel clean without treatment. In the second step each group then subdivided into two subgroups, ten teeth subjected to wetting with tab water and ten left dry. Following, storage for 24 hours at 37°C in distilled water, shear debonding force was measured using a Universal Testing Machine with a cross–head speed of 10 mm/minute. **Results:** The result indicated that the highest shear bond strength was for acid etched enamel under wet condition with lowest mean for normal dry enamel. the Mann–Whitney analysis estimated a significant difference between wet and dry condition in general with high probability of bond failure for the dry than that of wet conditions. **Conclusions:** The suitable enamel conditions regarding the shear bond with the mode of bond failure had been shown to be the wet and dry situation of group III and wet situation of group IV. But, it could be concluded that the most suitable enamel condition may be that treated with a coarse finishing disk under wet condition.

Key Words: Shear bond, Resin modified glass ionomer cement, Different enamel treatments.

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INTRODUCTION

Clinical improvements related to orthodontic bonding are still needed in two major areas; reduction of white spot lesions and increased tolerance to moisture contamination during bonding to reduce the incidence of bond failure[1]. Add to the disadvantages of conventional acid etching resin bonding agent which are the loss of enamel during etching and the remaining resin residue that cannot be easily removed after debonding of the bracket[2].

The introduction of resin modified glass ionomer cements (RMGICs) which are auto set by the acid–base reaction of glass ionomer cements, have a diffusion–based adhesion between the cement and the tooth surface[1], combines the advantages of conventional glass ionomer cements with the ability to form chemical bonds with enamel, dentine and metal, significant amount of fluoride release to protect against decalcification[3], absorb fluoride from other sources, such as fluoride toothpastes and mouth rinses, thus acting as a rechargeable, slow–release fluoride device, they also possess the advantage of easier debond with less potential for damage to the enamel; finally their ability of adhesion even in wet condition[4]. However, RMGICs have lower shear bond strength (SBS) compared to composite resins[5,6], particularly within the first half hour after bonding[7], with widely varying bond strengths have been reported, ranging from 5.39 to 18.9 MPa[1].

Moreover, besides the improvement achieved by the combination of resin composites, the RMGICs still have a lower shear bond strength[8,9]. As a result, The aim of this study is to evaluate various enamel conditions trying to reach to best resin modified glass ionomer cement bond properties (shear bond and mode of bond failure).

MATERIALS AND METHODS

A random selection of 100 freshly extracted human premolars, that had been stored in a 0.1% thymol solution after their debridement from soft tissues remnant. The criteria for tooth selection included intact buccal enamel, no cracks caused by the extraction forceps, no restoration material and no caries.

The roots of teeth were grooved to aid retention and then mounted in plastic ring with stone with their long axes vertical and their crowns protruding. The bonding area was cleaned with a mixture of water and fluoride–free pumice powder, with a rubber polishing cup in a low–speed handpiece for 10 seconds, rinsed with water for 15 seconds, and dried with oil–free compressed air for 15 seconds, then the samples were randomly divided into five groups.

Enamel treatment: The enamel treatment composed of two steps:

The first step composed of the following groups each of 20 teeth:

Group I: the buccal enamel surfaces were acid etched with 37 % phosphoric acid for 20seconds, washed and dried thoroughly[4].

Group II: the buccal enamel surfaces were sandblasted with a micro–etcher (DANVILLE Materials Innovative Dental Product) using 50 µm (Recommended by the manufacture) aluminum oxide for 5 seconds at a distance of 4 mm and then blown with air to remove any residual contamination[10].

Group III: the buccal enamel surfaces were air polished with 45 µm sodium bicarbonate for 10 second then were blown with air to remove any residual contamination[11].

Group IV: the buccal enamel surfaces were treated with coarse finishing disk for 10 second[12].

Group V: the enamel left clean.

The second step involved subdividing each group into 2 subgroups each of 10 teeth. The first subgroups were left as they are and the second subgroup subjected to wetting of the confined area (area to which brackets will attach) with tab water before applying the brackets with the adhesive cement to the buccal surfaces. Therefore the end result was 10 subgroups of different treatment modalities.

Bracket bonding: Dentarum (Dentarum, Pforzheim, Germany) standard edgewise orthodontic stainless steel premolar brackets, were used in this study, with an 0.022 × 0.030–inch slot and a base surface area of 10.64 mm^2. The bonding procedures followed the manufacturer's instructions, which involve mixing the base and catalyst of RMGIC in ratio of 3/1 for powder to liquid respectively after that the paste had been applied on the bracket base then applying the brackets on the confined area on the buccal surfaces after their treatment as shown above then a force of 200 g was applied to each bracket using a surveyor with simple modification to standardize the adhesive thickness. Any excess cement was removed with sharp probe. The bonding material was light–cured on the mesial, distal, incisal, and gingival aspects for 10 seconds for a total of 40 seconds, after that, the brackets were debonded with across head speed of 10 mm/ minute, the shear debonding strength was measured which first recorded in Newton then converted to Mega Pascal, then brackets were examined for adhesive remnant using 10× magnification Microscope (Olympus)[4]. Any adhesive remaining after bracket removal was assessed according to the modified adhesive remnant index (ARI) and scored with respect to the amount of resin material that adhered to the Bracket base[13].

The criteria for evaluation were: The modified adhesive remnant index scale has a range of 5 to 1 score according to the amount of adhesive remain on the bracket base:

Score Definitions:

5: All of adhesive remained on bracket.
4: More than 90% of adhesive remained on bracket.
3: More than 10% but less than 90% of adhesive remained on bracket.
2: Less than 10% of adhesive remained on bracket.
1: No adhesive remained on bracket.

RESULTS AND DISCUSSION

For the mean and Duncan grouping of shear bond strength, as presented in Tables (1and 4), it was observed that the highest mean and Duncan grouping are for acid etched enamel under wet condition with the lowest mean is for normal enamel under dry condition, with the more or less the same reading for the remaining groups, these results may ordinarily be due to the fact that the use of acid etching result in highest bond to enamel as explained before in literature[10, 19, 20, 21] (acid etching of enamel result in deep resin tag which may reach to a depth of 5–25 µ with the diameter of the defect ranging from 5–6 µ comparing to a uniform roughness of the enamel up to 5 µ in depth as produced by micro–etching technique for example). Although the manufacturer of Fuji Ortho LC (FOLC, GC Corporation Tokyo), reports that RMGICs can be used in a moistened environment with no acid etching and obtain clinically acceptable bond strengths. This was verified by Silverman *et al.*,[17] in a clinical study. These features would save chair time and allow a safe debonding without enamel damage. A previous study by Cacciafesta *et al.*,[18] using RMGIs showed that saliva contamination actually improved shear bond strength. and combining the results presented in Tables (1, 2 and 3) had been proved to be the same that of manufacturers instruction and direction, in that the use of RMGIC in wet condition could result in higher shear bond strength than in dry condition.

Table (1): Descriptive statistics of shear bond strength in MPa.

Factors					
Enamel condtion	**Enamel status**	**Mean**	**Minimum**	**Maximum**	**SD**
Acid–Etching	Wet	14.4930	12.35	17.53	1.88991
	Dry	12.0140	10.43	15.64	1.76657
Micro–etching	Wet	8.8820	7.89	10.03	.66676
	Dry	7.0110	5.80	8.40	.85183
Air Polisher	Wet	8.2280	6.78	10.02	1.08261
	Dry	5.6800	4.40	6.73	.86106
Coarse Finishing Disk	Wet	7.7420	6.73	8.40	.54328
	Dry	5.4810	3.90	6.70	.94598
Normal	Wet	7.3150	6.56	8.02	.53724
	Dry	3.3310	2.45	4.67	.72215

SD= standard deviation.

Table (2): One way ANOVA of shear bond strength for wet / dry.

Enamel Status	Shear bond strength	Sum of Square	df	Mean Square	F	Sig.
Wet	Between groups	346.536	4	86.634	75.045	.000
	Within group	51.949	45	1.154		
	Total	398.486	49			
Dry	Between groups	422.118	4	105.529	87.880	.000
	Within groups	54.038	45	1.201		
	Total	476.156	49			

df= dgree of freedom.

Table (3) Independent sample t–test**.**

	t–test for equality of Means		
	T	**df**	***p*–value**
Shear bond strength	4.399	98	.000

df= dgree of freedom.

Table (4) Duncan grouping of shear bond strength wet/ dry.

Factors	Wet	Dry
Acid etch	C	D
Micro–etch	B	C
Air polisher	AB	B
Coarse finishing disk	A	A
Normal	A	A

Referring to the results presented in Table (5) it had been shown that the Mann–Whitney analysis estimated a significant difference between wet and dry condition in general with high probability of bond failure for the dry than that of wet conditions.

But, reference to the Kruskal–Wallis analysis as it was presented in the same table, it had been shown that better mode of bonds failure are for normal enamel in dry and wet situation than the remaining enamel treatment approaches, add to acceptable mode of bond failure could be seen in the same table for the air polishing and coarse finishing disk treatment approach under dry situation and coarse finishing disk treatment approach under wet situation.

Furthermore, the coarse finishing disk treatment approach had been shown to produce a suitable SBS in both wet and dry situation referring to minimum and maximum value of the SBS readings, according to the standardization of SBS that presented by Reynolds[22] (the preferable SBS is 7.00 MPa which could withstand orthodontic forces, force of mastication add to their preferable mode of bond failure which is usually adhesive failure at bracket enamel interface).

Thus, all above could explain that the preferable enamel condition for bonding brackets using RMGIC Fuji Ortho LC is enamel treatment with coarse finishing disk under wet situation according to the combination of suitable bond strength and acceptable mode of bond failure that result in acceptable bond strength with nearly intact enamel surface after debonding.

Table (5): Mode of bond failure for all groups.

Scores	Wet					Dry				
	AE	ME	AP	CD	N	AE	ME	AP	CD	N
1	0	0	0	0	1	0	0	0	0	4
2	0	0	0	0	3	0	0	1	2	4
3	0	2	3	4	5	2	3	4	4	2
4	2	4	3	3	1	3	4	3	4	0
5	8	4	4	3	0	5	3	2	0	0
Kruskal–Wallis Test	Chi square= 22.353, df= 4; *p*= 0.000, Significant					Chi square= 24.758, df= 4; *p*= 0.000, Significant				
Mann–Whitney Test	Z= –2.269; Mann–Whitney U= 932.500, *p*= 0.000, Significant									

AE: Group treated with acid etching; ME:Group treated with microetching; AP: Group treated with air polisher; CD: Group treated with coarse finishing disk; N: Normal enamel condition.

CONCLUSIONS

It had been shown that the best enamel condition with regard to bond strength is that treated with 37% phosphoric acid for 20 seconds with the wet better than dry situation which come similar with the manufacturer recommendation. The best enamel condition in regard to the mode of bond failure as it had been presented with the enamel left clean. The suitable enamel conditions regarding the bond strength and the mode of bond failure are those air polished with 45 µm sodium bicarbonate for 10 second and wet situation of those treated with coarse finishing disk for 10 second. But, it could be concluded that the most suitable enamel condition is: Its treatment with coarse finishing disk under wet condition.

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