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Shear Bond Strength of Fixed Retainer Bonded with Different Types of Composites

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ABSTRACT

Aim: Aims of the study were to measure shear bond strength of different composite types used in bonding fixed retainer. **Subjects and methods:** The sample of this study consists of sixty extracted sound human premolar teeth that were divided into three wire groups and three fiber-reinforced composite groups. In wire and fiber-reinforced composite groups, one group is bonded with control conventional composite and two groups bonded using different types of flowable composites. Each sample was etched, bonded and then inserted into the universal testing machine. The resulted data were collected and then analyzed to obtain the mean values of shear bond strength of each sample. **Results:** In wire groups, the results demonstrated that the difference between groups was statistically non-significant (p value>0.05) as indicated by one way ANOVA. In FRC groups, the results demonstrated that the difference between groups was statistically significant (p value>0.05) as indicated by one way ANOVA. There was a statistically significant difference between conventional composite and Tetric-N flowable composite when used, respectively. **Conclusion:** In all FRC groups the results of shear bond strength were less than the results of wire groups. It was found that the FRC weakens instead of strengthens the fiber/composite complex.

KEYWORDS

Shear bond strength, fixed retainer, composite, CBCT, fiber-reinforced composite, flowable composites.

INTRODUCTION

Retention is usually necessary following orthodontic treatment to overcome the elastic recoil of the periodontal supporting fibers and to allow remodeling of the alveolar bone. With the possibility of acid etching and bonding, it has become common practice to apply bonded fixed retainers for long-term retention of the achieved orthodontic results.(1)

Bonded lingual retainers are fabricated in various designs that consist of combinations of different wires in different sizes and different composites.(2) Spiral or multistrand wires appear to be the most popular for direct bonded retainers. The main advantage of the use of multistrand wire is the irregular surface that offers increased

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mechanical retention for the composite without the need for the placement of retentive loops.[3,4]

Moreover, another asset is the flexibility of the wire that allows physiologic movement of the teeth, even when several adjacent teeth are bonded.[5] Although traditional methods are successful, splinting teeth with reinforcement fibers that can be embedded in composites has gained popularity in the last years.[6,7] Different composites have been suggested for use in fabricating retainers, including both restorative and orthodontic bonding materials.[8,9]

Several adhesives were developed especially for lingual retainers, and manufacturers offer ease of application and optimal handling properties for these adhesives.[10] These highly filled, light-cured resins are also claimed to be a better choice when longevity and durability are required. Flowable composites, originally created for restorative dentistry by increasing the resin content of traditional micro-filled composites, have been suggested as lingual retainer adhesives.[11,12]

However, previous reports have demonstrated that flowable composites present lower shear bond strength (SBS) values when used for bonding metallic orthodontic brackets.[13,14] This raises the question whether they can serve as well when they are used for lingual retainer bonding as there is not satisfactory evidence provided to rigidly answer this question.[15]

MATERIALS AND METHODS

A sample of 60 first premolar teeth extracted for orthodontic purpose was used and selected on the following inclusion criteria, intact enamel, non carious, on restored and no enamel hypoplasia. The teeth collected were stored at room temperature in distilled water (Aqua Bure lab) (PH : 6,50-6,8) for 24 hour . All teeth were mounted on self-cured acrylic resin block in a way that root was embedded into the acrylic just below the cemento-enamel junction level leaving the crown fully exposed.

The buccal surfaces of all teeth were etched with 37% Ortho-Phosphoric acid etching gel (Total etch, Ivoclar, Vivadent,Schaan, Liechtenstein) for 30 Sec, washing for 30 Sec and dryness of the enamel surface . For each experimental group, respective adhesive primer was applied, and light cured for 10 seconds then the assigned composite resin (according to the group) was added to the enamel surface. Insertions of the wire **(W)** or fixed retainer composite **(FRC)** were done according to each group and the composite was cured with a light source (HL-LED2 CURING LIGHT, ZONERAY, CHINA) for 40 seconds.

The samples were divided into four groups (15 for each group)

Group 1

- Adhesive primer used: Te-Econom Bond, universal dental adhesive, Ivoclar, Vivadent, Schaan, Liechtenstein.
- Composite resin used: Conventional light curing resin based dental restorative material (Te-Econom plus, Ivoclar, Vivadent, Schaan, Liechtenstein).
- Fixed retainer element (FRE): Multi-strand wire (0.0195 Straight Co-axial Ortho- organizers, USA). (Figure1)

Group 2

- Adhesive primer used: Light cure adhesive primer Transbond XT, 3M Unitek, Monrovia, Calif.
- Composite resin used: Light curing, Flowable, Low viscosity, direct restorative universal composite (Filtek Z350-XT, 3M ESPE, Monrovia, USA).
- Fixed retainer element (FRE): Multi-strand wire (0.0195 Straight Co-axial Ortho- organizers, USA). (Figure2)

Group 3

- Adhesive primer used: Te-Econom Bond, universal dental adhesive, Ivoclar, Vivadent, Schaan, Liechtenstein.
- Composite resin used: Conventional light curing resin based dental restorative material (Te-Econom plus, Ivoclar, Vivadent, Schaan, Liechtenstein).
- Fixed retainer element (FRE): Light curing, Fiber-reinforced composite with Fiber braids and high Strength Composite (Fiberspan, Biodental Technologies, Australia). (Figure3)

Group 4

- Adhesive primer used: Light cure adhesive primer Transbond XT, 3M Unitek, Monrovia, Calif.
- Composite resin used: Light curing, Flowable, Low viscosity, direct restorative universal composite (Filtek Z350-XT, 3M ESPE, Monrovia, USA).
- Fixed retainer element (FRE): Light curing, Fiber-reinforced composite with Fiber braids and high Strength Composite (Fiberspan, Biodental Technologies, Australia). (Figure 4)

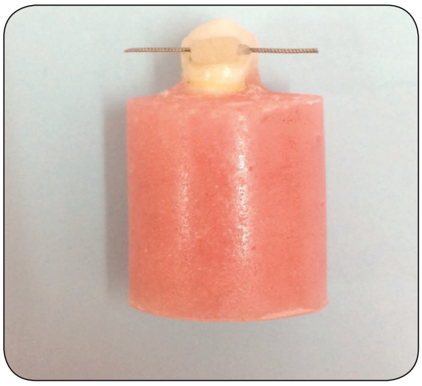

Fig. (1) Sample representing group 1.

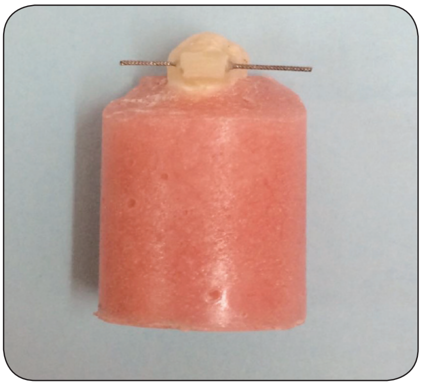

Fig. (2) Sample representing group 2.

Fig. (3) Sample representing group 3.

Fig. (4) Sample representing group If.

All Samples were individually mounted on a computer controlled Universal testing machine (Model LRX-plusi Lloyd instruments Ltd, Fareham, UK) with a load cell of 5 KN. The data were recorded using computer Software (nexygen-NT, Lloyd instruments).

Samples were secured to the lower fixed part of the testing machine by tightening Screws. Shearing test was done by compressive mode of load applied at resin-enamel interface using a mono-beveled chisel shaped metallic rod attached to the upper movable compartment of testing machine traveling at cross-head speed of 0.5 mm / min.

The load required to deboning was recorded in Newtons. The load at failure was divided by the bonding area (in mm2) to express the bond strength in Mpa. The data Collected were statistically analyzed.

Statistical analysis

Descriptive statistics including means, standard deviations (SD), and minimum and maximum values were calculated for every group. Analysis of variance (ANOVA) was used to determine whether there were significant differences in the shear bond strength between the groups.

If there were significant differences. Tukey's post-hoc test was used to determine which means were significantly different from each other. Student's t-test was used to determine significant differences between the two groups. The level of significance for all statistical tests was established as $p \leq 0.05$.

RESULTS

It was found that **group 1** (conventional composite) recorded the highest mean value (22.8±4.42 MPa) followed by **group** 2 (Z 350 XT) flowable composite (19.9±1 MPa) then **group** 3 (conventional composite + FRC) type (16.5±4.1 MPa), then **group** 4 (Z 350 XT +FRC) flowable composite (14.7±1.98 MPa). Table (1)

Table (1) *Descriptive statistics of shear bond strength results for all groups.*

	Group 1	Group 2	Group 3	Group 4
Mean	***22.8***	***19.9***	***16.5***	***14.7***
Std. Deviation	***4.42***	***1***	***4.1***	***1.98***
Std. Error	1.98	0.423	1.71	0.886

Table (2) *Comparison of shear bond strength results of all groups ranked from higher to lower.*

The difference between groups was statistically significant (p value < 0.05) as indicated by one way ANOVA test followed by pair-wise Tukey's multiple comparison post-hoc test. Table (2)

	Mean	*Std. Deviation*	*Rank*	*ANOVA*
Group 1	***22.8***	***4.42***	***A***	***P value***
Group 2	***19.9***	***1***	***B***	***<0.0001****
Group 3	***16.5***	***4.1***	***C***	
Group 4	***14.7***	***1.98***	***D***	

** significant (p<0.05) different letters showing significant difference (Tukey's <p<0.05)*

DISCUSSION

A certain amount of relapse is almost inevitable following orthodontic therapy, particularly in the lower anterior segment. Therefore, the need for secure retention after orthodontic treatment is unquestioned, and the bonded wire retainer is a good choice for the modern orthodontics.[16,17] With the advent of effective, new bonding materials, many orthodontists prefer to use canine-to-canine or premolar-to-premolar bonded retainers to obtain optimal retention of lower anterior teeth both functionally and esthetically.

From a large range of composites available, two flowable composites (Filtek Z350-XT, 3M ESPE, Monrovia, USA and Tetric N-Flow, Ivoclar, Vivadent, Schaan, Liechtenstein) and a control composite (Te-Econom plus, Ivoclar, Vivadent, Schaan, Liechtenstein) were selected in this study for testing. All these composites are widely used in dentistry and orthodontics.

The wire of choice for this testing procedure was multi-strand wire (0.0195 Straight Co-axial Ortho-organizers, USA). This wire is also commonly used in orthodontics for lingual retainer fabrication. A study by Bearn et al (44) showed that increasing the wire diameter from 0.0175 inch to 0.0215 inch increased the force required to pull the wire out of the composite.

A study by Bearn et al [18] showed that increasing the wire diameter from 0.0175 inch to 0.0215 inch increased the force required to pull the wire out of the composite.

In this study it was found that the two tested types of flowable composite (Filtek Z350-XT) and (Tetric N-Flow) recorded a shear bond strength values (19.9 Mpa) and (17.4Mpa) respectively when they were used for bonding orthodontic wire to an etched enamel surfaces, with no statistically significant difference between them and the control conventional composite (Te-Econom plus) (22.8 MPa) as indicated by one way ANOVA.

Thus, the present study indicated that Te-Econom plus and Filtek Z350-XT have comparable bond strength followed by slightly lower bond strength for Tetric N-Flow. At this juncture it is worthwhile to note that the bond strength of all the three adhesives is quite above the clinically acceptable level of 5.9 to 7.8 MPa as suggested by Reynolds. [19]

Lopez [20] recommended a value of 7 MPa as minimum bond strength for successful clinical bonding.

In contrary to these results and the results of current study Uysal[13] reported a very low value for flowable composites ranging from 6 to 8 MPa compared to 17.10 MPa showed for Transbond XT and concluded that flowable composites are not suitable for orthodontic bonding.

In the present study, it was surprising to find that there was a statistically significant difference in SBS values between the wire and FRC groups (as the FRE) with the same composites and in all corresponding groups. The wire groups yield higher bond strength than the FRC groups. This may be explained by application of fibers in a given composite volume which may change the load bearing capacity of the whole structure.These results were supported by those of a previous study [21] which comparing adhesive properties of bonded orthodontic retainers to enamel. It was concluded that, regardless of their application mode, stainless steel orthodontic bonded retainers delivered higher bond strengths than those of fiber retainers.

Another previous in vivo study by Rose et al,[22] 20 patients were randomly assigned to receive fiber or multi-stranded wire retainers from canine to canine following the completion of orthodontic treatment. The retainers remained intact in place for an average of 11.5 and 23.6 months, respectively, with a statistically significant difference. This limited clinical evidence indicates that the multistranded wire is superior to the woven fiber which adds to the results of this study.

The SBS for the tested flowable composites appeared to be clinically acceptable, implying that flowable composites can simplify and advocate its use in the bonding procedure.

CONCLUSION

From the results of this work the following conclusion could be extracted:

1. The flowable composites tested, yielded accepted SBS values, comparable to the control orthodontic composite.
2. Flowable composites advocated to be used as a reliable orthodontic retainer adhesive.
3. Considering the higher bond strength results obtained from the stainless steel wire groups vs. those of some FRCs tested, it has been found that the FRC actually weakens instead of strengthens the fiber/composite complex.

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قوة الشد لأنواع مختلفة من الكومبوزيت المستخدم لتثبيت أجهزة التثبيت الدائمة بعد علاج حالات تقويم الاسنان

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الملخص:

الهدف:تهدف هذه الدراسة الى قياس قوة الشد لأنواع مختلفة من الكومبوزيت المستخدم لتثبيت اجهزة التثبيت الدائمة التي يتم تركيبها بعد علاج حالات التقويم.

المواد والأساليب : وتكونت العينة المستخدمة في الدراسة من ستين ضرس ضاحك سليم تم خلعهم كجزء من خطة علاج التقويم وتم تقسيمهم المجموعتين رئيسيتين المجموعة الاولى تم فيها استخدام سلك التثبيت الدائم في حين تم استخدام الكومبوزيت المقوى بالألياف وتم تقسيم كل من المجموعتين الرئيسيتين ثلاث مجموعات فرعية في المجموعة الاولى تم تثبيت سلك التثبيت الدائم بواسطة مادة الكمبوزيت التقليدية والمجموعة الثانية والثالثة باستخدام مركبين مختلفين من الكومبوزيت عالي التدفق.

النتائج: وقد اظهرت نتائج الدراسة في المجموعة الاولى عدم وجود فوارق ذات اهمية احصائية بين المجموعات الفرعية الثلاثة في قوة الشد بينما وجدت فوارق ذات اهمية احصائية بين المجموعات الفرعية الثلاثة للمجموعة الرئيسية الثانية حيث اظهرت المجموعة المستخدم فيها نوع TETRIC-N قوة شد اعلى من باقي المجموعات.

الخلاصة: قوة الشد بالنسبة الكومبوزيت المقوى بالألياف اقل من مادة الكمبوزيت التقليدية المستخدم لتثبيت اجهزة التثبيت الدائمة التي يتم تركيبها بعد علاج حالات التقويم.

الكلمات المفتاحية: قوه الشد، اجهزة التثبيت، الكومبوزيت، الكومبوزيت المقوى بالألياف، الكومبوزيت المتدفق.