Original Article

Effects of Repeated Bonding on Shear Bond Strength of Orthodontic Brackets Rebonded with a Composite Resin Adhesive- An in Vitro Study

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Abstract

Background: *Bracket debonding is a frequent and undesirable problem during orthodontic treatment. Bracket debonding may be due to patient applying inappropriate forces to the bracket or due to poor bonding technique. Sometimes it is necessary to reposition inaccurately positioned brackets during treatment to take full advantage of archwire slot values and sliding mechanics. As a result, a significant number of teeth have to be rebonded in a busy orthodontic practice. The purpose of this study was to evaluate the effects of repeated bonding on the shear bond strength of orthodontic brackets bonded with light cured composite resin adhesive.*

Materials and Methods: *Twenty human extracted premolars without any defects were etched with 37% phosphoric acid and cleansed with water spray and air dried. The sealant (Ortho Solo) was applied on the tooth surface and the bracket was bonded using adhesive (Enlight). Adhesive was then cured with LED (D-LUX, Diadent) for 10 seconds. Then the brackets were debonded later using a Universal testing machine, operating at a crosshead speed of 2mm per minute until the brackets were detached from the tooth & force required to de-bond each bracket was recorded. After each debonding, each tooth was cleaned, and the bonding/debonding procedures were repeated two more times on the same tooth surface.*

Results: *The Shear bond strength in first time debonding sequence was 10.06±2.15 MPa, in second time debonding sequence it was 8.02±1.40 MPa and in third time debonding sequence it was 8.12±1.58 MPa. Significant difference was noted between the shear bond strength of first and second time debonding sequences, there was also significant difference noted in overall change between first and third time debonding sequences but there was no significant difference noted between second and third time debonding sequences.*

Keywords: *Debonding, Orthodontic brackets, Rebonding, Shear bond strength.*

Introduction

Bonding resin to enamel is a significant development that can be seen in all fields of dentistry. Buonocore introduced acid etching technique in 1955. In orthodontics, brackets are bonded to teeth by composite resin adhesive. Bonding orthodontic brackets over banding is preferable because of easier plaque removal by patient, less soft tissue irritation, no need of separation and absence of post treatment band spaces. The bond strength of adhesive and attachments should be sufficient to withstand the forces of mastication, the stresses exerted by the archwires, and patient abuse as well as allow for control of tooth movement in all 3 planes of space. At the same time, the bond strength should be at a level to allow for bracket debonding without causing damage to the enamel surface. Various studies have suggested bond strengths ranging from 2.8 MPa to 10 MPa as being adequate for clinical situations.[1] Retief in 1974 demonstrated enamel fractures on in vitro specimens with bond strengths as low as 9.7 MPa.[2]

However, the use of composite resins as the bonding medium in orthodontics has disadvantages. Enamel can be lost during the debonding procedures as well as the cleanup process of residual resin removal. This is of clinical significance since the concentration of fluoride is greatest at the surface of the enamel.[3]

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Bracket debonding is a frequent and undesirable problem during orthodontic treatment. Bracket debonding may be due to patient applying inappropriate forces to the bracket or due to poor bonding technique. Despite the significant improvement in quality of adhesive materials, more than 5-7% of brackets attachment failure is seen clinically which need to be rebonded.[4] Sometimes inaccurately positioned brackets should be repositioned during treatment to take full advantage of archwire slot values and sliding mechanics.[5]

The time it takes to clean, prepare, and bond a new bracket can be disruptive in a busy practice; it might also lengthen the overall treatment time.

As a result, it is important to better understand what to expect when a tooth is rebonded more than once.

An acid-etching adhesive system for orthodontic brackets mainly involves acid-etching, rinsing, drying, priming, and bonding steps. In a freshly etched tooth, the surface area available for forming a mechanical bond is increased because the liquid sealant allows for an easy flow into the interprismatic spaces formed during the etching process and sealant tags are formed. Most of these sealant tags remain embedded in the enamel after debonding.[6] On the other hand, a chemical bond occurs between the sealant and the adhesive paste, and in turn the adhesive paste mechanically adheres to the bracket base. Overall, this adhesive system provides optimum strength required to keep the bracket attached to the tooth during orthodontic force application.

Findings regarding bond strength of rebonded brackets have been misleading. Some investigators have reported lower rebond strength, while others have reported that it was similar with first time debonding or higher than initial bond strength.[7,8]

Jassem et al in 1981 found that thermal recycling of bonded and rebonded orthodontic attachments adversely affected both shear and tensile bond strength.[9] Mui et al in 1999 found that there were no significant differences between the rebond strength and the original shear bond strength if the enamel surface was reconditioned with a tungsten carbide bur.[10]

Regarding rebonding strength of orthodontic brackets bonded with light cured acrylic resin adhesive, very few researches has been published. Moreover, most of the articles present contradictory results. The purpose of this study was to evaluate the effects of repeated bonding on the shear bond strength of orthodontic brackets bonded with light cured composite resin adhesive.

Materials and Methods

At first 50 extracted premolars were collected. Then those teeth that does not meet the inclusion criteria were discarded.

Inclusion criteria:

1. Extracted both maxillary and mandibular premolars.
2. Teeth with intact buccal enamel.

Exclusion criteria:

1. Tooth with gross irregularities of the enamel structure, like caries or any kind of demineralization of enamel.
2. Tooth with hypoplastic areas, fractures, cracks, fissures, or those teeth that does not have a perfect facial surface.
3. Pretreated tooth with chemical agents, like derivatives of peroxide, acid, or alcohol and restorations.
4. Tooth with cracks from forceps extraction.

Then from the rest of the teeth 20 teeth were selected by simple random sampling (lottery method).

The test sample consisted of 20 (twenty) non carious human premolars (both maxillary and mandibular) extracted for orthodontic purposes in the department of orthodontics, BSMMU. Teeth with hypoplastic areas, cracks, gross irregularities of the enamel structure or forceps marks from extraction were excluded from the study. The teeth were stored in saline solution continuously after extraction and the solution had been changed weekly to avoid bacterial growth. At first each tooth was mounted vertically in auto polymerizing acrylic resin block with a dimension of 14 x 16 x 25mm, with the long axis of each tooth set vertically and the crown remaining exposed. Then buccal surfaces of the teeth were first cleaned and polished with rubber cup and polishing paste for 20 seconds, at low speed and then washed with water. After that each acrylic resin block was marked by number for ease of data collection i.e. marked by 01, 02, 03......20.

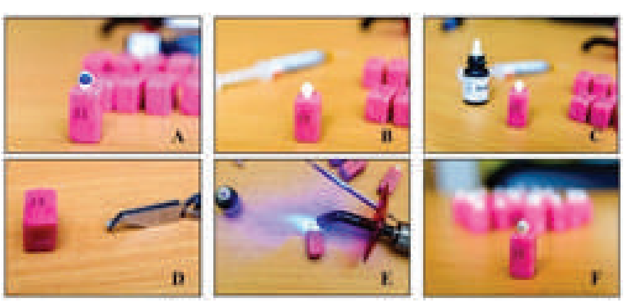

Figure 1: Steps in bonding of orthodontic bracket. A. Etching, B. Washing and Drying of enamel surface, C. Application of Primer, D. Placement of adhesive (Enlight) on bracket base, E. Placement of bracket on tooth surface and curing of adhesive with LED light, F. After curing bracket on the tooth.

For the first time debonding sequence these teeth were etched with 37% phosphoric acid and cleansed with water spray and air dried with oil free air. Then a thin layer of orthodontic adhesive primer (Ortho Solo) was applied on the tooth surface and orthodontic premolar metal bracket (Stainless steel Roth, Ormco) was bonded using adhesive (Enlight) according to the manufacturer's instructions, and all excess resin on the edges of the bracket was thoroughly cleaned before polymerization. Then adhesives were cured with the LED light (D-Lux, Diadent, Korea) for 10 seconds and stored in distilled water for 24 hours before debonding (Figure 1).

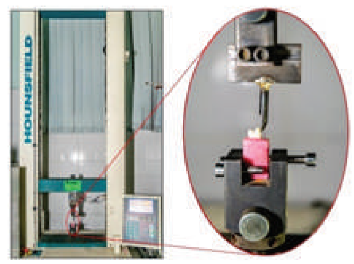

Figure 2: Measurement of Shear bond strength in Universal Testing Machine (HounsfieldH10KS, USA).

Then the shear bond strength of each of the specimens was evaluated with a Universal testing machine (Tinius Olsen, Hounsfield-H10KS, 500N sensor). Before debonding, the embedded specimens were secured in a jig attached to the base plate of universal testing machine. A chisel-edge plunger was mounted in the movable crosshead of the testing machine and positioned such that the leading edge aimed the enamel-adhesive interface before being brought into contact with bracket at a crosshead speed of 2 mm per minute. An occluso gingival load was applied to the bracket producing a shear force at the bracket-tooth interface (Figure 2).

The force required to dislodge the brackets was measured in Newton (N), and the shear bond strength (SBS) was calculated in Megapascal (MPa) by dividing the force values by the bracket (Roth 0.022, Ormco) base areas (3mm Ч 3.5mm = 10.5mm2).

Figure 3: Computer connected with the Universal Testing Mechine showing Force at break in Newton (N) of orthodontic bracket in the QMat software interface.

After first debonding all visible residual composite adhesive were removed with a finishing carbide bur until the enamel surface regained its gloss. Then all the teeth were rebonded with the same principal as described in first debonding group. Then shear bond strength of each specimen were measured again by Universal testing machine at a crosshead speed of 2 mm per minute until the brackets were detached from the tooth.

After second debonding all visible residual composite adhesive were removed again with a finishing carbide bur until the enamel surface regained its gloss. Then all the teeth were rebonded again with the same principal as described in first debonding group. Again shear bond strength of each specimen were measured by Universal testing machine at a crosshead speed of 2 mm per minute until the brackets were detached from the tooth.

During each series of bonding and debonding, the order of the teeth was maintained so that it was possible to compare the shear bond strength of each tooth in its proper sequence.

Data analysis was done using the Statistical Package for the Social Science (SPSS) for Windows (Version 21; Armonk, NY: IBM SPSS corp.; 2012)

Shapiro-Wilk's test (P>0.05), Kolmogorov-Smirnov test (P>0.05) and a visual inspection of their

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	p	Statistic	df	p
SBS of First Debonding Sequence Group	0.131	20	0.200	0.939	20	0.227
SBS of Second Debonding Sequence Group	0.128	20	0.200	0.961	20	0.557
SBS of Third Debonding Sequence Group	0.090	20	0.200	0.974	20	0.838

histograms, normal Q-Q plots and box plots showed that shear bond strengths of different debonding sequences were approximately normally distributed (Table 2).

Table 1: Tests of Normality

P>0.05 was considered as statistically significant

Paired sample t-test was performed to compare the shear bond strength between first and second time debonding sequences, second and third time debonding sequences and overall change between first and third time debonding sequences. P- Value was considered at p≤0.05.

Results

The study was performed with 20 non-carious human premolars extracted for orthodontic purposes in the department of orthodontics, BSMMU in the year 2017. These 20 teeth were debonded three times with new brackets, so each debonding sequence group had 20 data and a total of 60 data. Adhesives were cured with the LED light for 10 seconds and stored in distilled water for 24 hours before each sequence of debonding.

The Shear bond strength in first time debonding sequence was 10.06±2.15 MPa with a range of 7.21- 14.10 MPa, in second time debonding sequence it was 8.02±1.40 MPa with a range of 5.88-11.55 MPa and in third time debonding sequence it was 8.12±1.58 MPa with a range of 5.71-11.55 MPa (Figure 5).

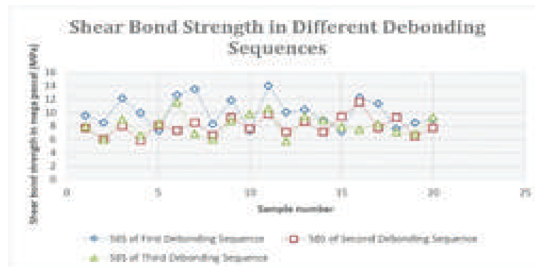

Figure 4: Scattergram with connected lines showing Shear Bond Strength in Different Debonding Sequences.

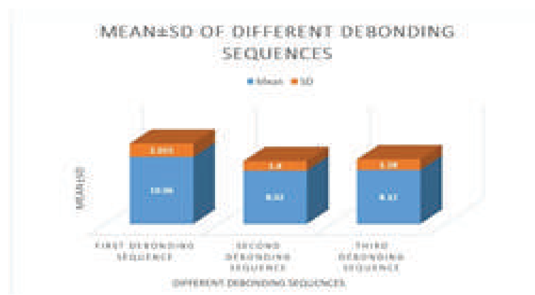

Figure 5: Bar diagram showing comparison of (Mean ± SD) the Shear Bond Strengths between the Different debonding sequence groups.

Debonding Sequences	Mean	SD	95% Confidence Intervals (CI)		t	p-Value
			Lower	Upper		
First debonding sequence – Second debonding sequence	2.038	2.108	1.051	3.025	4.324	**0.000**
Second debonding sequence – Third debonding sequence	-0.990	1.770	-0.927	0.729	-0.250	**0.805**
First debonding sequence – Third debonding sequence	1.939	2.188	0.915	2.963	3.963	**0.001**

Significant difference was noted between the shear bond strength of first and second time debonding sequences with a P value of 0.0003, there was also significant difference `noted in overall change between first and third time debonding sequences with a P value of 0.001 but there was no significant difference noted between second and third time debonding sequences with a P value of 0.805 (Table 2).
Table 2: Comparison of the Shear Bond Strengths between different debonding sequence groups
Data is presented as mean, standard deviation and 95% confidence interval (CI). P<0.05 was considered as significant.
From a clinical perspective, the present findings regarding shear bond strength suggested that, in most cases, a rebonded tooth had weaker bond strength than initial bond strength.

Discussion

Failure of orthodontic brackets during orthodontic treatment is relatively frequent and undesirable. The time it takes to clean, prepare, and bond a new bracket can be disruptive in a busy practice and might also lengthen the overall patient treatment time. As a result, it is important to better understand what to expect when a tooth is rebonded one or more times, since the literature provided contradictory findings regarding the shear bond strength of rebonded attachments.[11] The study was designed to evaluate of the changes in shear bond strength values of orthodontic brackets when they are bonded repeatedly on the same tooth with new brackets. The aim of my study was to compare the shear bond strength of brackets between different debonding sequences.
This study demonstrated a significant difference in shear bond strength between the first and second debonding sequences, there was also significant difference in overall changes in bond strength between shear bond strength of first and third time debonding sequences. However there was no significant difference noted between second and third time debonding sequences.
The present study showed that there was significant difference in shear bond strength between first and second time debonding sequences and also between first and third debonding sequences, this was similar with the findings of other in vitro studies.[12] While there were no significant difference in shear bond strength between second and third time debonding sequences. Findings regarding shear bond strength of rebonded brackets have been contradictory. Some investigators have reported that rebond strength was lower,[12] while others have reported that it was comparable[8] with or higher[7] than original bond strength. Jassem et al in 1981 found that thermal recycling of bonded and rebonded orthodontic attachments adversely affected both shear and tensile bond strength.[9] Mui et al in 1999 found that there were no significant differences between the rebond strength and the original shear bond strength if the enamel surface was reconditioned with a tungsten carbide bur.[10]
The Shear bond strength in first time debonding sequence was 10.06±2.15 MPa, in second time debonding sequence it was 8.02±1.40 MPa and in third time debonding sequence it was 8.12±1.58 MPa. Various studies have suggested shear bond strengths ranging from 2.8 MPa to 10 MPa as being adequate for clinical situations.[1,13] According to this minimum requirement, different debonding sequences shown satisfactory level of shear bond strength. From a clinical perspective, the present findings regarding shear bond strength suggested that, in most cases, a rebonded tooth had weaker bond strength than initial bond strength.

Conclusion

Based on the methodology applied in this study and according to the results obtained, the present findings indicated the following:
1. The highest values for shear bond strength were obtained after the initial bonding.
2. Rebonded teeth had significantly lower shear bond strength.
3. Three debonding sequences provided adequate and clinically acceptable shear bond strength without any enamel fracture.

References

1.Keizer S, Ten Cate JM, Arends J. Direct bonding of orthodontic brackets, Am J Orthod Dentofac Orthop. 1976;69:318–327.

2. Retief DH. Failure at the dental adhesive etched enamel interface, J Oral Rehab. 1974;1: 265–284.

3. Retief DH, Sadowsky PL. Clinical experience with the acid-etch technique in orthodontics, Am J Orthod Dentofac Orthop. 1975; 68:645 –654.

4. O'Brien KD, Read MJ, Sandison RJ, Roberts CT. A visible light-actived direct-bonding material an in vivo comparative study, Am J Orthod Dentoface Orthop. 1989;95:348251.

5. McLaughlin R, Bennett J. Finishing and detailing with a preadjusted appliance system, J Clin Orthod. 1991;25:251-264.

6. Diedrich P. Enamel alterations from bracket bonding and debonding: a study with the scanning electron microscope, Am J Orthod Dentofacial Orthop. 1981;79:500–522.

7. Wright WL, Powers JM. In vitro tensile bond strength of reconditioned brackets, Am J Orthod. 1985;87:247–252.

8. Egan FR, Alexander SA, Cartwright GE. Bond strength of rebonded orthodontic brackets, Am J Orthod Dentofacial Orthop. 1996;109: 64– 70.

9. Jassem HA, Retief DH, Jamison HC. Tensile and shear strengths of bonded and rebonded orthodontic attachments, Am J Orthod. 1981;79: 661–668.

10. Mui B, Rossouw PE, Kulkarni GV. Opitimization of a procedure for rebonding dislodged orthodontic brackets, Angle Orthod. 1999;69: 276– 281.

11. Rosenstein P, Binder RE. Bonding and rebonding peel testing of orthodontic brackets, Clin Preventive Dent. 1980;2:15–17.

12. Ireland AJ, Sherriff M. Use of an adhesive resin for bonding orthodontic brackets, Eur J Orthod. 1994;6:27–34.

13. Reynolds IR. A review of direct orthodontic bonding, Br J Orthod. 1985;2:171–178.

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