Caspian Journal of
Dental Research

Original Article

Comparison of shear bond strength of the stainless steel metallic brackets bonded by three bonding systems

Mehdi Ravadgar (DDS)[1], Valiollah Arash (DDS)[2], Hamid Pachenari[3]✉

1. Assistant Professor, Department of Orthodontics, Faculty of Dentistry, Babol University of Medical Sciences, Babol-Iran.
2. Assistant Professor, Dental Materials Research Center, Department of Orthodontics, Faculty of Dentistry, Babol University of Medical Sciences, Babol-Iran.
3. Dental Student, Dental Materials Research Center, Faculty of Dentistry, Babol University of Medical Sciences, Babol-Iran.

✉**Corresponding Author:** Hamid Pachenari, Faculty of Dentistry, Babol University of Medical Sciences.
Email: hpachenari@yahoo.com **Tel:** +989113761901

Abstract

Introduction: In orthodontic treatment, it is essential to establish a satisfactory bond between enamel and bracket. After the self-etch primers (SEPs) were introduced for the facilitation of bracket bonding in comparison to the conventional etch-and-bond system, multiple studies have been carried out on their shear bond strengths which have yielded different results. This study was aimed at comparing shear bond strengths of the stainless steel metallic brackets bonded by three bonding systems.

Methods: In this experimental in vitro study, 60 extracted human maxillary premolar teeth were randomly divided into three equal groups: in the first group, Transbond XT (TBXT) light cured composite was bonded with Transbond plus self-etching primer (TPSEP); in the second group, TBXT composite was bonded with the conventional method of acid etching; and in the third group, the self cured composite Unite TM bonding adhesive was bonded with the conventional method of acid etching. In all the groups, Standard edgewise-022 metallic brackets (American Orthodontics, Sheboygan, USA) were used. Twenty-four hours after the completion of thermocycling, shear bond strength of brackets was measured by Universal Testing Machine (Zwick). In order to compare the shear bond strengths of the groups, the variance analysis test (ANOVA) was adopted and $p \leq 0.05$ was considered as a significant level.

Results: Based on megapascal, the average shear bond strength for the first, second, and third groups was 8.27±1.9, 9.78±2, and 8.92±2.5, respectively. There was no significant difference in the shear bond strength of the groups.

Conclusions: Since TPSEP shear bond strength is approximately at the level of the conventional method of acid etching and within the desirable range for orthodontic brackets shear bond strength, applying TPSEP can serve as a substitute for the conventional method of etch and bond, particularly in orthodontic operations.

Keywords: Shear bond strength, Metallic brackets, Self-etching primer

Received: 29 May 2013 **Accepted: 21 Jul 2013**

[DOR: 20.1001.1.22519890.2013.2.2.2.7]
[DOI: 10.22088/cjdr.2.2.29]

مقایسه ی استحکام باند برشی براکت های فلزیSteel Stainless باند شده توسط ۳ نوع سیستم باندینگ

[DOR: 20.1001.1.22519890.2013.2.2.2.7]

[DOI: 10.22088/cjdr.2.2.29]

چکیده

مقدمه: در درمان ارتودنسی ایجاد یک باند مناسب بین مینا و براکت ضروری است. پس از معرفی سلف اچ پرایمرها (SEPs) جهت تسهیل باند براکت ها در مقایسه با سیستم معمول اچ وباند، مطالعات زیادی درباره ی استحکام باند برشی آنها صورت گرفته و نتایج متفاوتی بدست آمده است. هدف از این بررسی، مقایسه ی استحکام باند برشی براکت های فلزی Steel (SS) Stainless باند شده توسط ۳ نوع سیستم باندینگ است.

مواد و روش ها: در این مطالعه تجربی آزمایشگاهی، ۶۰ دندان پرمولر فک بالای کشیده شده ی انسانی، بصورت تصادفی به ۳ گروه مساوی تقسیم شدند: در گروه اول کامپوزیت TransbondXT(TBXT) لایت کیور با Transbond plus self-etching primer(TPSEP)، در گروه دوم کامپوزیت TBXT با روش معمول اسید اچ و در گروه سوم کامپوزیت سلف کیور Unite TM bonding adhesive با روش معمول اسید اچ در تمامی گروه ها، براکت های (American Orthodontics, Standard edgewise-022Sheboygan, USA) استفاده شدند. ۲۴ ساعت پس از انجام ترموسایکلینگ، استحکام باند برشی براکت ها توسط دستگاه Universal testing machine(Zwick) اندازه گیری شد. جهت مقایسه ی استحکام باند برشی گروه ها با یکدیگر از آزمون آنالیز واریانس ANOVA استفاده شد و $p\leq0.05$ به عنوان سطح معنی داری در نظر گرفته شد.

یافته ها: میانگین استحکام باند برشی برحسب مگاپاسکال برای گروه اول: ۱/۹±۸/۲۷، گروه دوم: ۲±۹/۷۸و گروه سوم: ۲/۵±۸/۹۲ بود. استحکام باند برشی بین گروه ها اختلاف معنی داری نداشت.

نتیجه گیری: با توجه به اینکه میزان استحکام باند برشی TPSEP تقریباً در حد روش معمول اسید اچ و در محدوده ی مطلوب جهت استحکام باند برشی براکت های ارتودنسی می باشد، استفاده از TPSEP می تواند جایگزینی برای روش معمول اچ و باند خصوصاً در اعمال ارتودنسی باشد.

واژگان کلیدی: استحکام باند برشی، براکت فلزی، سلف اچ پرایمر

Introduction

In orthodontic treatment, it is necessary to develop a satisfactory bond between the enamel and brackets (1). Desirable shear bond strength of the orthodontic brackets should be to the extent that it can resist oral and treatment forces in the different treatment periods and at the same time facilitate debonding at the end of treatment without causing damage to the enamel. The range recommended for desirable shear bond strength in the clinic as suggested in the study conducted by Reynolds is from 5.9 to 7.8 megapascals (MPa) and should not exceed 14 MPa, that is the level of enamel breaking (2).

The conventional bonding system uses 3 different materials to bond the orthodontic brackets to the enamel: 1) enamel conditioner, 2) primer solution, and 3) composite (3).

Although the acid etching system is necessary in orthodontics, it is required that the techniques should be improved in such a way that they do not only have suitable clinical bond strength but also minimize loss of enamel, thus facilitating etching with a reduction in working stages (4).

In order to facilitate the working stages and reduce the time spent on orthodontic bonding, self-etching primers (SEPs) were supplied to the dental market in which a combination of acid and primer is used in a solution. Based on White's study, self-etching primers are easily prepared and used and therefore comfort the patients and decrease their waiting time on the units by 65% (5). A combination of acid and primer leads to the elimination of washing and drying steps, which were essential at the conventional method.

Moreover, applying SEPs could reduce the clinical time and working processes, errors in moisture and saliva control, enamel demineralization, and the level of resin tag penetration (6). It is claimed that the loss of enamel in the etching process is less in this method than in the conventional method (2).

Among its other merits are lessening technical sensitivity, minimizing saliva-related contamination, facilitating bonding and debonding, and decreasing the necessary time for the removal of adhesive additives in comparison to the conventional method (3). As a rule, SEPs should be used along with light cured adhesives so that the brackets will promptly stabilize in place (7).

There is a significant difference in the bonding strength of the brackets bonded by SEPs in comparison to the conventional method of bonding. Such differences may arise from different sample selections, bracket mechanisms, mode of bonding, and the type of adhesive employed (3).

The reason to select TPSEP in this study to prepare the enamel is its extensive application to orthodontics and more shear bond strength when compared to other SEPs (7).

TPSEP was presented by (3M Unitek, Monrovia, Calif). In late 2000 in which the steps of acid etching and priming are summarized in one step (8). TPSEP is the sixth generation of composite adhesives, invented for orthodontic bonding, and its chemical formulation resembles the phosphoric acid. Moreover, its solid matrix is composed of 2 chains; the same monomer which effects acid etching allows the primer to penetrate (5).

In view of the different results of the studies carried out on this area and lack of comparison of the shear bond strength of TPSEP bonding system with the conventional Transbond XT (TBXT) light cured system and self-cured Unite TM Bonding adhesive (3M Unitek), and since the type of primer and polymerization method of the light-cured and self-cured systems is different, this study is aimed at comparing the shear bond strength of the stainless steel metallic brackets bonded by the 3 above-mentioned bonding systems.

Methods

In this experimental in vitro study, 60 intact maxillary premolar teeth extracted for the purpose of orthodontic treatment were used. The collected teeth were examined and finally the unbroken, non-decayed teeth with no record of bleaching were selected for this study. Once they were gathered, the teeth were preserved in the 0.2% (wt/vol.) thymol disinfectant solution so that bacterial growth would be inhibited in them.

The surface of the buccal enamels of all teeth was polished with fluoride-free pumice for 10 seconds prior to enamel preparation and then dried with the air pressure. The samples were randomly divided into three 20-item groups, and the brackets were bond on buccal surface of the teeth based on the following principles:

Group 1: Transbond plus Self Etching Primer (TPSEP) (3M, Unitek); Transbond XT Light-cured Resin (TBXT) (3M, Unitek), and Stainless Steel Metallic

[DOR: 20.1001.1.22519890.2013.2.2.2.7]
[DOI: 10.22088/cjdr.2.2.29]

Brackets: Transbond Plus self-etching primer is rubbed on the enamel surface softly for nearly 3 seconds, and then by using dry air poar, the tooth surface is gently dried. Next, the composite Transbond XT light-cured resin (TBXT) (3m, Unitek) is placed onto the surface of the upper premolar stainless steel metallic brackets Standard edgewise-022 inch (American Orthodontics, Sheboygan, USA) and the bracket is bonded vertically to the longitudinal axis of the tooth buccal surface with a force of about 300gr.

By the manual dynamometer Tension and Compression Gauge (Dentaurum–Germany), already set by the measurement Correx Gauge (Dentaurum–Germany). The brackets are placed centrally on the buccal surface in such a way that the center of the bracket is placed 4mm away from the tooth cusp.

Group 2: AE (Conventional Etch and Primer) and Transbond XT Light Cured Resin (TBXT) (3M, Unitek) and Stainless Steel Metallic brackets: Etch-Rite 38% phosphoric acid (Pulpdent Corporation, Watertown, USA) is placed on the buccal surface of enamel for 15 seconds using a micro-brush, washed with water spray for 30 seconds and dried with air poar in 20 seconds and frosty appearances were seen.

Then, a layer of bonding agent (adhesive primer TBXT) is put on the tooth surface and aired with poar for one to three seconds. Next, Transbond XT (light cured resin) (TBXT) (3M, Unitek) is placed on the above-mentioned bracket surface, and the brackets are bonded to the tooth surface in accordance with the first group.

Group 3: AE (Conventional Etch and Primer) and Unite TM Bonding Adhesive (self-cured Resin) (3M, Unitek) and Stainless Steel Metallic Brackets: In this group, the enamel of the buccal surfaces of the samples is etched in accordance with the same method as the second group, then washed with spray and dried with air poar. Then, a layer of bonding agent (adhesive primer Unite TM Bonding) is paced on the tooth and air poar for one to two seconds.

Next, Unite TM bonding adhesive (self-cured resin) (3M, Unitek) is put on the above-mentioned bracket surface, and the brackets are bonded to the tooth surface in accordance with the first group and yet without the completion of the light curing stage.

In all teeth, once the bracket was adhered to the tooth, the additional composite was removed from the side surfaces of the bracket by means of the explorer. In the first-and second-group teeth, the metallic brackets bonded by light cured Transbond XT were cured for 20 seconds from the mesial side and 20 seconds from the distal side in accordance with the order of composite manufacturer for LED curing with the machine LED (Valo-Ultradent, USA) with a light density of 1000 mW/cm^2, confirmed by the radiometer. After curing, in order to ensure the removal of the additional composite, the side areas of the brackets were gently polished by the turbine and diamond bur for composite polishing.

Some molds in the form of rectangular cube with the dimensions and cross surface of 2.3×3.5 cm and the thickness 1.5 cm were provided. Buccal surface of the dental crown was stuck to the bottom of the molds by the aid of wax. Then, the inside part of the molds was filled with self-curing diluted acryl (Acropars Co.–Iran).

Therefore, the teeth were placed inside the acryl rectangular cube blocks in such a way that the buccal surface of their crown would be visible. The teeth were placed inside the acryl in such a way that the brackets surface would stand completely vertically-horizontally.

Before measuring the shear bond strength, the samples underwent thermocycling in a water bath with a degree between 5±2 and 55±2 centigrade in the Dental Materials Research Center at Babol School of Dentistry in accordance with the standard TR 11450 (500 cycles :each cycle contains 30 seconds' hot water bath–20 seconds' interval–30 seconds' cold water bath). Next, the samples were maintained in the water and inside the flax for 24 hours until they were transferred to Shahid Beheshti University for the purpose of shear bond strength measurement.

In the Dental Materials Research Center, School of Dentistry, Shahid Beheshti University, in order to measure the shear bond strength, the samples were placed in jig of the Universal Testing Machine (Zwick/Roell–ZO20–Germany), and the force was imposed on the surface between the bracket and tooth by the machine with a speed of 0.5 mm/min and this force was increased until separation of the bracket. (figure1). The most force separating the brackets from the tooth surface was recorded.

The force was measured based on Newton and the shear bond strength was determined with its division by the surface of the brackets (surface of the bracket is 11.85 mm^2).

In order to compare the shear bond strength of the groups with one another, ANOVA test was

[DOR: 20.1001.1.22519890.2013.2.2.2.7]
[DOI: 10.22088/cjdr.2.2.29]

administered, and $p \leq 0.05$ was considered as a significant level.

Results

In the first group, the average, lowest and highest degrees of shear bond strength were 8.27, 4.54 and 11.21 megapascals, respectively (table 1). In the second group, the average, lowest and highest degrees of shear bond strength were 9.78, 5.62 and 13.36 megapascals, respectively (table 1). In the third group, the average, lowest and highest degrees of shear bond strength were 8.92, 4.65 and 14.29 megapascals, respectively (table 1).

Once the average and standard deviation of the groups' shear bond strength were computed, the results were compared by IBM, SPSS and Statistics 21 applications and by means of the one-way. ANOVA test this test suggested no significant statistical difference between the groups (figure 2).

Table 1. Descriptive statistics of shear bond strength in different bonding system groups

	Bonding System		Statistics
Shear Bond Strength	Transbond plus self etching primer+TBXT Light cured	Mean±SD	8.2725±1.98
		Minimum	4.54
		Maximum	11.21
	Acid Etch & primer+TBXT Light cured	Mean±SD	9.7885±2.07
		Minimum	5.62
		Maximum	13.36
	Acid Etch & primer+Unite TM bonding Self cured	Mean±SD	8.9295±2.51
		Minimum	4.65
		Maximum	14.29

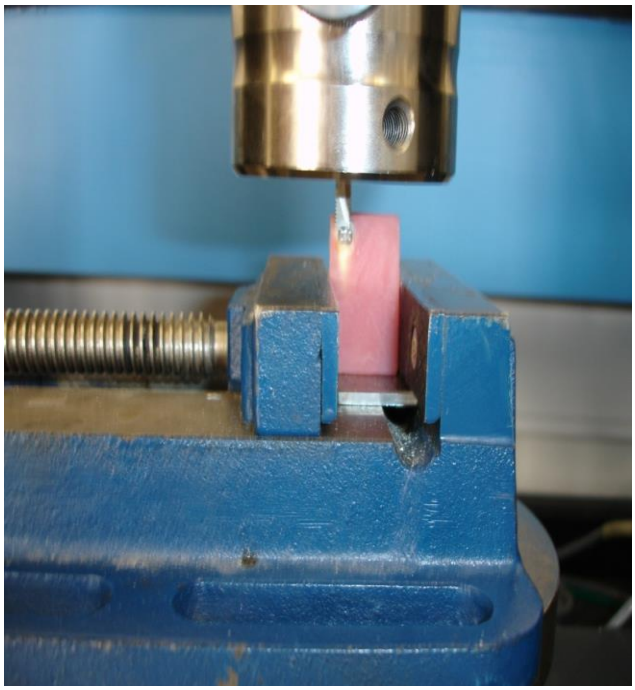

Figure 1. The sample placed in the universal testing machine

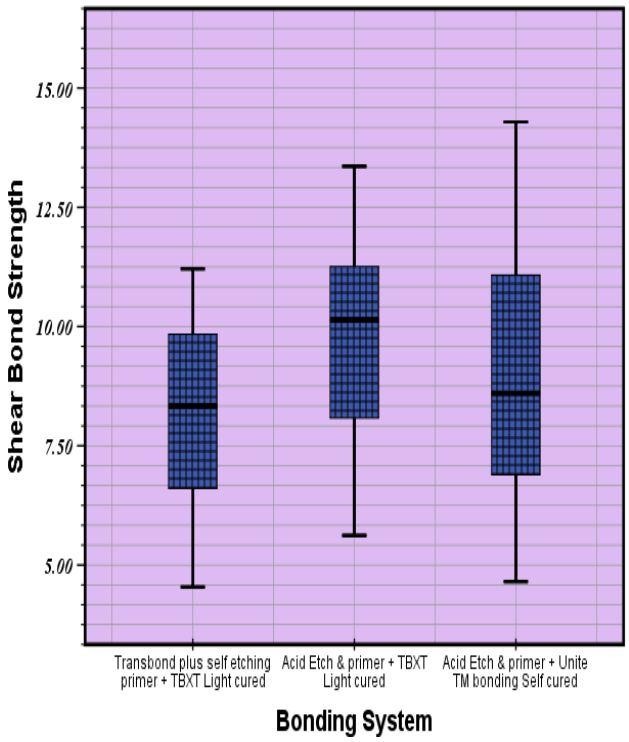

Figure 2. Comparing shear bond strength of the groups

[DOR: 20.1001.1.22519890.2013.2.2.2.7]
[DOI: 10.22088/cjdr.2.2.29]

Discussion

In this study, there was no significant difference between the shear bond strength of the metallic brackets bonded by the abovementioned 3 types of bonding systems. Shear bond strength of the metallic brackets with the bonding method of SEPs was less than that with the conventional method of etch and bond in two other groups, but this difference was no significant**.**

The surveys on the shear bond strength of the SEPs present contradictory results to verify their connection power in the bond of orthodontic brackets. Most of the studies, of course, have led to the results similar to those of the present study. Below, we point to some of these articles.

Mirzakouchaki et al. Stated that Shear Bbond Strength (SBS) is less in TPSEP than the acid etching system, which is different from the result of the present study. In this study, of course, the type of bracket adopted and the thermocycling method (1000 cycles) is different, and debonding occurred one week later (3).

Scougall-Vilchis et al. concluded that TPSEP could be successfully applied in bonding the metallic orthodontic brackets. Moreover, in their study, as in ours, the duration of 24 hours after bonding was designated for administration of the shear bond strength test via the Universal Testing Machine because this duration will provide the necessary time for the completion of the polymerization process of the adhesives and their maximum strength (7).

Cal-Neto et al. remarked that there is no significant difference in the level of debonding caused by the conventional method (conventional multi-step system) and the method of TPSEP along with Transbond XT, and both benefit orthodontic bonding. The results of their study bear a resemblance to those of ours (4).

Scougall- Vilchis et al. arrived at this conclusion that SBS of the orthodontic brackets in the 37% phosphoric acid group do not significantly differ from the TPSEP group. The result of their study is also similar to ours, but its degree of shear bond strength is remarkably more than our study–the difference which is justifiable given lack of thermocycling in this study. Furthermore, the type of bracket employed and its surface (13.58mm^2) are also different (9).

In another study, Scougall-Vilchis et al. concluded that TPSEP are stronger than the SBS recommended for clinical bond of the orthodontic brackets (5.9 to 7.8 MPa) and could be successfully employed in the clinic (10). Romano et al. stated that the SBS of the bonded orthodontic metallic brackets is not affected by the type of enamel preparation.

In this study, in addition to the overall result of the examination, the obtained degree of bond strength is also akin to the present study, which might be due to the fact that the surface of the brackets in this study is the same as the current study (5).

Holzmeier et al. also stated that there exists no significant difference between the SBS of acid etch adhesives and self-etching primers; therefore, not only TPSEP is suitable for orthodontic bonding, but it also reduces the risk of enamel cracks, and on the other hand, depth of etching and accordingly loss of enamel (11). In their investigation, Hedayati et al. drew this conclusion that the level of SBS relating to the acid etch group is significantly more than the TPSEP group. In this study, of course, micro shear bond strength was measured by Instron machine (SANTAM-Iran), which has a method and process completely different from the present study and other studies (2).

In their longitudinal, clinical study, Banks et al. concluded that there is no significant difference between the level of bond breaking in two acid etch and self-etching primer systems, while the bonding pace is significantly more in SEP system (6).

Grubsia et al. stated that shear bond strength of the acid etch group is significantly more than the self-etching primer group.

Despite the fact that the overall result of this survey is different, shear bond strength of its groups resemble the present study. In this piece of research, the thermocycling process (750 cycles) was completed, which could be the cause of this similarity (8).

In this study, the SBS obtained in all groups is more than the minimum bond strength (5.9-7.8MPa) recommended for the orthodontic brackets bond. Thus, all these products could be used in the clinic, and yet the merits of self-etching primer system in comparison to the conventional etch and bond method should not be overlooked.

The differences between similar in vitro studies could be examined in some ways. Regardless of the importance of accuracy of all steps completed in these kinds of studies, there are various variables which can influence their results, including: conditions of sample maintenance, method of sample disinfecting, the type of bracket employed (surface area, type of base

[DOR: 20.1001.1.22519890.2013.2.2.2.7]
[DOI: 10.22088/cjdr.2.2.29]

plan,…) completion or lack of thermocycling process, method of thermocycling fulfillment (the periods of thermocycling,…), the kind of light curing machine, the force adopted for bonding, etc.

Conclusion

Since shear bond strength of TPSEP is approximately at the level of the conventional etch and bond (acid etching) method and within the desirable range for the shear bond strength of the orthodontic brackets (5.9-7.8MPa), and taking into account its merits including the facilitation of the working stages (elimination of washing and drying stages), reducing the time of orthodontic bonding (by 65%), reducing technical sensitivity and humidity and saliva control errors, reducing the depth of enamel demineralization and the level of resin tag penetration, debonding facilitation and reducing the necessary time for removal of the adhesive additives and minimizing the loss of enamel, using the self-etching primers could serve as a suitable substitute for the conventional etch and bond method, particularly in orthodontic operations.

Nevertheless, in order to finally opine on the bonding power of these systems, it is recommended that controlled clinical studies should be carried out and these bonding systems should be applied in long-term orthodontic treatments.

Acknowledgments

We would like to express our gratitude to the staff at the Dental Materials Research Center, Babol and Shahid Beheshti Schools of Dentistry, who assisted us in conducting this research project.

Funding: This study was a part of thesis and research project (Grant No: 9133632) which was supported and funded by Babol University of Medical Sciences.
Conflict of interest: There was no conflict of interest.

References

1. Bishara SE, VonWald L, Laffoon JF, Warren JJ. Effect of a self–etch primer/adhesive on the shear bond strength of orthodontic brackets.AM J Orthod Dentofacial Orthop 2001; 119: 621-4.
2. Hedayati Z, Gholinia F, Pakshir HR, Alavi AA. The Effect of Different Tooth Surface Preparation Methods on Microshear Bond Strength. J Dent Shiraz Univ Med Sci 2008; 9: 253-62.[In Persian]
3. Mirzakouchaki B, Kimyai S, Hydari M, Shahrbaf S, Mirzakouchaki-Boroujeni P. Effect of self etching primer/ adhesive and conventional bonding on the shear bond strength in metallic and ceramic brackets. Med Oral Patol Oral Cir Bucal 2012; 17: 164-70.
4. Cal-Neto JP, Quintão CA, Almeida MA, Miguel JA. Bond failure rates with a self–etching primer: A randomized controlled trial. AM J Orthod Dentofacial Orthop 2009; 135: 782-6.
5. Romano FL, Correr AB, Correr Sobrinho L, Borges de Araújo Magnani MB, de Siqueira VC. Shear bond strength of metallic brackets bonded with a new orthodontic composite. Braz J Oral Sci. 2009; 8: 76-80.
6. Banks PA. Thiruvenkatachari. B. Long-trem clinical evaluation of bracket failure with a self–etching primer: a randomized controlled trial. J Orthod 2007; 34: 243-51.
7. Scougall-Vilchis RJ, Zárate-Díaz C, Kusakabe S, Yamamoto K. Bond strength of different orthodontic adhesives after enamel conditioning with the same self–etching primer. Aust Orthod J 2010; 26: 84-9.
8. Grubisa HS, Heo G, Raboud D, Glover KE, Major PW. An evaluation and comparison of orthodontic bracket bond strengths achieved with self – etching primer. Am J Orthod Dentofacial Orthop 2004; 126: 213-9.
9. Scougall-Vilchis RJ, Ohashi S, Yamamoto K. Effects of 6 self-etching primers on shear bond strength of orthodontic brackets. Am J of Orthod Dentofacial Orthop 2009 ;135:424.
10. Scougall-Vilchis RJ, Yamamoto S, Kitai N, Yamamoto K. shear bond strength of orthodontic brackets bonded with different self–etching adhesives. Am J Orthod Dentofacial Orthop 2009; 136: 425-30.
11. Holzmeier M, Schaubmayr M, Dasch W, Hirschfelder U. A new generation of self–etching adhesive: comparison with traditional acid etch technique. J Orofac Orthop 2008; 69: 78-93.