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Comparison of Shear Bond Strength and Adhesive Remnant Index Between Different Adhesive Systems in Bonding and Rebonding of Orthodontic Brackets

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Research Article

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ABSTRACT

Aim: The purpose of this *in vitro* study was to compare the shear bond strength (SBS) and adhesive remnant index of stainless-steel brackets bonded with different orthodontic adhesive systems.
Materials and Methods: In our study performed on 60 premolar teeth extracted because of orthodontic reasons, MBT prescription 0.022'' stainless-steel brackets (Discovery Smart®, Dentaurum, Germany) were used. Teeth randomly divided into 3 groups, bonding was performed with Group 1: Trulock Light Activated Bonding System (RMO, USA), Group 2: Bisco Ortho Bracket Paste LC (Bisco, USA), Group 3: Transbond XT Light Cure Adhesive (3M, USA). SBS and residual adhesive indexes (ARI) were evaluated by breaking the samples. Adhesive residues were cleaned with tungsten carbide burs from the surfaces of the teeth, rebonding was made after sanding the brackets' surfaces. SBS and ARI values were re-evaluated. One-way ANOVA test were used for statistical analysis of the data, $p<0.05$ was considered statistically significant.
Results: Statistically significant differences were observed between Group 1 and Group 2 in comparison to the first SBS values of three different orthodontic adhesive systems to enamel ($p<0.05$). Among the adhesive systems, only a statistically significant difference was found between the first bonding values and the rebonding values of Group 2 ($p<0.05$). There was no statistically significant difference between the first and rebond strengths of the other two adhesive systems. Rebonding values of three different orthodontic adhesive systems were very close to each other.
Conclusions: The results of this *in vitro* study suggest that the adhesive systems developed for using in orthodontics can show clinically enough bond strength even if the rebonding strengths of the falling stainless-steel brackets to the same enamel surfaces decrease slightly.
Key Words: Orthodontic Adhesives, Orthodontic Brackets, Shear Bond Strength, Adhesive Remnant Index

Farklı Adeziv Sistemlerinin Metal Braketlerde Bonding ve Rebonding Sonrası Makaslama Bağlanma Dayanımları ve Artık Adeziv İndeksleri Açısından Değerlendirilmesi

Süreç

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ÖZ

Amaç: Farklı ortodontik adeziv sistemlerinin, metal braketlerin mine yüzeyine ilk ve tekrar yapıştırılmaları (rebonding) sonrasında makaslama bağlanma dayanımlarının (MBD) ve artık adeziv indekslerinin karşılaştırılmasıdır.
Yöntem: Ortodontik nedenlerle çekilmiş 60 adet premolar diş üzerinde gerçekleştirilen çalışmamızda, MBT prescription 0.022'' slotlu metal braketler (Discovery smart, Dentaurum, Almanya) kullanılmıştır. Rastgele 3 gruba ayrılan dişlerde bonding işlemi Grup 1: Trulock Light Activated Bonding System (RMO, ABD), Grup 2: Bisco Ortho Bracket Paste LC (Bisco, ABD), Grup 3: Transbond XT Light Cure Adhesive (3M, ABD) ile gerçekleştirilmiştir. Örnekler kırılarak makaslama bağlantı dayanımları ve Artık Adeziv İndekleri (AAİ) değerlendirilmiştir. Dişlerin yüzeylerinden tungsten karbid frezler ile adeziv artıkları temizlenip, braketler kumlanarak, rebonding yapılmıştır. MBD'ları ve AAİ tekrar değerlendirilmiştir. Verilerin istatistiksel analizinde; Tek yönlü ANOVA testi kullanılmış, $p<0.05$ istatistiksel olarak anlamlı kabul edilmiştir
Bulgular: Üç farklı ortodontik adeziv sistemin mineye ilk MBD değerlerinin karşılaştırmasında Grup 1 ile Grup 2 arasında istatistiksel olarak anlamlı farklılıklar gözlenmiştir ($p<0.05$). Adeziv sistemlerden sadece Bisco'nun ilk bağlanma dayanımıyla tekrarlanan bağlanma dayanımları arasında istatistiksel olarak anlamlı bir farklılık tespit edilmiştir. Diğer iki adeziv sisteminin ilk ve tekrarlanan bağlanma dayanımları arasında istatistiksel olarak önemli bir fark gözlenmemiştir. Üç farklı ortodontik adeziv sisteminin tekrarlanan bağlanma değerleri birbirine oldukça yakın değerler göstermiştir.
Sonuçlar: Bu çalışmanın sonuçları, ortodontik braketlerin mineye bağlantısı için geliştirilen adeziv sistemlerinin düşen metal braketlerin aynı mine yüzeylerine tekrar bağlanma dayanımlarını, bir miktar azalmış olsa bile, klinik olarak yeterli bir bağlantı dayanımı gösterebildiklerini ortaya koymaktadır.
Anahtar Kelimeler: Ortodontik Adezivler, Ortodontik Braket, Makaslama Bağlanma Dayanımı, Artık Adeziv İndeksi.

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Introduction

The number of adult patients seeking orthodontic treatment and aesthetic expectations are increasing day by day.[1] Patients are not only concerned about their smile, but also about the materials used during the treatment. Increasing expectations in the field of aesthetics have also changed the treatment strategies which preferred in orthodontics and have led to the development of many innovations, from the first approaches using stainless-steel brackets and wires to aesthetic brackets produced in a similar color to the tooth, lingual orthodontics and clear aligner treatments.[2] Clinical behavior and bond strength of orthodontic brackets play an important role for successful orthodontic treatment.[3] After Buonocore introduced the enamel etching technique, many studies have been conducted over the years evaluating the attachment of brackets to the enamel surface.[4]

In order to increase the bond strength in orthodontics, many processes such as acid etching, surface roughening, surface conditioning with chemical agents have been applied.[5,6]

As a result of these studies, the factors that determine the success for a successful orthodontic connection are as follows; the orthodontic material used and its mechanical features, tooth surface, enamel surface preparation and morphology, the composition and bond strength of the bonding agent used.[7]

From past to present, many changes have occurred in areas such as mechanism of action, chemical content, application technique, clinical effectiveness in order to increase the success of dental adhesives. The current trend is to provide an effective connection by reducing clinical steps. These products, which are defined as single-bottle adhesive systems, consist of a single product that contains both desensitizer, adhesive and etchant.[8]

The aim of this *in vitro* study was to analyze the SBS and adhesive remnant index of stainless-steel brackets bonded with different orthodontic adhesive systems. The null hypothesis is there is no difference between SBSs and ARI values of different orthodontic adhesive systems after first and rebonding of stainless-steel brackets to enamel surface.

Materials and Methods

This study was conducted at the Selcuk University Faculty of Dentistry Department of Restorative Dentistry in Konya, Turkey. The protocol was approved by the Ethical Committee of Clinical Investigations of Selcuk University Faculty of Dentistry.

In this study, 60 extracted premolar teeth for orthodontic purpose were used. 0.1% thymol solution was used to keep the extracted teeth. Test groups were created by randomly selecting teeth without fractures and /or cracks among the collected teeth to be included in 3 separate bond groups. Group 1; Trulock Light Activated Bonding System (RMO, USA), Group 2: Bisco Ortho Bracket Paste LC (Bisco, USA), Group 3: Transbond XT Light Cure Adhesive (3M, USA). Enamel surfaces were applied 35% acid etch agent, rinsed and dried thoroughly with moisture and oil-free air to obtain an opaque white appearance. After that 0.022'' slot metal premolar brackets (Discovery Smart®, Dentaurum, Germany) were bonded according to the manufacturers' instructions, as shown in Table 1.

The SBS test of samples was carried out in an universal testing device (Instron Corp., Massachusetts, USA). For the flat end of the universal testing machine by means of a tool through the crosshead to build up the load.

The fractured samples were examined after debonding and ARI was decided.

To determine the spots of failing of the adhesive between bracket, resin composite and tooth enamel, ARI scores were used. The ARI scores were assessed by using an optical stereomicroscope (Nicon E400, Nicon Corporation, Warsaw, Poland) with a magnification of x40.

Following the debonding process all teeth surfaces were removed from adhesive remnants by using tungsten carbide burs (No:18, Worlddent, Taiwan), all brackets were cleaned with sandblasting (Al_2O_3 particles). Then rebonding and debonding processes were performed as mentioned above. ARI was reassessed. A power analysis was performed to determine the adequacy of the sample number. It showed that 17 tooth samples per group would provide at least an 80% chance (power) to detect differences of 0.5 standard deviations. Statistical analysis of the data was performed using one-way ANOVA test in SPSS version 22.0 program and $p<0.05$ was considered statistically significant.

Results

In the comparison of the SBS values of three different orthodontic adhesive systems, the highest values were observed in Group 2, Group 3, and Group 1, respectively. When the groups were compared between each other, it was observed that there was a statistically significant difference between the Group 2 and the Group 1. When the bond strengths of all groups were compared after rebonding, it was observed that the bond strength of all groups decreased compared to the initial bonding values, but there was no statistically significant difference between the groups (Figure1, Table2).

When first bonding and rebonding values of the groups were compared, the difference between the first and rebonding values was statistically significant only in the Group 2.

When ARI scores were compared, an increase in ARI 3 score was observed after rebonding in all groups. Compared to the initial bond strengths, there was a decrease in the bond strength values in all groups after rebonding, and in this context, the increase in the ARI 3 score, which defines bracket-cement breakage, was found significant in all groups (Table 2).

Table 1. Application methods of adhesive systems

Materials	Manufacturers	Application Methods of Bonding Systems
Trulock Light Activated Bonding System (Group 1)	RMO. CO. USA	• Dry the etched surfaces thoroughly with moisturefree and oil-free compressed air. The etched surface should appear dull and frosty white • Dispense two drops of Light Activated Bracket Bonding Resin onto a dispensing pad or other suitable surface. With a brush apply one thin uniform layer onto each etched and dried tooth surface to which the bracket is to be bonded. It is not necessary to cure the bonding/sealant resin at this time. n, the bonding/sealant resin may be cured for 10-15 seconds • Apply a thin layer of Trulock™ Light Activated Bracket Adhesive to the underside of the bracket base. Place the bracket onto the tooth and press lightly in the desired position. Excess adhesive can be removed easily from the periphery of the bracket base after bracket is in place. • With a metal bracket, position the curing light to shine from the incisal edge and illuminate for 20 seconds and for 15 seconds from the gingival, mesial or distal bracket edge. Curing may be done directly through a transparent bracket from the labial for 20 seconds. The curing light tip must be placed as close to the bracket base as possible during curing.
Bisco Ortho Bracket Paste LC (Group 2)	Bisco. IL. USA	• Rinse thoroughly with plenty of water. Isolate the teeth and dry with the a syringe. • Dispense LIQUID ETCHANT* into a mixing well. Dab etchant for 20-30 seconds on the surfaces to be bonded. • Rinse etched teeth thoroughly to remove all traces of acid. Re-isolate and dry teeth to be bonded • Brush a thin coat of ORTHO-ONE No Mix Primer on to each etched and dried tooth surface to be bonded. The thin primer coat should be confined to the etched area • Brush a thin coat of ORTHO-ONE No Mix Primer on the underside of the bracket base • Apply a thin layer of ORTHO-ONE No Mix Paste to the underside of the bracket base and immediately place bracket on tooth with a slight rotating motion. Immediately position the bracket to desired angulation and press firmly to insure paste is in a thin uniform layer. All adjustments to brackets must be made within 20 seconds (prior to gelation of paste). Remove excess adhesive from the periphery of the bracket base after the brackets are in place. Keep teeth isolated for approximately 3 minutes.
Transbond XT Light Cure Adhesive (Group 3)	3M Unitek, CA, USA	• Isolate the teeth and dry with the air syringe. • Press the self etching primer capsule, fold and press again. Mix exceeding component for 5 seconds and rub on teeth for 3-5 seconds. Apply air burst gently for 1-2 seconds. • Apply adhesive syringe or capsule to bracket base then place bracket on the teeth. Remove exceeding material carefully.

Table 2. Mean values of tested groups

Groups	N	Mean	Std. Deviation	Minimum	Maximum	p
Group 1	19	192.8275	81.45947	12.45	307.52	0.04*
Rebonded Group 1	19	177.0858	65.76963	19.61	291.23	0.12
Group 2	19	283.0166	143.19018	94.14	721.33	0.24
Rebonded Group 2	19	188.3502	64.50740	98.75	329.68	0.35
Group 3	20	226.6584	119.26257	88.06	628.27	0.19
Rebonded Group 3	20	177.5004	73.78790	50.64	347.72	0.28

* Sign is statistically significant ($p<0.05$)

Table 3. ARI scores of all adhesive system groups

Groups	ARI 0	ARI 1	ARI 2	ARI 3
Group 1	2	7	4	6
Rebonded Group 1	1	3	0	14
Group 2	4	16	0	0
Rebonded Group 2	1	0	4	14
Group 3	11	7	1	1
Rebonded Group 3	1	4	5	10
		p= 0.068		

- Score 0: No adhesive remaining on the tooth
- Score 1: Less than half of the adhesive remaining on the tooth
- Score 2: More than half of the adhesive remaining on the tooth
- Score 3: All adhesive remaining on the tooth, with a distinct impression of the bracket mesh

Figure 1. Comparison of adhesive system groups

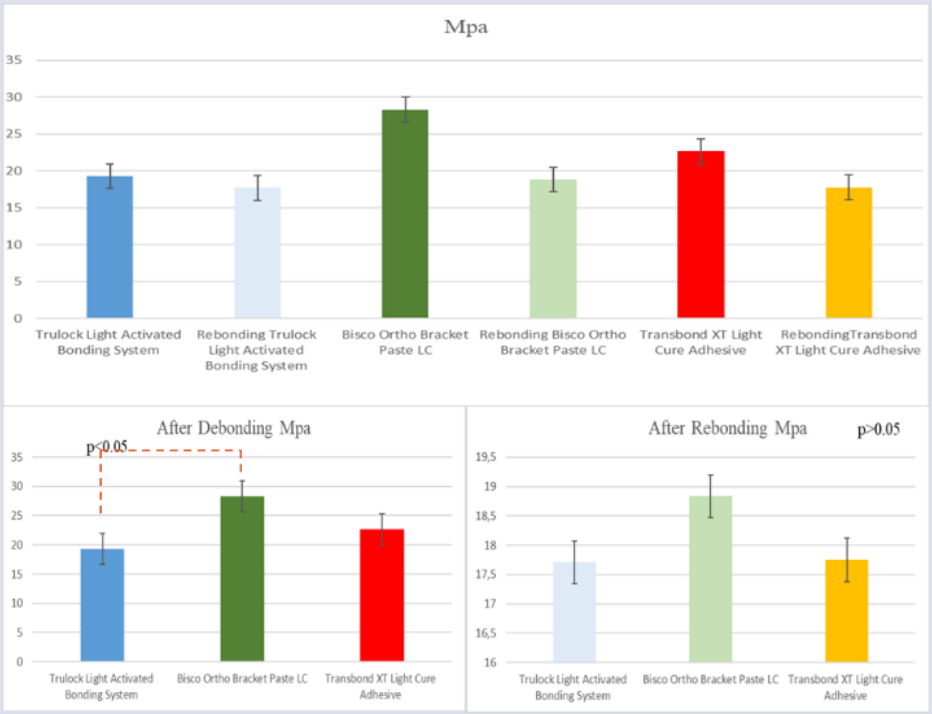

Figure 2. Comparison of adhesive system groups

Discussion

The use of direct bonding systems has opened a new era in orthodontics as in restorative dentistry. Today, acids and primers are used as important components of the adhesion process.[9] With the development of materials and the production of new materials, enamel loss has decreased and the time spent at the patient's side has been shortened. In addition, adhesion procedures have become shorter and more anticipated.[10] The increase in bond strength causes the failure during the removal of the brackets; as desired, it will ensure that it is in the bracket - adhesive interface instead of in the adhesive or in the adhesive - enamel interface.[11]

Many different adhesive systems are used in the literature for bonding orthodontic brackets. However, a study evaluating the bond strength of three different adhesive systems used in our study to orthodontic brackets has not been found in the literature. Therefore, we believe that the data obtained from this study will guide the clinical use of three different adhesives for orthodontic purposes.

According to the results of this study, statistically significant differences were observed between groups in comparison to the first SBS values. Therefore, the null hypothesis was denied.

In the present study Transbond XT showed similar results.[12,13] Hellak *et al.* compared two different adhesive system with Transbond XT and showed similar SBS values with this study (15.49 ± 3.28 Mpa).[14]

There are not many studies on Bisco ortho bracket paste LC in the literature. An *in vitro* study performed by Condo *et al.* compared Bisco Ortho Bracket Paste LC, Transbond XT and Leone LC Orthodontic Paste. According to the obtained results of study all adhesives showed similar SBS values. In the present study Transbond XT and Bisco Ortho Bracket Paste LC showed similar results and this suits with the other studies in literature.[15]

After removing the brackets, removing the resin from the enamel surface may be clinically appropriate to reduce the damage that may occur due to bracket debonding.[16,17] To assess the bracket debonding interface,

one of the frequently used indexes in orthodontics is ARI, which is often calculated.[18]

In this study, ARI scores of 0 and 1 were obtained in most of the samples after the first test. In this study, ARI 0 and 1 scores were obtained in almost all of the samples, except for Group 1, after the first test. When the samples were retested after rebonding, a significant increase was observed in ARI 3 values in all groups. The samples tested in this study were found to have a higher number of bond failures at the adhesive-enamel interface similarly in literature. The low ARI scores are considered positive, therefore there was less remnant on the enamel surface and successively less damage while enamel polishing.[19,20]

Conclusions

Within the limitations of this study, according to the obtained results the adhesive systems developed for using in orthodontics can show clinically enough bond strength even if the re-bonding strengths of the falling stainless-steel brackets to the same enamel surfaces decrease slightly.

It should be noted that these are the results of an *in vitro* study. Clinical results may be differed under the oral environment conditions. Further comparative clinical studies are needed to investigate the bond strength and stress distribution of different adhesives with orthodontic brackets.

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