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Shear bond strength of orthodontic brackets bonded with conventional and fluoride-releasing bonding materials with and without adhesive application

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Abstract

Objective: To evaluate the shear bond strength of a composite resin and a compomer for bonding brackets with and without adhesive application.

Methods: Eighty-eight extracted human premolars were divided into four groups: Control group resin (CGR), in which conventional resin Transbond™ XT Light Cure (3M Unitek™, USA) was used to bond the brackets with prior application of the adhesive; Experimental group resin (EGR), in which conventional resin Transbond™ XT Light Cure was used without prior adhesive application; Control group compomer (CGC), in which compomer Transbond™ Plus Color Change (3M Unitek™, USA) was used with prior adhesive application; and Experimental group compomer (EGC), in which compomer Transbond™ Plus Color Change was used without prior adhesive application. A shear debond test was performed using an EMIC machine and results were analyzed by ANOVA and post hoc Tukey multiple comparison test.

Results: No statically significant difference was found between control and experimental groups for the conventional resin and compomer ($P=0.802$ and $P=0.837$). The compomer presented lower shear bond values than conventional resin ($P=0.004$ and $P=0.003$).

Conclusion: Considering the shear bond strength, the four groups evaluated presented adequate values, irrespective of using adhesive or not.

Keywords: Dental adhesive; orthodontics; shear bond

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Resistência ao cisalhamento de bráquetes ortodônticos colados com materiais de colagem convencional e com liberação de flúor com e sem a aplicação de adesivo

Resumo

Objetivo: Avaliar a resistência ao cisalhamento de uma resina composta ortodôntica e um compômero para colagem de bráquetes com e sem aplicação de adesivo.

Métodos: Oitenta e oito pré-molares humanos extraídos foram divididos em quatro grupos: grupo controle de resina (CGR), em que a resina convencional Transbond XT™ fotopolimerizável (3M Unitek™, USA) foi utilizada com aplicação prévia de adesivo; grupo experimental resina (EGR), no qual a resina convencional Transbond XT™ foi utilizada sem aplicação de adesivo; grupo controle compômero (CGC), em que compômero Transbond Color Change™ Plus (3M Unitek™, USA) foi utilizado com adesivo e grupo experimental compômero (EGC), em que compômero Transbond™ Color Change Plus foi utilizado sem aplicação de adesivo. Um teste de cisalhamento foi realizado utilizando uma máquina EMIC e os resultados foram analisados por ANOVA e post hoc teste de Tukey de comparação múltipla.

Resultados: Não houve diferença estatisticamente significativa foi encontrada entre os grupos controle e experimentais para a resina convencional e compômero ($P=0,802$ e $P=0,837$). O compômero apresentou valores mais baixos de cisalhamento que a resina convencional ($P=0,004$ e $P=0,003$).

Conclusão: Considerando a resistência ao cisalhamento, os quatro grupos avaliados apresentaram valores adequados, independentemente do uso de adesivo ou não.

Palavras-chave: Adesivo dental; ortodontia; cisalhamento

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Introduction

The technique of direct bonding of brackets to enamel has been widely studied in orthodontics due to the biomechanical importance of obtaining a stable interface between the bracket and bonding material. The loads generated by the arch wires are transferred to the tooth through the bonded brackets, which may remain attached to the tooth [1]. Ideal bonding materials would present adequate bond strength, be easy to use, and would avoid enamel demineralization.

Many orthodontists who were accustomed to bonding brackets with the use of self-curing orthodontic resins, and who migrated to photo activated systems suppressed the use of the adhesive empirically. Previous studies have shown that the use of self curing resins without the application of adhesive for bonding brackets does not have a harmful influence on shear bond strength [2] and the cytotoxic effect is reduced [3]. The use of light cured bonding materials (compomers and resins) without the application of adhesive for bracket bonding must be investigated, because it undoubtedly simplifies the clinical procedure and can reduce the possibilities of hypersensitivity among dental staff.

Another point that needs clarification is the addition of fluoride to the bonding materials. Enamel demineralization around orthodontic accessories is a possible adverse effect of orthodontic treatment for patients with poor oral hygiene [4-6], because appliances in the oral cavity create new plaque-retention sites [7,8]. Thus, fluoride has been added to the composition of materials used for bracket bonding. However, the bond strength of these materials requires further investigation when adhesive is or is not used.

Transbond XT (3M Unitek) is a conventional orthodontic resin largely used for bonding orthodontic accessories. Transbond Plus Color Change (3M Unitek) is a resin modified by addition of ionomer (compomer). This compomer has the property of fluoride releasing, preventing demineralization around brackets during orthodontic treatment. Considering the bonding procedure, the main difference between these two materials is that the Transbond Plus Color Change is more fluid than the conventional resin. Because of the difference on wetting capacity between these two materials and between them and restorative resins, it is possible that the use of adhesive is needless prior to bracket bonding.

The aims of this in vitro study were to evaluate the shear bond strength (SBS) and failure mode of the resin Transbond XT and the compomer Transbond Plus Color Change with and without the prior use of adhesive to treat the etched enamel surface.

Methods

This work was approved by the *Ethical Committee* of the “Centro Universitário Franciscano” (Santa Maria, Brazil). The sample was composed of 88 (eighty eight) human upper premolars, previously cleaned and stored in a glucose-free physiological solution, which was provided by the Human Tooth Bank (HTB) of the “Centro Universitário Franciscano” (Santa Maria, Brazil). Teeth with cracked or damaged enamel surfaces were excluded. The specimens were sectioned 10mm below the cement enamel junction, using a diamond disk (H22GK-314-016 – Komet™, USA). The root portion was embedded in PVC tubes and filled with self-polymerizing acrylic resin.

The teeth were then randomly distributed into four groups: Control group resin (CGR), in which conventional resin Transbond™ XT Light Cure (3M Unitek™, Monrovia – CA – USA) was used to bond the brackets with prior application of the adhesive; Experimental group resin (EGR), in which conventional resin Transbond™ XT Light Cure was used without prior adhesive application; Control group compomer (CGC), in which the compomer Transbond™ Plus Color Change (3M Unitek™, Monrovia – CA – USA) was used with prior without prior adhesive application; and Experimental group compomer (EGC), in which the compomer Transbond™ Plus Color Change was used without prior without prior adhesive application (Table 1).

Table 1. Division of control and experimental groups.

Group	N	Liquid resin	Bonding agent
CGR	22	Yes – Transbond XT	Resin Transbond XT Light Cure
EGR	22	No	Resin Transbond XT Light Cure
CGC	22	Yes – Transbond XT	Compomer Transbond Plus Color Change
EGC	22	No	Compomer Transbond Plus Color Change

The tooth crowns were cleaned with a rubber cup and pumice for 10 seconds. Then they were washed with jets of water/air and dried with compressed air for 10 seconds. Bracket bonding was preceded by etching with 37% phosphoric acid gel for 15 seconds (3M Unitek, Monrovia – CA – USA), rinsed with a water/spray combination for 30 seconds, and dried until a characteristic frosty white etched area was observed (about 60 seconds). In groups CGR and CGC the adhesive Transbond XT was applied. Metal brackets for upper premolars (Kirium™ – Abzil, São Paulo – SP – Brazil) were bonded to the vestibular surface, parallel to the long axis of the tooth. The same amount of bonding material was used in all the groups and excesses were removed with an exploratory probe with a rhomboid tip. Light polymerization was performed with a photopolymerization appliance (Radii-cal™ SDI, Bayswater – Victoria – Australia) with intensity of 1200 mw/cm^2 at a constant distance of 3 mm for 40 seconds at an angle of 45º to the tooth surface. A single trained operator performed the entire bonding procedure in accordance with the manufacturer’s specifications.

All specimens were washed with deionized water and dried with compressed air and submitted to mechanical testing in a universal testing machine – mechanical model (EMIC DL 20.000, Curitiba, Brazil). Each specimen was stressed at the junction of the bracket and adhesive in an occlusogingival direction at a crosshead speed of 1 mm/min until the brackets were debonded. After this, the adhesive remnant index (ARI) was visually recorded according to the four-point scale: 0, no adhesive left on the tooth; 1, less than half the adhesive left on the tooth; 2, more than half the adhesive left on the tooth; 3, all the adhesive left on the tooth with a distinct impression of the bracket mesh.

A one-way analysis of variance with post hoc Tukey multiple comparisons was undertaken in order to detect a significant difference in the shear bond strengths among the four groups. Chi-square test was used to compare the ARI scores. Statistical analyses were performed using SPSS Statistical Package (SPSS 20, SPSS Inc, Chicago, USA).

Results

Descriptive statistics and the results of the one-way ANOVA/Tukey are presented in Table 2. This showed that there was a statistically significant difference in the shear bond strength among the groups (P<0.001). The resin Transbond XT (CGR AND EGR) showed higher shear bond strength than compomer Transbond Color Change (CGC AND EGC). However, use of adhesive after the acid etching procedure showed no improvement in bracket bond strength when using Transbond XT (CGR and EGR) and Transbond Color Change (CGC and EGC).

The ARI scores for groups CGR and EGR were mainly 0 and 1, whereas the scores for CGC were mainly 1, and for EGC, score 2 (Table 3). When the compomer was used, the presence of adhesive increased the amount of remnant bond material. No enamel fractures were observed in any of the groups.

Table 2. Descriptive statistics and ANOVA/Tukey comparison among the groups.

Group	N	Mean	Standard deviation	Minimum	Maximum		Significance (*P*)*	
							EGR	0.837
CGR	22	16.60	4.55	9.15	23.24	A	CGC	0.004
							EGC	0.000
							CGR	0.837
EGR	22	15.67	4.52	6.68	28.55	A	CGC	0.045
							EGC	0.003
							CGR	0.004
CGC	22	12.71	2.44	8.71	17.13	B	EGR	0.045
							EGC	0.802
							CGR	0.000
EGC	22	11.71	2.63	6.99	16.49	B	EGR	0.003
							CGC	0.802
Total	88	14.17	4.14	6.99	28.55	–	–	–

* Groups with different letters are statistically different at a 0.05.

Table 3. ARI score distribution and Chi-square comparison among the groups.

Group	0	1	2	3		Significance (*P*)*	
						EGR	0.463
CGR	7 31.8%	13 59.1%	1 4.5%	1 4.5%	A	CGC	0.004
						EGC	0.001
						CGR	0.463
EGR	10 45.5%	12 54.5%	0 0%	0 0%	A	CGC	0.019
						EGC	0.000
						CGR	0.004
CGC	2 9.1%	16 72.7%	3 13.6%	1 4.5%	B	EGR	0.019
						EGC	0.003
						CGR	0.001
EGC	3 13.6%	4 18.2%	10 45.5%	5 22.7%	C	EGR	0.000
						CGC	0.003

* Groups with different letters are statistically different at a 0,05.

Discussion

Although the direct bracket bonding technique has been used for about 45 years, some deficiencies in its performance can still be observed, such as undesirable detachment of accessories, decalcification around the brackets during treatment and the time consuming procedure for removing the remaining adhesive after debonding [3].

Composite resins are still the most widely used materials in the bracket bonding procedure, due to their adequate bond and cohesive strengths [9]. Alternatively, materials with added fluoride have been used. Although conventional glass ionomer cements are capable of releasing fluoride and preventing enamel demineralization adjacent to the orthodontic accessories, their bond strength is limited and they are not recommended for clinical use [10,11]. Thus, resin-modified glass ionomer cements and polyacid-modified resins (compomers) have been more frequently used in orthodontic clinics and research studies because have an adequate bond strength for clinical use. The findings of this study showed that the resin Transbond XT showed higher shear bond strength than the compomer Transbond Plus Color Change. However, all the four groups presented adequate SBS for clinical use, according Reynolds [12].

Other studies have previously compared these two bonding materials. Pseiner et al. [13] found no statistical difference between groups bonded with Transbond XT and Transbond Plus Color change when using SEP to prepare the enamel. Santos et al. (14) verified that when using SEP and Transbond Plus Color Change the SBS was lower than when using total etching, adhesive and resin Transbond XT under dry conditions, in agreement with the present study. However, under humid conditions, this situation changed.

The use of acid etching on the tooth surface, proposed by Buonocore [16], increases the mechanical interlocking between the enamel surface and resinous material due to the mechanical microporosity produced by the phosphoric acid in contact with the enamel. After the acid etching procedures, the use of a adhesive is recommended to wet the enamel surface and maximize the bond strength [2]. Then, composite resin is applied. As regards the shear bond strength of brackets, this in vitro study showed that it was not improved by the use of adhesive. A previous retrospective study evaluated the retention of fixed orthodontic appliances bonded with a self curing resin (Phase II) without adhesive [2]. Seventy four patients were divided into two groups, an experimental group in which brackets were bonded using the composite material without adhesive; and another in which brackets were bonded with Phase II composite and adhesive (control group). The duration of the appliance survival, from the date of appliance bonding to the date of first accidental bracket loss, was analyzed by Kaplan-Meier product limit method and log-rank test. The data suggested that metal orthodontic brackets seemed to work equally well either with or without the use of adhesive. The total percentages of bond failure, roughly 6%, were similar in both test and control groups. Approximately 73% of all patients in the test group and 57% of the patients in the control group experienced no bond failure at all throughout the entire course of treatment.

Recently, Bazargani et al. [16] prospectively evaluated the effect of adhesive on lingual retainer failure after a 2-year follow-up. Fifty-two patients were randomized into two groups: a resin group and a nonresin group. The lingual retainers in the resin group were bonded to the enamel surfaces with two-step bonding resin, Optibond FL, and Tetric Evolution Flow. The nonresin group followed the same retainer bonding procedure but without applying the Optibond FL. In the resin group, the incidence of retainer failure was 4% and it occurred at the composite-wire interface; in the nonresin group, the incidence was 27% and failure occurred at the enamel-composite interface, with difference being statistically detected (P= .049). The incidences of calculus accumulation and discoloration adjacent to the composite pads were 27% and 69% (P= .003) higher in the nonresin group, respectively. Resin application for bonding of lingual retainers seemed to reduce the incidence of retainer failure as well as the incidence of calculus accumulation and discoloration adjacent to the composite pads.

In the present study, the ARI scores for groups CGR and EGR were mainly 0 and 1, whereas the scores for CGC were mainly 1 and for EGC it was score 2. When the compomer was used, the presence of adhesive increased the amount of remnant bond material. Differing from the findings of the present study, Pseiner et al. [13] found mainly score 2 when using both Transbond XT and Transbond Plus Color Change with SEP. Whereas, Santos et al. [14] found that sixty-two percent of the samples bonded with total etching and Transbond XT had a score of 0. Among the samples bonded with SEP and Transbond Plus Color Change, score 2 was predominant. The use of SEP probably influenced the ARI scores. In agreement with the results of the present study, no enamel fracture was observed [13,14].

Although the SBS of brackets bonded with and without adhesive did not significantly differ when using Transbond XT or Transbond Plus Color Change, clinical trials must be conducted before the results of the present study are extrapolated. Other factors, such as demineralization of the enamel around the brackets, calculus formation, discoloration and clinical success of bond strength should be evaluated.

Conclusions

The resin Transbond XT showed higher shear bond strength than the compomer Transbond Color Change.

The use of the adhesive to treat the etched enamel showed no improvement in bond strength when using the two bonding materials.

When the compomer was used, the presence of adhesive increased the amount of remnant bond material.

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