Flowable Composite for Orthodontic Bracket Bonding (in vitro study)

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Key words

flowable composite; shear bond strength; orthodontic bracket.

Abstract

Flowable resin composites have been recommended for many clinical uses and have been formulated in a variety of compositions and viscosities to meet various uses. The aim of this study was to determine if flowable composite with or without resins could be used as orthodontic bracket bonding. Sixty noncarious human premolars were divided into three equal groups. Metal brackets were bonded to etched enamel using a composite resin control (Resilience® orthodontic adhesive) and flowable composite with and without sealant resin (Resilience® flowable composite). After 72 hours of incubation in deionized water at 37 C°, debonding was performed with a shearing force. The shear bond strength (SBS) and the mode of bond failure were examined. High significant difference was observed in the SBS between control and flowable groups. Clinically acceptable SBS was found for the two flowable adhesives with bond failures occurred mostly in the bracket–adhesive interface. No significant differences between flowable groups. In conclusion, the use of flowable composite with and without sealant resin is advocated for orthodontic bracket bonding.

Introduction

Current trends in orthodontic materials research focusing on visible light–cured orthodontic adhesives bonding system. The advantages of this system are the high early bond strength[1], minimal extent of oxygen inhibition[2], and the extended working time for optimal bracket placement[3].

However, such a system still has a number of shortcomings such as loss of enamel after acid etching[4], enamel damage caused by postdebonding cleanup procedures[5], and enamel fracture (EF), which may take place during debonding.

Clinicians and researchers have worked to improve the qualities of bonding agents. The qualities that have been of most interest include bond strength, adequate working time , shorter cure time, and

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improved ease of use. Among the composite resins that could be used in orthodontics as bonding agents today, flowable composite merits great attention because of its clinical handling characteristics: (1) nonstickiness, so that materials could be packed or condensed, and (2) fluid injectability [6]. They are created by retaining the same small particle size of traditional hybrid composites but reducing the filler content and allowing the increased resin to reduce the viscosity of the mixture.

Recently, in orthodontics flowable composites has been suggested for bonding lingual retainers[6,7,8] but there are contradictory reports on the shear bond strength of flowable resins compared to the conventional one as orthodontic bracket bonding [9,10].

Frankenberger et al[11] indicated that composites with a thinner viscosity can adequately bond to enamel without the requirement of an intermediate bonding resin; this indicating the ability of flowable composites to infiltrate acid-etched enamel and form an adequately strong bond with the enamel.[12,13] . While Uysal et al [10] not suggest that flowable composite can be applied for orthodontic use.By reducing the number of steps during bonding, clinicians can save time and reduce potential errors related to contamination during the bonding procedure [14].The aim of this study is to determine if flowable composite with or without resins could be used as orthodontic bracket bonding.

Material and Methods
Teeth

Sixty noncarious human premolars, extracted for orthodontic indications, were collected and stored for a maximum of 3 months in a 0.2% thymol solution were used for this study. Teeth with hypoplastic areas, cracks, or irregularities of the enamel structure were excluded from the study. The criteria for tooth selection dictated no pretreatment with chemical agents such as alcohol, formalin, and hydrogen peroxide. The sample was randomly divided into 3 groups of 20 each.

Experimental Groups

The buccal enamel surface of the teeth were cleansed and polished with nonfluoridated pumice and rubber prophylactic cups, washed with water, and dried. enamel surfaces were etched for 30 seconds, a common etching time in orthodontic bonding[15], using a 37% phosphoric acid (Gel Etch, Resiliace, USA), rinsed with water for 20 seconds, and dried with oil free air for 10 seconds until the etched enamel exhibited a frosty, white appearance. Premolar stainless steel brackets (Bionic™ by orthotechnology, USA) were bonded to the teeth using the bonding protocols, according to the manufacturer's instructions. The average

surface area of the orthodontic bracket base was 13.40 mm².The upper premolar brackets were bonded to the teeth according to manufacturers' instructions .After acid etching, the brackets were bonded in the following manner:

Group 1:Resiliance® orthodontic adhesi - -ve by orthotechnology, USA (Control C); A Resilience sealant resin was applied to the etched surface in a thin film and light cured for 10 second. The bracket base was coated with adhesive paste, and then placed onto the enamel surface and pressed firmly. All excess adhesive was removed carefully.
Light curing was performed for 20 seconds on both the mesial and distal sides (40 seconds total) using a quartz-tungsten-halogen (QTH) light curing unit (Optilux 501, Kerr, Dansbury, CT, USA) at 800 mW/cm2.

Group 2: Resilience® flowable composite by orthotechnology with sealant resin (FR), USA; Etching, rinsing, and drying were done according to the bonding protocol. During this procedure, an intermediate unfilled low-viscosity liquid resin was applied on the air-dried and etched enamel surface and light cured for 10 second. Flowable composite paste was applied to the bracket base, and the bracket was positioned on the tooth and light cured total 40 seconds.

Group 3: Resilience® flowable composite by orthotechnology, USA without sealant resin (F); Etching, rinsing, and drying were done according to the resilience protocol. No intermediate low-viscosity liquid resin was applied on the etched enamel surface.
Flowable composite adhesive was applied to the bracket base, the base was positioned, and the adhesive was light cured total 40 seconds. The teeth after bonding were immersed in sealed containers of deionized water and placed in an incubator at 37 C° for 72 hours to permit adequate water absorption and equilibration[16].

Debonding Procedure

Each tooth was mounted vertically in a self-cure acrylic block so that the crown was exposed. To minimize variation in the direction of the debonding force, each block was secured in a bench vice with the pad of the bracket positioned parallel to the plunger of the testing machine (Fig.1). The load applied at failure was recorded in Newtons (N), and the stress was calculated in megapascals (1 MPa =1 N/mm2) by dividing the force in N by the bracket base area of 13.40 mm2. The surface area of the base was determined by measuring length and width and by computing the mean area. Shear bond strength (SBS) of each group was measured using a universal testing machine (Tinius Olsen, UK) at a crosshead speed of 1 mm/min. A steel rod with a flattened end was attached to the crosshead of the test machine. A shear force was then applied along the long axis of the tooth. At this time, the base of the bracket was placed as close as possible to the steel rod. The maximum load to debond the bracket was thus recorded.

Bond Failure Assessment

After debonding, the residual adhesive remaining on the teeth was assessed by using the adhesive remnant index (ARI), as described by A°rtun and Bergland[17] and modified by Lalani et al [18] to include a score for enamel fracture (EF). The ARI scores were used as a more complex method of defining the site of bond failure between the enamel, the adhesive, and the bracket.The ARI of zero indicates that no adhesive remained on the tooth after debonding and, consequently, that the bond failure occurred at the enamel-adhesive interface. The ARI scores of 1 and 2 indicate, respectively, that less than 50% or more than 50% of the adhesive remained on the tooth after debonding, which is defined as a cohesive failure within the adhesive. The ARI score of 3 indicates that the entire adhesive remained on the tooth after debonding and, consequently, that the bond failure occurred at the adhesive- bracket interface.

The enamel surface of each tooth was examined under an optical microscope to determine the amount of residual adhesive remaining on each tooth.

Results
Shear Bond Strength

The descriptive statistics, including the mean, standard deviation, minimum and maximum and range values of SBS in MPa for each of the three groups are presented in Table 1. The data were analyzed using a one-way ANOVA with Tukey HSD test. The group C achieved the highest bond strength (24.43 MPa), while the bond strengths for flowable composites with resin (FR) and without resin (F) are 15.38 MPa, 14.66 MPa respectively. Results of ANOVA revealed statistically high significant differences in bond strengths among the various groups tested ($P < 0.01$) are presented in Table 2. Multiple comparisons results of Tukey HSD test displayed high significant differences in bond strengths between control group and flowable composites while there is a non significant difference between flowable composites with resin (FR) and without resin (F) as shown in Table 3.

Adhesive Remnant Index

The residual adhesive on the enamel surfaces was evaluated by the ARI scores (Table 4). The group F, the greatest frequency was observed at ARI scores of 3 and no frequency of EF after debonding. In groups C and FR more of the composite remained on the tooth (ARI scores 2 and 3). This finding shows a greater trend for the three adhesives to remain on the tooth surface after debonding, with a distinct impression of the bracket mesh on the adhesive remaining on the tooth surface. The site of bond failure was mostly occure at adhesive-bracket interface. The lowest score of 0 occurred less frequently than the other scores in three groups. Teeth with EF in both groups C and FR displayed ARI score of 0 or 1.

Discussion

The goal of current orthodontic research is to improve the bonding procedure by minimizing the time of working during bonding and debonding without jeopardizing the ability to maintain a clinically useful bond strength. The bond strength for the Resilience® orthodontic adhesive (control composite) ,at 24.43 MPa, was similar to that Transbond XT (control composite) found by Rock and Abdullah [19]. Sinha et al[20]. Tang et al,[21]and Rix et al[22] .The SBS of control composite is greater than flowable adhesives due to the influence of adhesive filler concentration on bond strength, Ostertag et al [23] found there is an increase in shear and torsional bond strength with increasing concentrations of adhesive filler. A reduction in filler volume led to a reduction in the total contact area between the filler and resin matrix. Such a reduction then lowered the resultant bond strength within the specimens. In terms of correlation, neither specific trend nor correlation was found between the ARI scores of the tested specimens and their corresponding SBS values. Although higher stresses can occur during mastication[24].Various studies have already suggested that the appropriate bond strength for orthodontic brackets in a clinical situation ranges from 2.8 MPa to 10 MPa. [25,26,27,28,29] . The bond strengths of two tested flowable composite with and without resin (15.38 MPa, 14.66 MPa respectively) were less than control adhesive but they are greater than maximum bond strength recommended for successful clinical bonding. So we can expect a decrease in unexpected debonding during treatment. The non significant differences in bond strength between flowable composites with and without resin indicate the liquid phase of the composite is present in sufficient amount to flow into the enamel porosities and act independently of the filler particles[13,23,30,33].Thus improve the bonding procedure by minimizing the working time by reducing the number of steps during bonding with flowable composite without using resin.Many investigators indicated in SBS studies that metal brackets failed predominantly at the bracket-adhesive interface[23,34,35].Flowable composite without resin adhesive trend to remain on the enamel surface after debonding (ARI score 2,3). This indicates wetting and penetration of the composite into the enamel surface was occurred even without using resin, this penetration into the enamel surface gave clinically acceptable SBS (14.66 MPa). The bond failure occurs due to adhesive failure at the adhesive/bracket interface and cohesive failure within the adhesive which indicate the low mechanical properties of the flowable composite and presence of air bubbles within the resin[11].Furthermore, flowable composite without resin showed no evidence of EF. Considering that the clinical search for optimal bond strength means (1) minimizing unexpected debonding during treatment14 and (2) obtaining an undamaged enamel surface after debonding[36].The SBS for the flowable composites appeared to be clinically acceptable, although lower than that for control adhesive, implying that flowable composites can simplify the bonding procedure by eliminating the need to apply an intermediate bonding resin without deteriorating the bond strength. In conclusion, the flowable composites which displayed clinically acceptable bond strengths with the lower frequency of EF after debonding, can be used for bonding orthodontic bracket.

Fig.(1):- Plunger of the testing machine

Table(1):- descriptive statistic for each groups.

Groups	Sample size	Mean	S.D	Min.	Max.	Range
C	20	24.43	2.85	21.01	31.08	10.07
FR	20	15.38	2.06	11.19	18.11	6.92
F	20	14.66	2.62	11.55	20.65	9.10

Table(2):- ANOVA test between group.

Groups	Sample size	Mean	S.D	F	P-value	Sig.
C	20	24.43	2.85			
FR	20	15.38	2.06	92.40	0.000	H.S
F	20	14.66	2.62			

H.S : Highly Significant at level   P < 0.0

Table(3):- Tukey HSD Multiple Comparisons.

Group	Group	Mean Difference	P-value	Sig.
C	FR	9.04600	0.000	H.S
C	F	9.76950	0.000	H.S
F	FR	0.72350	0.640	N.S

N.S : Non Significant at level P > 0.05.
H.S : Highly Significant at level   P < 0.01.

Table(4):- Adhesive Remnant Index (ARI) scores of adhesives tested.

Tested groups	N	0	1	2	3	EF
C	20	2	5	7	6	4
FR	20	1	2	10	7	1
F	20	0	2	8	10	0

ARI ; **0** indicates no adhesive remained on the tooth; **1,** less than 50% of the adhesive remained on the tooth; **2**, more than 50% of the adhesive remained on the tooth; and **3**, all adhesive remained on the tooth. **EF**, enamel fracture.

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