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Original Article

Comparison of shear bond strength of stainless steel brackets bonded with three light- cured adhesives

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Abstract

Introduction: The bonding process of the brackets to enamel has been a critical issue in orthodontic research. The purpose of this study was to evaluate the shear bond strength of 3 light-cured adhesives (transbond XT, Z250, light bond).

Materials &Methods: In this study sixty extracted human premolars were collected and randomly divided into 3 test groups. All teeth were etched by 37% phosphoric acid. In first group brackets were bonded by Transbond XT adhesive, in group two brackets were bonded by Light bond adhesive and in third group were bonded by filtek Z250 composite. All of them were cured with Ortholux xt for 40 seconds. 24 hours after thermocycling, Shear Bond Strength (SBS) values of these brackets were recorded using a Universal Testing Machine. Adhesive Remnant Index (ARI) scores were determined after the failure of the brackets, using Stereo Microscope the data were analyzed using ANOVA and Chi-square tests.

Results: Mean shear bond strength of Transbond XT, light bond and Z250 were 28.9±2.25 MPa, 25.06±1.98 MPa and 26.8±2.57 MPa, respectively. No significant difference was observed in the SBS among the groups and a clinically acceptable SBS was found for the three adhesives. ARI scores were not significantly different between the various groups (P>0.05).

Conclusion: This study showed that the Z250 can be used as light bond and transbond xt to bond orthodontic brackets and ARI and SBS scores were not significantly different.

Keywords: Adhesives, Shear strength, Resin cements, Composite resins

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مقایسه ی استحکام باند برشی براکت های فلزی Stainless Steel باند شده توسط سه نوع ادهزیو لایت کیور

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چکیده

مقدمه: فرآیند اتصال براکت به مینا یک مسئله مهم در تحقیقات ارتودنسی است. هدف از این مطالعه مقایسه استحکام باند برشی براکتهای فلزی stainless steel چسبانده شده توسط ادهزیوهای light bond، transbond xt و Z250 با یکدیگر می باشد.

مواد و روش ها: در این مطالعه ۶۰ دندان پرمولر کشیده شده ی انسانی، بصورت تصادفی به ۳ گروه مساوی تقسیم شدند: همه دندان ها با ژل اسید فسفریک ۳۷٪ اچ شدند. در گروه اول براکت ها با ادهزیو Transbond XT ، در گروه دوم با ادهزیو light bond و در گروه سوم با کامپوزیت Z250(filtek) بر روی دندانها قرار گرفت و با ortholux xt به مدت ۴۰ ثانیه کیور گردید. ۲۴ ساعت پس از انجام ترموسایکلینگ، استحکام باند برشی براکت ها توسط دستگاه Universal testing machine (Instron) اندازه گیری شد. بعد از دی باند ایندکس رزین باقی مانده (ARI) با استریو میکروسکوپ تعیین گردید. یافته ها توسط آنالیز واریانس ANOVA و Chi-square ارزیابی گردیدند.

یافته ها: میانگین استحکام باند برشی برحسب مگاپاسکال برای گروه اول ۲/۲۵ ±۲۸/۹، گروه دوم ۱/۹۸±۲۵/۰۶ و در گروه سوم ۲/۵۷±۲۶/۸ بود. استحکام باند برشی بین گروه ها اختلاف معنی داری نداشت (P= 0.2) و هرسه ادهزیو SBS کلینیکی قابل قبولی داشتند. سنجش ARI در بین گروه ها اختلاف معنی داری را نشان نداد (P>0.05).

نتیجه گیری: این تحقیق نشان داد که Z250 جهت باند براکت های ارتودنسی می تواند همانند light bond و transbond xt مورد استفاده قرار گیرد و تفاوت معناداری از نظر ARI و SBS با آنها ندارد.

واژگان کلیدی: ادهزیو، استحکام برشی، سمان های رزینی، کامپوزیت های رزینی

Introduction

Buonocore introduced the technology that led to the concept of direct bonding in orthodontics.[1] Ten years later, Newman described acid-etching technique to enhance the mechanical adhesion of orthodontic brackets to the teeth.[2] Since then several factors that affect the mechanical adhesion of orthodontic brackets to the teeth consist of utilized adhesive material, the concentration and duration of etching agent, the general features of brackets such as design and also expertise of the clinician have been described.[3] One of the most common reasons of the brackets failure is due to the forces induced immediately after bonding process by the clinician or the patient. Previous studies have introduced a resistant force of 6 to 8 MPa as an appropriate one to avoid single failure of the brackets bonding.[4] The acid etched/composite technique is the most widely accepted bonding system in contemporary orthodontic practice.[5] Recently, several visible light–cured orthodontic adhesives have been illustrated. The main benefits of visible light–cured orthodontic adhesives are the high early bond strength, minimal oxygen inhibition and enough working time. Filled dental restorative materials were also used as orthodontic adhesives. These materials consist of an organic diacrylate (BIS-GMA), a coupler (Silane) and a higher percentage content of inorganic filler (quartz or silica). These fillers obviously improve abrasion resistance and also Shear Bond Strength (SBS) values, significantly reduce thermal expansion and consequently prevent long-term micro leakage, too.[6] Charged particle in the composite resin may limit the free flow of adhesive into enamel pores [7] but researches have been shown that the liquid phase of the composite is sufficient to flow into the etched enamel and form resin tags[8] Z250 is a widely used restorative composite for bracket bonding but there is lack of evidence in comparison of this composite related to common orthodontic adhesives. The purpose of this

investigation was to evaluate the SBS and the mode of bond failure of 2 light-cured composite resin adhesives (Transbond XT, light bond) and Z250 composite.

Materials &Methods

Sixty human premolar teeth were collected and they were held in distilled water at room temperature with thymol crystals (0.2%) to prevent bacterial growth. Previously, restored teeth or teeth with enamel defects or cracking (observed at ×10 magnification) were not included in the study. The 60 teeth were randomly divided into three equal groups. After a 15-second polish with fluoride and oil free pumice by using a rubber cup and a slow speed hand piece, the buccal crown surface of each tooth was rinsed and dried.

Stainless steel metal premolar 0.022 inch Standard Edgewise brackets (American orthodontics, Sheboygan, USA) were bonded to the teeth with a different adhesive in each group. The average surface of the used orthodontic bracket base was 11.85 mm^2. [9] All brackets were bonded by the same operator. The bonding adhesives were all light cured with a curing light Ortholux XT, (3M/Unitek Co, St Paul ,USA) calibrated for 470 nm to ensure intensity consistent light.

Group 1: Transbond XT (Unitek/3M, St Paul, USA.): The buccal surface of the teeth was etched and rinsed for 30 and 10 seconds, respectively and finally was dried using moisture free air until the enamel had a white appearance. Transbond XT primer was applied and light cured for 10 seconds. Transbond XT adhesive paste was applied to the bracket base and the bracket was positioned 4 mm height to the cusp tip on the mid buccal surface of tooth and firmly pressed with an instrument to expel the excess adhesive. Each bracket was subjected to a 250g compressive force using a force gauge for 10 seconds, after which excess bonding resin was removed using a sharp scaler. Then, the adhesive was light cured for 20 seconds from the mesial and 20 seconds from the distal of the bracket.

Group 2: Light bond (Reliance Orthodontic Products, Itasca, USA): Etching, rinsing, and drying were done following the Transbond XT protocol. Light bond was primerly applied in a thin film to the etched surface and light cured for 10 seconds, then light bond paste was used following the Transbond XT protocol.

Group 3: Filtek Z250 (3M ESPE, St Paul, USA.): Etching, rinsing, and drying were done following the Transbond XT protocol. 3M Single bond adhesive was applied in a thin film to the etched surface and light cured for 10 seconds. Then, Z250 paste was applied following the Transbond XT protocol. A 5cm 0.021×0.025–inch stainless steel (American orthodontics, Sheboygan, USA) wire was ligated with elastic module to each bracket slot to minimize bracket deformation during debonding, helping for parallel placement to horizon and mounting the tooth vertically in a self-cure acrylic block.

The bracketed teeth were immersed in sealed containers of distilled water, placed in room temperature and permitted to absorb adequate water and equilibrate. Samples were thermocycled (Nemo industrial, Mashhad, Iran) in water between 5±2, 55±2 C for 500 cycles according to TR11450 protocol .[10]

24 hours after thermocycling, SBS of brackets was measured by Universal Testing Machine (Zwick/ Roell, ULM, Germany). The testing machine was prepared using a chisel-edge plunger. The edge of the plunger was positioned at the enamel – composite interface vertically and regulated at a speed of 0.5 mm per minute. The peak force levels automatically recorded on the testing machine were converted into stress per unit area (MPa) by dividing the force (N) by the mean unit area of the base of the bracket (11.85 mm^2). One-way analysis of variance (ANOVA) was used to compare the SBS between the groups and $P < 0.05$ was considered as significant.

Residual adhesive: After deboning, all teeth and brackets were examined under (10 x) magnifications with Stereo Microscope (Nikon instrument INC, USA). The remnants of the adhesive material were evaluated using Adhesive Remnant Index (ARI) and scored considering resin material to enamel surface ratio (table 1). The ARI was used for definition of the sites of bond failure among the enamel, the adhesive and the bracket base. [11] The ARI data were analyzed with the Chi-square test at the 0.05 significant level.

Table1. Scoring definition of Adhesive Remnant Index (ARI)

Score	Definition
1	All the composite remains on the enamel surface(OES)
2	More than 90% of composite remains OES
3	10% to 90% of composite remains OES
4	Less than 10% of composite remains OES
5	No composite remains OES

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Results

The SBS results are listed in table 2. The analysis of variance showed no significant differences in mean SBS among the three groups (p=0.2).

The residual adhesive on the enamel surfaces was evaluated by the ARI scores. The Chi-square test indicated that there were no significant differences (p=0.1) among the various groups. Figure 1 shows the distribution and frequency of ARI scores. The most frequent scores among three groups were III and IV.

Table2. Descriptive Statistics of Shear Bond Strength (MPa) of the three Groups

Bonding System	Statistic
Transbond xt	
Mean	28.9
Std. Deviation	2.25
Minimum	24.1
Maximum	32.3
Range	8.2
Light bond	
Mean	25.06
Std. Deviation	1.98
Minimum	21.6
Maximum	28.6
Range	7
Z250	
Mean	26.8
Std. Deviation	2.57
Minimum	23.2
Maximum	31
Range	7.8

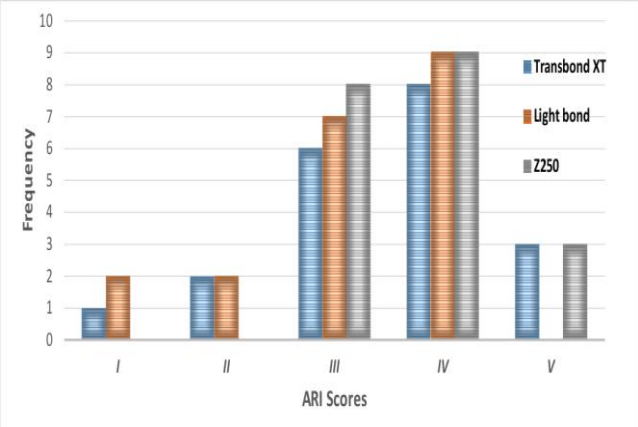


Figure 1. Frequency of the ARI for each group

Discussion

In this experimental study, there were no significant differences in the mean SBS and ARI among tested adhesives. A balance in bond strength must be achieved when the bracket-adhesive combination is chosen for fixed orthodontic treatment. Bond strength should be enough to resist the forces during the orthodontic treatment; however, it must allow the removal of the bracket without complications at the end of orthodontic treatment.[12]

Guidelines for adequate in vitro SBS have not been reported. However, some reports have suggested that previous bonding studies could be used as a guideline for SBS analysis. SBS studies using metal brackets have reported bond strengths in the 2 to 25 MPa range.[12] Several factors have evident influence on bracket adhesiveness including bracket design, clinical situation, acid etching factors and type of the adhesives. The mean SBS values of adhesives used in this study were clinically acceptable. The mean SBS values of all composites tested were greater than 6 to 8 MPa were considered adequate for routine clinical use by Reynolds. [6]

However, in the current study, the bond strength for Transbond XT, light bond and Z250 was more than 25 MPa and not significantly different, which was similar to the results of D'Attilio [5] who stated that SBS of metal bracket to enamel was over 25 MPa. However, some data showed mean SBS of metal bracket to enamel with Transbond XT was 17[6] or 8[13] MPa. These differences could be because of different experimental conditions.

The ARI developed by Artun and Bergland [14] has been used by many investigators to help standardize bond failure analysis. The ARI does allow for statistical analysis and cross-study comparisons for bond failure analysis. A review of the researches shows that many investigators use an ARI system, but they make some modification in the criteria, the number of system, or both.[15,16] In the present study, the ARI scores followed the comprehensive criteria used by Bishara et al.[17]

No significant differences among the three groups were observed in the ARI scores. This was similar to Owens[13] and D'Attilio [5] studies. The ARI for the groups is appropriate because failure site is far from the enamel and is safe enough to decrease the damage to enamel and it shows enough bonding to bracket, too. The ARI data are helpful in characterizing the bond failure, since fracture may occur in several interfaces.

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The point of bond failure may be at the tooth surface (adhesive failure at enamel surface, no resin on tooth), at the bracket (adhesive failure at bracket material surface, cement on tooth not on bracket) or within the adhesive cement (cohesive failure within the cement, cement on both tooth and bracket surfaces). Mixed failures are very common and show the stronger bond strength values.

Uysal et al.[6] used Bishara ARI score but significant difference was observed in the groups because of low bonding strength of flow composites to brackets in comparison of Transbond XT. In our study, the ARI scores in all groups showed there was good adhesive bond to enamel and metal. It has been suggested that if the brackets debond at the enamel-adhesive interface, the fluoride-rich surface enamel can be damaged. According to these observations, the bond failure at the bracket-adhesive interface is desirable.[5]

According to the literatures, orthodontic forces can vary between 5 and 20 MPa. This extensive range is owing to the large variations in experimental design and procedures. Bonds are subjected to different stresses such as torsion, tension, shear or a combination of them and it is difficult to precisely quantify these forces. Establishing the threshold for clinical shear bond strength would be valuable; however, this may be impossible because of the previous mentioned limitations. Therefore, individual clinicians must select the type of adhesive to use on the basis of their own clinical experience and available researches.[13]

Conclusion

Z250 is an available and common restorative composite and is more economical than routine orthodontic adhesives. This investigation revealed that Z250 can be used for bonding orthodontic brackets and ARI and SBS scores were not significantly different in comparison to light bond and transbond xt.

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Conflict of interest: There was no conflict of interest

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