Clinical, Cosmetic and Investigational Dentistry

Dovepress
open access to scientific and medical research

Open Access Full Text Article

ORIGINAL RESEARCH

Shear bond strength of precoated orthodontic brackets: an *in vivo* study

This article was published in the following Dove Press journal:
Clinical, Cosmetic and Investigational Dentistry
12 June 2010
Number of times this article has been viewed

Ali H Hassan

Department of Preventive Dental Sciences, Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia

Objective: To evaluate the shear bond strength of precoated orthodontic brackets bonded with self-etching primer relative to that of noncoated conventionally-bonded brackets at two different time intervals.

Methods: Twenty-one subjects were selected for randomized split-mouth bonding of two types of brackets to the maxillary arch. Half of the teeth had precoated brackets bonded using self-etching adhesive, and the other half had regular brackets bonded using Transbond XT adhesive. Nitinol wires were tied to the upper arch and were left until the time of debonding. The patients were randomly divided into two groups: one debonded after one hour and the other debonded two weeks after the initial wire placement. The shear bond strength was directly recorded from the patients' mouths using an *in vivo* debonding device.

Results: There were no significant differences in shear bond strength between the precoated and conventional groups or within each group at different time intervals. There were significant differences between anterior and posterior teeth in both the precoated and conventional groups.

Conclusion: Pre-coated brackets bonded with self-etching adhesive have the same bonding strength as the conventionally bonded brackets.

Keywords: shear bond, bonding, orthodontics, precoated, brackets, self-etching adhesive

Introduction

Pre-coated orthodontic brackets (POBs) are a new generation of brackets designed to reduce chair-side time and thereby increase work efficiency. However, their bonding characteristics are still questionable and need to be scientifically evaluated.

POBs (APC; 3M Unitek Dental Products, Monrovia, CA, USA) were introduced in 1992.[1] They are claimed to provide more uniform adhesive thickness and to reduce the number of required bonding procedures.[2] The composition of the adhesive layer of the pre-coated brackets differs from that of conventional adhesives such as Transbond XT™ (3M Unitek; Dental Products) in the percentage of the different ingredients incorporated into the material. The precoated adhesive contains more filler (80%) than the regular Transbond XT adhesive (77%), which helps to increase its viscosity to allow better adhesion between the bracket surface and the tooth surface during the initial stages of bonding the bracket.[3]

The combined use of self-etching primer (SEP) (Transbond™ Plus Self Etching Primer; 3M Unitek Dental Products) together with POBs is assumed to reduce the steps required for bonding. This method provides the etching and priming in a single step, which may limit procedural errors, thus minimizing the technique's sensitivity.

Correspondence: Ali H Hassan
Department of Preventive Dental Sciences, Faculty of Dentistry, King Abdulaziz University, P.O. Box: 122423, Jeddah, 21332 Saudi Arabia
Tel +9666401000 Ext 21172
Fax +9666403316
Email alihabib169@hotmail.com

Several models have been used to evaluate and compare different orthodontic bonding materials, including *in vitro*, *ex vivo*, and *in vivo* models.[2–7,10,12] *In vivo* models are assumed to be the most valid because bond strength is tested in the normal oral environment, which contains a number of parameters that are impossible to reconstruct in an *in vitro* or *ex vivo* model. Some of these factors include the stress arising from an activated arch wire coupled with occlusal loads, extreme pH and temperature variations, and the presence of complex oral micro flora and their by-products.[5,9,12] As a result of these factors, shear bond strength of brackets is expected to be different when measured *in vivo* rather than *in vitro*. The *in vivo* evaluation was performed using two different designs: either measuring the failure rate of brackets during orthodontic treatment or measuring the force required to debond the brackets (bond strength). Two studies have shown that the *in vivo* testing of bond strength of brackets was significantly lower than *in vitro* testing.[5,6]

Hajrassie and Khair[6] found that the *in vivo* shear bond strength of Transbond XT adhesive to enamel was not significantly different for loading periods of 10 minutes, 24 hours, one week, or four weeks. Ching et al found that orthodontic brackets can be loaded 15 minutes after bonding without a clinically significant difference in bond strength of the tested adhesive.[8]

A new debonding device (The Digital Force Gauge, DFG) was developed and used to evaluate the shear bond strength of orthodontic brackets *in vivo*.[5,6] It consists of a digital gauge and accessories (model FGE/V-0.5X-100X, NIDEC, Shimpo America, Itasca, Ill, USA) (Figure 1). The DFG is contained in a strong aluminum box to ensure accurate measurement of the shear debonding force. It has a metal shank connected to the sensor of the digital gauge, and it terminates with a tip similar to that of regular debonding pliers. There is also an attached metal rod whose end acts as a pad to support a separating plier that is used to transfer the load to the sensor without disturbance. To perform debonding, a custom-made acrylic splint is placed over the bonded teeth for protection during the debonding procedure. The metal shank tip of the debonding device is placed over the gingival bracket surface. Then the separating plier is placed between the metal pad of the metal rod and the protective acrylic splint. Compressing the separating plier slowly generates a steadily increasing force on the tested bracket until failure. The force is automatically recorded by the DFG.

Precoated brackets have been evaluated in several studies, and these have reported conflicting results.[2,3,7,12] One *in vitro* study found no significant difference between the shear bond strengths of precoated and conventional brackets.[2] Another *in vitro* study, however, found that precoated metal brackets exhibited lower bond strength than conventional ones when the same adhesive was used for both.[3] Similar results were reported in an *ex vivo* study.[12] The failure rate of precoated brackets was also evaluated in a clinical trial, which found insignificant differences in the clinical failure rate between precoated brackets and conventional nonprecoated brackets.[7]

Figure 1 The Digital Force Gauge and its components.

The objective of the present study was to measure the shear bond strengths of precoated orthodontic brackets as compared to conventional metal brackets bonded to different teeth using the DFG at two different times: one hour after bonding and two weeks after wire loading.

Materials and methods

This research was approved by the Ethical Research Committee at the Faculty of Dentistry, King Abdulaziz

University. Twenty-two patients were selected from the general pool of patients waiting for orthodontic treatment at King Abdulaziz University in Jeddah, KSA. The selection criteria for the subjects included the following: willingness to participate in this study, the presence of intact upper dentition, the absence of caries, cracks, and dental restorations, and no missing teeth. A consent form was signed by each subject containing the full details of the study procedures. Patients were randomly assigned into one of two groups: one-hour debonding (OHDG) and two-week debonding (TWDG). In the OHDG, the one-hour debonding time was selected to be longer than the initial setting time registered for bracket bonding, which was estimated to be 15 minutes.[8] In the TWDG, the timing of debonding was selected to be two weeks to ensure adequate time for the brackets to be exposed to the oral environment and wire loading.

The total number of bonded teeth was 218, with 110 teeth in the conventional group (CG) (60 in the OHDG and 60 in the TWDG), and 108 teeth in the precoated group (PG) (60 in the OHDG and 58 in the TWDG). The minimum sample size needed for this study was estimated to be 50 teeth in each group. This was calculated based on the sample size of a previous *in vitro* study using the following equation:

$$n = (2s^2\ Xt^2)/D^2$$

Where n = the minimum number of subjects needed to achieve significance at 0.05

S = the average standard deviation for the two groups

t = the *t*-test value at $P = 0.05$

D = half of the mean standard deviation of the two groups.[13]

In the TWDG, two brackets came off and were excluded from the study. All bonding and debonding procedures were performed by one clinician to eliminate any inter-examiner errors. Intra-examiner errors were assessed by conducting repeated bonding and debonding two weeks apart, and they were insignificant. The shear bond strength was measured in Newtons (N) by the device and then converted to megapascals (MPa) by dividing the force by the individual bracket surface area (Table 1).

Table 1 Bracket base surface area for both groups (sq mm)

Bracket	sq mm
Central	10.52
Lateral	8.97
Cuspid	10.19
Bicuspid	9.61
Lower anterior	9.81

Teeth in the upper arch were used in each subject and were divided into two quadrants. In each subject, the two quadrants were randomly assigned into one of two groups: the precoated group (PG) or the conventional group (CG). In the PG, POBs (APC; 3M Unitek Dental Products) were bonded to the teeth using SEP (Transbond™ Plus Self Etching Primer, 3M Unitek Dental Products). In the CG, conventional metal brackets (Gemini; 3M Unitek Dental Products) were bonded using regular Transbond XT™ bonding resin (3M Unitek Dental Products).

Bonding was performed according to the manufacturer's instructions for both types of brackets and adhesives. The teeth were cleaned and polished using a rubber cup and pumice, and then dried. Appropriate intraoral tooth isolation was maintained during the procedure. In the PG group, POBs were bonded to the teeth using SEP. In the CG, the buccal surface of each tooth was etched using 37% phosphoric acid gel for 20 seconds. The teeth were then rinsed and dried until they appeared chalky white. Then Transbond XT bonding system was used to bond the metal brackets. After proper positioning of the brackets in both groups, the brackets were exposed to light cure (ElisparTM S10 LED Curing Light) for 30 seconds divided between the mesial and distal surfaces of each bracket. Each patient received a light 0.014" nickel titanium wire that was tied to the brackets using ligature wires and left in place until the time of debonding. All patients in the TWDG were given specific standard instructions regarding food intake and oral hygiene maintenance during the experiment.

Brackets were debonded one hour after bonding in the OHDG and two weeks after bonding in the TWDG. Debonding was performed using the DFG device (Figure 1) as described by Hajrassy and Khier (2007).[6] Then, the remaining adhesive on surface of the teeth was cleaned off, and the teeth were polished.

Statistical analysis was performed using the SPSS software package (SPSS for Windows 98, version 16.0, SPSS Inc, Chicago, IL, USA). An unpaired *t*-test at a threshold of $P < 0.05$ was used to compare the shear bond strengths of anterior and posterior teeth. An unpaired *t*-test at a threshold of $P < 0.05$ was also used to compare the mean bond strengths of the PG and CG groups. A paired *t*-test at a threshold of $P < 0.05$ was used to compare the mean bond strengths of the OHD and TWD groups.

Results

Table 2 shows the comparison between the CG and PG at two different times: OHDG and TWDG. There was no statistically significant difference between the shear bond strength of the

Table 2 Comparison of the shear bond strength (MPa) between pre-coated brackets and conventional brackets at one hour and two weeks after bonding

Shear bond strength					
Time	**Bracket**	**Pre-coated brackets**	**Conventional brackets**	**Unpaired *t*-test**	***P***
		Mean ± SD	**Mean ± SD**		
OHDG		3.96 ± 1.0 n = 60	4.1± 0.84 n = 60	0.689	0.49
TWDG		3.96 ± 0.96 n = 58	4.27 ± 1.3 n = 60	1.71	0.090
Paired *t*-test		0.38, $P = 0.71$	1.2, $P = 0.27$		

Note: $^{*}P < 0.05$. Significant difference between the two groups.

precoated and that of the conventional brackets in either the OHDG or the TWDG ($P < 0.05$). There was no significant difference between the shear bond strength of the precoated brackets debonded after one hour and those debonded after two weeks ($P < 0.05$). There was also no significant difference between the shear bond strength of the conventional brackets debonded after one hour and those debonded after two weeks ($P < 0.05$).

There was a significant difference between the shear bond strength of anterior and posterior teeth within both groups (PG and CG) regardless of the time of debonding (Table 3) ($P < 0.05$). The shear bond strengths of both conventional and precoated brackets to the anterior teeth were significantly higher than those of the same brackets to the posterior teeth in both the OHDG and the TWDG ($P < 0.05$).

Discussion

The main aim of this study was to compare the shear bond strength of precoated brackets that are bonded to the teeth by a single-step etching material to the shear bond strength obtained using a conventional bonding system (Transbond XT). The suggested advantages of precoated systems over conventional light-cured systems include consistent quality and quantity of the adhesive as well as easier clean-up.[12] In addition, the use of these systems decreases the number of steps required for the bonding procedure, which helps to reduce the overall chair-side time. The present study is one of the first studies to evaluate the shear bond strength of pre-coated brackets combined with self-etching primer.

Unlike *in vivo* models, *in vitro* models for testing the bond strength of brackets (which were used in many studies) fail to adequately simulate the oral environment. This study represents the only *in vivo* experiment to evaluate the shear bond strength of precoated brackets combined with the use of self-etching primer. A new device (DFG), which was previously validated and calibrated,[5,6] was used in this study to measure directly the shear bond strength upon intraoral debonding. A split-mouth design control group was also used, to which one quadrant of the upper arch in each patient was randomly assigned. This was very important to control for inter-patient variation.

Unlike other previous *in vivo* studies that evaluated the shear bond strengths of brackets bonded only to first premolar teeth,[2,3,5,6,12] this study used all teeth mesial to the permanent first molars in the upper arch. This was done to ensure a more accurate assessment of the shear bond strength of brackets to different types of teeth and not only to first pr emolars. To reduce the effects of anatomical variability, a larger sample size was used than in the previous *in vivo* studies. Kula et al[10] evaluated the clinical bond failure of brackets bonded to all teeth, and found that the premolars had a higher failure rate than incisors and canines; our study confirms these findings. There was a significant difference between the anterior and posterior teeth regardless of the system of bonding used or the time

Table 3 Comparison of the shear bonding strength between anterior and posterior teeth

Duration	**Pre-coated brackets**		***t***	***P***	**Conventional brackets**		***t***	***P***
	Anterior teeth	**Posterior teeth**			**Anterior teeth**	**Posterior teeth**		
	Mean ± SD **n = 66**	**Mean ± SD** **n = 42**			**Mean ± SD** **n = 66**	**Mean ± SD** **n = 44**		
1 hour	4.1 ± 1.0	3.52 ± 1.1	2.2	0.031*	4.2 ± 0.95	3.5 ± 0.80	2.96	0.005*
2 weeks	4.22 ± .870	3.4 ± .872	3.48	0.001*	4.6 ± 1.22	3.7 ± 1.23	2.5	0.016

Note: $^{*}P < 0.05$. Significant difference between the two groups.

of debonding. This might be explained by the fact that posterior teeth are less accessible than anterior teeth, which makes boding to premolar teeth more sensitive than that to anterior teeth. However, there was a difference in the sample size between anterior teeth group and posterior teeth group used in this study, which necessitates future investigation.

In the OHDG, one hour of debonding was selected because it is longer than the initial bracket bonding setting time, which was estimated to be 15 minutes.[8]

In the TWDG, the timing of debonding was selected to be two weeks so that the effects of the oral environment and wire loading on bond strength could be evaluated after an adequate duration of loading.

This study agrees with one *in vitro* study that evaluated the bond strength of precoated brackets relative to conventional brackets.[2] There was no significant difference in shear bond strength between the precoated and conventional brackets. However, our study disagrees with Bishara et al[3] who used an *in vitro* model, and Julio et al[12] who used an *ex vivo* model. They showed that precoated brackets exhibited lower bonding strength than conventional brackets.

In addition, the present study agrees with Kula et al[10] and Hjrasi and Khier[5] regarding the shear bond strength at different time intervals. There was no statistically significant difference between the OHDG and TWDG groups.

The bond strength required for clinical use was estimated to be between 2.8 and 10 MPa.[6] The bond strengths recorded in this study are within that range.

Based on these results, which indicate similar bonding strength between precoated and conventional brackets, it can be concluded that the use of SEP combined with POBs provides adequate shear bond strength and might be suitable for clinical use. This bonding system is more convenient than the conventional system because it requires fewer steps, which could be highly appreciated by orthodontists. Future studies may be directed to evaluate clinical bond strength after longer period of time than two weeks.

Conclusion

The shear bond strength of precoated brackets combined with SEP is equivalent to that of conventional brackets. These data support the use of precoated brackets as an alternative to conventional brackets because their bonding requires fewer clinical steps and at the same time, has similar bonding strength to the conventional brackets.

Acknowledgments/disclosure

The author reports no conflicts of interest in this work. The author would like to thank Dr Manar Hajrassi for providing the DFG, Dr Samar Al-Saeed for help in collecting the data, and 3M Unitek Company for providing the brackets.

References

1. Sfondrini MF, Cacciafesta V, Klersy C. Halogen versus high-intensity light-curing of uncoated and pre-coated brackets:a shear bond strength study. *J Orthod.* 2002;29:45–50.
2. Vicente A, Bravo LA. Shear bond strength of pre-coated and uncoated brackets using a self-etching primer. *Angle Orthod*. 2007; 77:524–527.
3. Bishara S, Olsen M, Von Wald L. Comparisons of shear bond strength of pre-coated and uncoated brackets. *Am J Orthod Dentofacial Orthop.* 1997;12:617–621.
4. Murray SD, Hobson RS Comparison of in vivo and in vitro shear bond strength. *Am J Orthod Dentofacial Orthop*. 2003;123:2–9.
5. Pickett KL, Sadowsky PL, Jacobson A, Lacefield W. Orthodontic in vivo bond strength: Comparison with in vitro results. *Angle Orthod*. 2001;71:141–148.
6. Hajrassie MK, Khier SE. In vivo and in vitro comparison of bond strengths of orthodontic brackets bonded to enamel and debonded at various times. *Am J Orthod Dentofacial Orthop*. 2007;131:384–390.
7. Wong M, Power S. A prospective randomized clinical trial to compare pre-coated and non-pre-coated brackets. *J Orthod*. 2003;30:155–158.
8. Ching E, Cook PA, Bubb NL, Wood DJ. The effect of early static loading on the in vitro shear/peel bond strength of a 'no-mix' orthodontic adhesive. *Eur J Orthod*. 2000;22:555–559.
9. Matasa CG. Microbial attack of orthodontic adhesives. *Am J Orthod Dentofacial Orthop*. 1995;108:132–141.
10. Kula K, Schreiner R, Brown J, Glaros A. Clinical bond failure of pre-coated and operator-coated orthodontic brackets. *Orthod Craniofac Res*. 2002;5:161–165.
11. Cooper RB, Goss M, Hamula W. Direct bonding with light-cured adhesive pre-coated brackets. *J Clin Orthod*. 1992;27:477–479.
12. Cal-Neto JP, Miguel JA, Zanella E. Effect of a self-etching primer on shear bond strength of adhesive pre-coated brackets in vivo. *Angle Orthod*. 2006;76:127–131.
13. Lunsford TR, Lunsford BR. The research sample, part II: Sample size. *JPO.* 1995;7:137–141.