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Bond Failure Rate of MBT Brackets Bonded with either Self-Etching Primer or Resin Modified Glass Ionomer *vs* Conventional Method – an *in Vivo* Study

Odsetek niepowodzeń utrzymania się zamków ortodontycznych MBT za pomocą samowytrawiającego się primeru lub szklano-jonomeru modyfikowanego żywicą w porównaniu do metody tradycyjnej w badaniu *in vivo*

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Abstract

Background. Self-etching primer and resin modified glass ionomer has been introduced to counter phosphoric etching disadvantages.
Objectives. Evaluation of the bond failure rate of MBT stainless steel brackets bonded with either self etching primer SEP or resin modified glass ionomer RMGI in comparison with conventional methods CM.
Material and Methods. 46 patients with complete permanent dentition were involved in this study. A total of 920 Gemini MBT® brackets (3M Unitek, Monrovia, Calif) were bonded using a split-mouth design. For each patient, four adhesives systems were used: self etching primer SEP (Transbond Plus®, 3M, Unitek, USA), resin-modified glass ionomer RMGI (Fuji Ortho® LC, GC Corp, Japan), light cure LC (Transpond XT®, 3M, Unitek, USA) and chemical cure CC (Unite®, 3M, Unitek, USA). All brackets were bonded by the same clinician. Only first-time bracket failures with tooth number and the remnant adhesive on the enamel were recorded through to 12^{th} month of treatment and observation. Significant differences in bracket failure rate with regard to bonding procedure, patient sex, arch site, and tooth type were determined using the chi-square. The adhesive remnant index was used to determine the bond failure interface.
Results. The bond failure rates were 7%, 15.7%, 7% and 6.5% for the SEP, RMGI, LC, CC respectively. Significant differences in failure rates were found between the groups. The maximum bond failure sites were at the enamel-adhesive interface in SEP and RMGI groups.
Conclusions. The clinical study showed that Transbond Plus can be used effectively for bonding brackets, whereas using Fuji Ortho LC is not effective in clinical practice **(Dent. Med. Probl. 2015, 52, 4, 440–446).**

Key words: self-etching primer, resin modified glass inomer, adhesive remnant index, failure rate.

Słowa kluczowe: samowytrawiający się primer, szklano-jonomer modyfikowany żywicą, wskaźnik oceny ilości pozostałości kleju, odsetek niepowodzeń.

As capability of the enamel surface to micromechanical adhesion with adhesives is not good enough to provide sufficient bond strength, enamel preparation is considered a necessary step before bonding [1]. With the development of the acid etching by Buonocore, enamel preparation by phosphoric acid is considered the most popular used method among orthodontists. Although this technique provides sufficient bond strength to resist orthodontic and masticatory forces [2], it is a multi-stage method and has many disadvantages, including enamel loss through etching [3], the need to dry the field during bonding [4] and the difficulty in removing the remnant resin after debonding [5].

In the attempt to reduce phosphoric acid disadvantages and to simplify bonding procedure, different alternatives have been tested [6]. Self-etching primer SEP as a new system was introduced in order to move away from acid etching or to merge it chemically in the other conventional bonding stages [7]. SEP is a single solution that combines etching and priming stages [8], allowing them to take place at the same time and create the chance for the primer to penetrate the whole etched surface depth [9], achieving good mechanical adhesion [10]. This method has many advantages of decreasing bonding stages, simplifying bonding procedures, shortening bonding time required [11, 12], and minimizing the probability of contamination by moisture and saliva [1, 13] without affecting brackets bonding strength [14].

Resin modified glass ionomer (RMGI) (Fuji Ortho® LC; GC America®, Alsip®, Ill) is a hybrid cement [15] that was developed to counteract resin sensitivity to moisture [16–18] and at the same time to improve clinical performance of conventional glass ionomer cement [19] while retaining its good properties like chemical adhesion with enamel surface in wet conditions [20–22] without the need for acid etching[5], in addition to reducing enamel demineralization by fluoride release [23, 24].

The aim of this clinical study was to determine the effect of using either self-etching primer SEP with light cure composite or a resin modified glass ionomer RMGI (Fuji Ortho LC; GC America, Alsip, Ill) in wet conditions without etching on the mean bond failure rate and the bracket/adhesive failure mode in comparison with conventional bonding systems.

Material and Methods

Forty-six patients (33 girls and 13 boys) were selected. The selection criteria are: complete permanent dentition, nonextraction class I malocclusion cases with absence of buccal enamel defects, restorations, veneer or crowns. The characteristics of the sample are shown in Table 1.

Table 1. Sample characteristics

	Number	%
Number of patients	46	
Distribution of patients by patient sex		
Female	33	71.7
Male	13	38.3
Distribution of patients by age		
15–16 y	7	15.2
16–17 y	14	30.3
18–19 y	19	41.3
19–20 y	6	13.1
Number of brackets	920	100
Distribution of brackets by bonding Procedure		
Unite	230	25
Transbond XT	230	25
Transbond Plus	230	25
Fuji Ortho LC	230	25
Distribution of brackets by patient sex		
Female	660	71.7
Male	260	28.3
Distribution of brackets by arch site		
Unite		
Upper	120	52.2
Lower	110	47.8
Transbond XT		
Upper	125	54.3
Lower	105	45.7
Transbond Plus		
Upper	105	45.7
Lower	125	54.3
Fuji Ortho LC		47.8
Upper	110	52.2
Lower	120	
Distribution of brackets by tooth type		
Unite		
Anterior	132	60
Posterior	92	40
Transbond XT		
Anterior	138	60
Posterior	92	40
Transbond Plus		
Anterior	138	60
Posterior	92	40
Fuji Ortho LC		
Anterior	138	60
Posterior	92	40

A total of 920 Gemini® MBT Bracket (3M Unitek) were bonded. Bonding involved a split mouth design and, for every patient, the quadrants assigned to each adhesive were consequently alternated so that these were distributed equally. Patients did not inform which adhesive had been applied on each quadrant. All buccal teeth surfaces were cleaned, rinsed, and dried with compressed air free of oil. All brackets were bonded following manufactures instructions by the same clinician to exclude the clinician variable on bond performance.

1 – In SEP quadrants, buccal surface was wetted with water, and dried incompletely by compressed air. Self-etching primer Transbond Plus® (3M,Unitek, USA) was applied on the enamel, rubbed for 3–5 seconds and gently dried by compressed air for 1–2 seconds. Transbond XT® (3M, Unitek, USA) was then applied on brackets before placement on the enamel. Excess adhesive was removed from the brackets bases margins, then the adhesive was light cured for 20 second from two directions using a visible light-curing unit (Cromalux-E®; Mega Physik Dental).

2 – In RMGI quadrants, buccal surface was wetted with water. Fuji Ortho LC (GC Crop, Japan) was mixed and applied on brackets before being

placed on the enamel. Excess adhesive was removed from the brackets bases margins; then, the adhesive was light cured for 40 seconds from two sides using a visible light-curing unit as in SEP group.

3 – In LC quadrants, 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. Light cure resin Transbond XT (3M,Unitek, USA) was applied on brackets before placement on the enamel. Excess adhesive was removed from the brackets bases margins; then, the adhesive was light cured as in SEP group.

4 – In CC quadrants, buccal surface was prepared as in the LC group. Adhesive primer (3M Unitek®) was applied to the etched surface and to the bracket base. Chemical cure resin Unite (3M,Unitek, USA) was applied on brackets before being placed on the enamel.

After 5 minutes of bonding, no presence of any occlusal interference was verified. The initial wires placed were 0.014 nitinol (3M Unitek), followed by different sizes of nitinol and stainless steel wires (3M Unitek) as every case required. Strict instructions about appliance keeping and types of foods that patients can eat were given. Observation period during treatment was 12 months for all patients with an appointment every 4 weeks. Only first time brackets failures were registered with the tooth number and the remnant adhesive amount on the enamel surface according to adhesive remnant index [25] (ARI). Second time failures after replacement of the failed brackets were not included in the study to exclude rebonding effect on bond strength.

Significant differences in bracket failure rate with regard to bonding procedure, patient sex, arch site, and tooth type were determined using the chi-square (χ^2), 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 bonding procedures ($p < 0.05$).

Results

The overall failure rate was 9.02%. 83 bracket were failed in the four bonding through 12 month of treatment. The higher failure rate 36 (15.7%) were found with RMGI group followed by SEP and CC groups 16 (7%) for each, where as LC group showed the lowest 15 (6.5%) (Table 2). The χ^2 test showed significant differences in failure rate between the bonding groups ($P = 0.012$). No significant differences were found in the bracket failure rate between males and females and between upper and lower arch in each of the four bonding groups whereas significant differences were found between the anterior and posterior teeth in each of the four bonding groups.

The frequency distribution and result of the Kruskal-Wallis and Mann-Whitney U test of the ARI scores are presented in (Table 3, 4). Most failure was found at the adhesive enamel interface in each of SEP and RMGI groups, whereas the failure was at the adhesive bracket and in the adhesive in the CC and LC groups respectively. A significant difference was found between the bonding procedures ($P = 0.000$). Mann-Whitney U test showed significant difference between CC group and each of SEP and RMGI, and also between RMGI and each of LC and SEP.

Discussion

Self-etching primers (SEP) as a new bonding system that combines both etching and priming stages in one stage has a benefit of shorting and simplifying bonding procedures. Resin modified glass ionomer cements (RMGI) were introduced as an adhesive that can be used in wet conditions without etching, which also minimizes bonding steps and has the benefit of releasing fluoride, thus minimizing the potential risk of enamel decalcification around the brackets.

In this study, bond strength of brackets bonded with each of SEP and RMGI were evaluated clinically and compared with the use of CM. Bond failure rate is an acceptable index that can be used to evaluate bond strength clinically, and to make comparisons with the results of preceding studies [26]. In general, conducting precise comparisons with another study is not easy as many variables might affect bond failure rates, such as sample size, clinicians number, adhesives type, treatment duration [27]. The effect of many variables on brackets failure rates was investigated in this study, such as bonding procedures, patients sex, arch site, and tooth type.

With regard to the bonding procedures, bond failure rates were 7% for SEP and 15.7% for RMGI in comparison with CM (6.5%, 7% for LC and CC respectively). No significant difference was found between SEP and CM, while significant differences were found between RMGI and each of SEP and CM. Mavropoulos et al. [28] recommended that the accepted clinical bond failure rate is under 10%, so using SEP and CM in brackets bonding is considered clinically acceptable unlike RMGI. These findings can be explained by the difference in the mechanism of adhesion, which is a chemical

Table 2. Bracket failure rates for bonding procedures, patients sex, arch site, tooth type

		Number	Bracket Failures	Failure Rate, %	P value
Bonding procedure					0.012*
Unite		230	16	7.0	
Transbond XT		230	15	6.5	
Transbond Plus		230	16	7.0	
Fuji Ortho LC		230	36	15.7	
Patient sex					
Unite	male	65	6	6	0.395
	female	165	10	10	
Transbond XT	male	65	4	4	0.887
	female	165	11	11	
Transbond Plus	male	65	6	6	0.395
	female	165	10	10	
Fuji Ortho LC	male	65	11	11	0.739
	female	165	25	25	
Arch site					
Unite	upper	120	8	6.7	0.857
	lower	110	8	7.3	
Transbond XT	upper	125	11	8.8	0.127
	lower	105	4	3.8	
Transbond Plus	upper	105	7	6.7	0.874
	lower	125	9	7.2	
Fuji Ortho LC	upper	110	18	16.4	0.776
	lower	120	18	15.0	
Tooth type					
Unite	anterior	138	4	2.9	0.003*
	posterior	92	12	13.0	
Transbond XT	anterior	138	3	2.2	0.001*
	posterior	92	12	13.0	
Transbond Plus	anterior	138	4	2.9	0.003*
	posterior	92	12	13.0	
Fuji Ortho LC	anterior	138	14	10.1	0.005*
	posterior	92	22	23.9	

* significant.

Table 3. Frequency distribution and the result of the Kruskal-Wallis test of the adhesive remnant index (ARI)[a]

	0	1	2	3	x^2	P value
Unite	3	2	1	10	23.182	0.000*
Transbond XT	5	1	5	4		
Transbond Plus	7	3	2	4		
Fuji Ortho LC	28	4	2	2		

[a] ARI: 0, no composite left on enamel surface; 1, less than half of composite left; 2, more than half of composite left; and 3, all of composite left. * significant.

Table 4. Result of Mann-Whitney U test

		U value	P value
Unite	Transbond XT	83.0	0.120
	Transbond plus	77.5	0.043*
	Fuji Ortho LC	91.0	0.000*
Transbond XT	Transbond plus	103.0	0.482
	Fuji Ortho LC	135.0	0.001*
Transbond Plus	Fuji Ortho LC	182.0	0.011*

* significant.

one with RMGI while its micromechanical with the other groups [29].

The failure rate for the Transbond Plus (SEP) coincides with the preceding studies. Ozer et al. [30] and Cal-Neto et al. [31] have found no significant differences in bond failure rate between SEP (2.18%, 6.88%) and Transbond XT (2.97%, 4.78%) respectively. In contrast, Murfitt et al. [32] and Ireland et al. [33] have found significant differences in failure rate as they recorded failure rate for Transbond Plus (11.2% and 10.99% respectively) more than in our study. Pettemerides et al. [34] have found significant difference between RMGI (11.4%) in wet conditions without etching and CM (3.41). The lower failure rate in this study in comparison with our study (15.7%) may be related to the small sample (20 patient) and to the shorter treatment period (6 months). Gaworski et al. [35] also have found significant differences between RMGI and CM in 16 patients. The failure rate they recorded (24.9%) was about twice what we have found. In contrast, Silverman et al. [36] have recorded acceptable failure rate 3.2% without etching in the presence of saliva for 8 months of treatment. Summer et al. [5] and Choo et al. [37] have shown no significant differences in failure rate between Fuji Ortho LC (5.9%) and Transbond XT (7.2%). However, conditioner was used before bonding.

With regard to the patient sex, failure rate were higher in males but the differences were not statically significant and that may be related to the strict instructions that were given after bonding. These findings coincide with preceding studies [5, 30, 31, 38–40], whereas Murfitt et al. [32] have found the failure rate at males 2.4 times more than at females.

With regard to the dental arch, no significant differences were found between upper and lower arch in each of the four groups, which coincides with preceding studies [5, 30, 31, 38–40], whereas Lovius et al. [41] have found more failures on the mandible with conventional bonding.

With regard to the tooth type, premolars have shown significantly higher failure rate in comparison with the anterior teeth in each of the four groups. This may be related to the more prismatic enamel on premolars [42], the inability to provide complete dry field in posterior region [43], and to the more masticatory forces in this region [40]. These findings coincide with preceding studies [26, 27, 30, 31, 40].

According to the adhesive remnant index, the SEP and RMGI groups have shown failure at the enamel adhesive interface, whereas most failure was at the adhesive bracket in CC group, and in the adhesive in LC group. This may be related to the less micro pores that SEP produces in comparison with phosphoric acid [32] and to difference in adhesion mechanism between RMGI and the other groups. This mode of failure is clinically advantageous for both clinician and patient because less adhesive to remove from the enamel is needed which will decrease patient discomfort. These results coincide with those of other studies [30–32], whereas Miguel et al. and Hegarty and MacFariane [44] have recorded failure at cement-bracket for RMGI and that may be due to using etching before bonding.

Transbond pluls SEP has shown acceptable failure rate with a favorable mode of an enamel adhesive failure while Fuji Ortho LC (RMGI) has shown unacceptable failure rate. SEP can be used effectively in boding orthodontic brackets.

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