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Comparative evaluation of shear bond strength of three different bonding agents under dry & moist conditions- an in vitro study

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Abstract

Aim: The aim of the present study was to compare the shear bond strength of self-etch primer and self-adhesive resin cement and to study the effect of adhesion booster on self-adhesive resin cement, under dry and moist condition.

Materials and Methods: The 120 teeth were randomly divided into two groups, of 60 each, according to the dry and moist condition (D and M). The two groups of 60 teeth were further subdivided into 4 groups of 15 each, according to the adhesives being used. These were, conventional etch and resin system, (Transbond XT), group D1 & M1; self-etch primer (SEP, 3M) plus Transbond XT adhesive, group D2 & M2; self-adhesive resin cement (Rely-X U200, 3M Unitec), group D3 & M3; and self-adhesive resin cement (Rely-X U200, 3M Unitec) with adhesion booster (Enhance L.C, Reliance), group D4 & M4. The shear bond strength was detected using universal testing machine (INSTRON). Statistical analysis used: T test, one way ANOVA, followed by Post-Hoc test (Post Hoc Analysis, Bonferroni) was used.

Results: Under dry and moist condition highest mean shear bond strength, 8.80±4.96 MPa and 7.18±6.15 MPa, was of samples bonded under Group D2. The shear bond strength of Group D4 demonstrates the mean value, which is below clinical significance. Under moist the mean shear bond strength of all the other groups was below clinical significance.

Conclusion: Self-adhesive resin cement under moist condition showed the shear bond strength below clinical acceptance. The self-adhesive resin cement when used with adhesion booster also did not improve the shear bond strength, under dry or moist condition. Self-etch primer was least affected by salivary contamination.

Keywords: Shear bond strength, Self-etch primer, Self-adhesive resins, Adhesion booster, Artificial saliva.

Introduction

Orthodontists around the world are now able to successfully & reliably carry out bonding procedures. The method of fixing attachments directly over the enamel surface using an adhesive is called bonding. Enamel bonding procedure was introduced in Orthodontics in 1955 by Bunocore.(1)

With advances in acid-etch techniques and composite resin materials, orthodontic technique has evolved from cemented bands to bonded attachments.(2) Bonding of molar tube has great advantage over banding. Elimination of bands has greatly reduced gingival inflammation and eliminated the need to insert separators around molar teeth. It has greatly enhanced the esthetics & oral hygiene maintenance. Ease of placement of attachment & greater patient comfort are appreciable consequences.

But these bonded attachments must be able to withstand all the forces, like, tensile, torsional, shear & compressive forces occurring during the treatment as well as by stomatognathic functions (like mastication and occlusion). The inability to withstand these forces can lead to fracture of bonded attachment.

Although bonding agents have evolved over the years, the traditional bonding agents use an etchant, a primer & an adhesive resin. The process of etching requires a clean & dry enamel surface, to which etchant can be applied for 20 to 30 seconds. It is then washed with slurry of water and air-dried. Etching enhances the surface area and porosity thus increasing the surface energy. It is followed by the application of a thin layer of primer, which is air thinned by application of gentle stream of air for 1 to 2 second. Then the molar tubes are bonded using bonding adhesive. Although traditional adhesives are used successfully in orthodontics, the procedure required is an elaborate one. Attempts are being made to reduce the bonding steps while maintaining the sufficient bond strength between the molar tube and enamel.

Studies have shown that adhesive systems combining conditioning and priming, known as self-etch primer, can be successfully used to bond orthodontic brackets to enamel. Combining conditioning and priming into one step has resulted in decreased chair time and cost-effectiveness for clinicians and patients. The main feature of self-etch primer bonding system is that no separate acid etching to the enamel surface and subsequent rising with water and spray is required. Also the depth of etch and primer surface are identical. The shear bond strength of these adhesives is found to be significantly high which suggest its use in clinical treatment.

A newer adhesive which can directly bond to enamel surface had been recently introduced in dentistry. It has combined all the three steps of bonding procedure-etching, priming and bonding. The advantage of self-adhesive (Rely- X Unicem) is that it reduces the bonding procedure to a single step and is moisture insensitive.

Moisture contamination during bonding is an unavoidable condition and can lead to bond failure. Traditional adhesive systems cannot be used under these scenarios, especially to bond on lingual surfaces of posterior teeth, as they require a clean and dry field. But the newer adhesives available can be used for bonding on lingual surface of molars. Manufacturers claim that these adhesives have sufficient bond strength without dry field.[3]

Many in-vitro experimental studies had been carried out to study the shear bond strength (SBS) of self-adhesive resin cements which showed that the bond strength of new self-adhesive resin cements was not clinically sufficient.[4,5]

Many new products to increase the bond strength are now available in the market, known as adhesion boosters (Enhance L.C). These products claim to increase the adhesion of light cure primer to enamel surface thus increasing the shear bond strength of adhesive. It can even be used on enamel surface close to gingiva, where moisture contamination can compromise the bond strength of adhesive. Many studies have been conducted to study the efficiency of adhesion boosters in clinical orthodontics.[6,7]

Thus this study was carried out to evaluate and compare the shear bond strength of self-etch primer and self-adhesive resin cements under dry and moist condition, and also to study the effect of adhesion boosters on shear bond strength of self-adhesive resin cements for their use in clinical orthodontics.

Materials and Methods

Materials Used: This study was conducted on 120 extracted human molars with intact crown. Grossly decayed teeth, teeth with cracks and abrasion and fluorosed teeth were excluded from the study. The teeth collected were stored in 0.1% (wt/vol) thymol solution for not more than one month. The micro-etched 80 gauge mesh, molar tubes, Victory Series™ was used for this study (Gemini, 3M Unitek, Monrovia, CA).

Method of study: The 120 teeth were randomly divided into two groups, of 60 samples each, according to the dry and moist condition (D and M), in which they were bonded. The two groups of 60 teeth were further subdivided into 4 groups of 15 each, according to the adhesives being used (Table 1). These were, conventional etch and resin system, (Transbond XT) (Fig. 1), group D1 & M1; self-etch primer (SEP, 3M) (Fig. 2) plus Transbond XT adhesive, group D2 & M2; self-adhesive resin cement (Rely-X U200, 3M Unitec) (Fig. 3), group D3 & M3; and self-adhesive resin cement (Rely-X U200, 3M Unitec) with adhesion booster (Enhance L.C, Reliance) (Fig. 4), group D4 & M4.

Table 1: Represents the distribution of samples under 4 groups of adhesives according to the dry and moist condition.

Group	Bonding agent	Dry condition (60 teeth)	Moist condition (60 teeth)
Group 1	Conventional resin (Transbond XT)	15 (D1)	15 (M1)
Group 2	Self-etch primer (SEP-3M Unitek) + Transbond XT adhesive	15 (D2)	15 (M2)
Group 3	Self-adhesive resin cement (Rely-X U200, 3M Unitec)	15 (D3)	15 (M3)
Group 4	Self-adhesive resin (Rely1-X U200, 3M Unitek) & adhesion booster (Enhance L.C, Reliance)	15 (D4)	15 (M4)

Fig. 1: Conventional group (Transbond XT)

Fig. 2: Self etch primer

Fig. 3: self-adhesive resin cement

Fig. 4: Adhesion boosters

The base surface area for the molar tubes was recorded with the vernier caliper. It was found to be 25.01square millimeter (mm^2). Artificial saliva (Wet Mouth, ICPA) (Fig. 5) was used to bond the teeth under moist condition. A plastic mold was used to mount the tooth in cold cure acrylic bases (Fig. 6), by keeping the long axis of the tooth parallel to the true vertical plane, such that the full crown was exposed above cemento-enamel junction (Fig. 7). Bonding was done according to manufacturers instructions.

Fig. 5: Artificial saliva

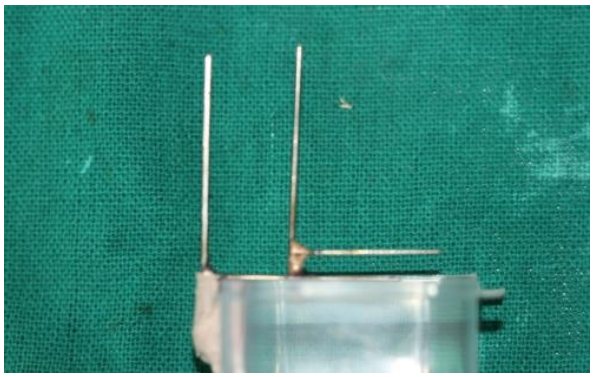


Fig. 6: Plastic split mold soldered guide

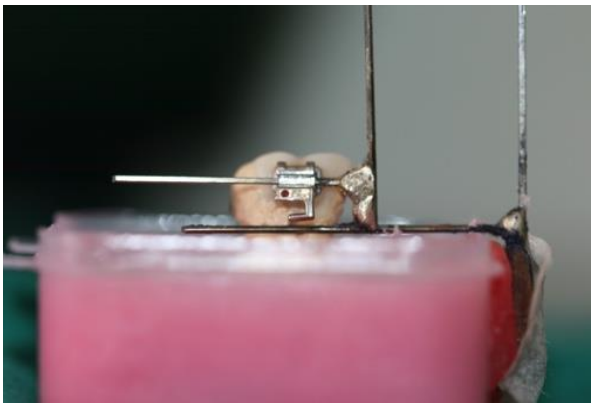


Fig. 7: Soldered guide with tooth

Method of bonding

For Group D1 (Conventional resin system) molar tubes were bonded on extracted teeth by using traditional etch and rinse technique. Excess of adhesive was removed with the explorer and then was light cured on each proximal side for 10 seconds. For Group D2 self-etch primer (SEP, 3M) was applied to the tooth surface for 5 seconds and left for 5 seconds. The tooth surface was then dried and molar tube was bonded with adhesive. It was light cured for 20 seconds as above. Extracted teeth in Group D3 were treated with etchant and rinsed and dried. Tubes were bonded using Rely-X U200, self-adhesive resin cement. Mixed cement was applied to the molar tube base and placed on the tooth and light cured as above. Extracted teeth were treated with etchant and rinsed and dried, in Group D4. Then 3-4 generous coats of adhesion booster (Enhance L.C, Reliance) were applied to the enamel surface with the brush. After the last coat, surface was lightly dried with air. The enamel then appears to be shiny. The molar tubes were then bonded with self-adhesive resin cement, Rely-X U200, and light cured as above.

For bonding under moist condition, a thick layer of saliva was applied on buccal surface of the tooth, after etching and priming. The molar tubes were bonded similar to the samples in their respective dry condition.

After bonding the molar tubes, the samples were stored in distilled water for 24 hours at room temperature.

Debonding procedure

The shear bond strength was measured using universal testing machine (INSTRON) at Shriram Industrial Research Institute. Each specimen was stressed in occluso-gingival direction. The blade was driven at a crosshead speed of 1 mm/min, & the force at which bond failure occurred was recorded. (Fig. 8)

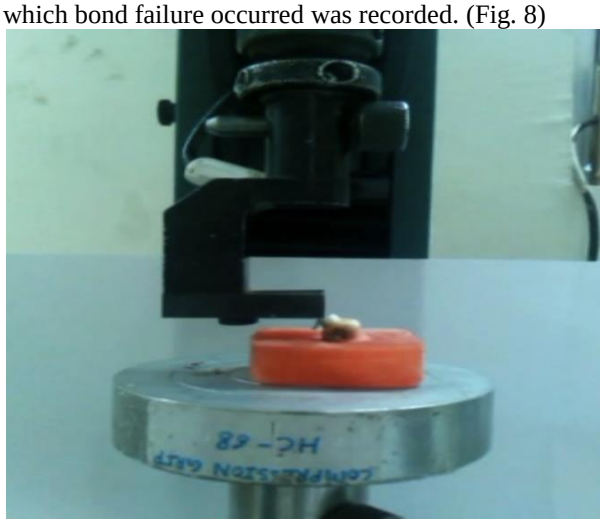


Fig. 8: Represents the debonding procedure carried out on Universal Testing Machine

Statistical Analysis

For comparison of shear bond strength under dry and moist condition in respective groups T test was used. To compare intergroup changes, one way ANOVA was used, followed by Post-Hoc test (Post Hoc Analysis, Bonferroni).

Result

Descriptive statistics for shear bond strengths are shown in Table 2. The teeth bonded under dry condition with the self-etch primer, in Group D2, produced the highest bond strength but was statistically non-significant with other groups under dry condition ($p>0.05$).

For teeth bonded under moist condition the highest shear bond strength was recorded for Group M2, which was significantly higher to Group M3 and Group M4 ($p<0.05$). Statistically non-significant differences were found with Group M1 ($p>0.05$).

The statistics of Table 2 shows comparison of bonding materials under dry ad moist condition. The shear bond strength under dry condition was statistically significant ($p<0.05$) for Group 1 (Transbond XT), Group 3 (Self-adhesive resin cement; RelyX U200) and Group 4 (Self-adhesive resin cement; RelyX U200 + Adhesion booster; Enhance LC). But for Group 2 (Self-etch primer + Transbond XT), the difference was found to be statistically non-significant ($p>0.05$).

Table 2: Shows the intra-group comparison of shear bond strength of the four groups under dry (D) and moist (M) conditions

Groups		Mean	N	SD	Mean diff	P value	Significance
Group 1 (Transbond XT)	D	8.146	15	4.372	3.495	0.032	*
	M	4.651	15	2.862			
Group 2 (Self-etch primer +Transbond XT)	D	9.44	15	4.82	2.26	0.254	NS
	M	7.181	15	6.153			
Group 3 (Self-adhesive resin cement; RelyX U200)	D	6.705	15	3.951	3.235	0.013	*
	M	3.470	15	1.389			
Group 4 (Self-adhesive resin cement; RelyX U200 + Adhesion booster; Enhance LC)	D	5.749	15	2.414	2.397	0.012	*
	M	3.352	15	1.658			
The value of p value; *- $p\leq0.05$, **- $p\leq0.01$, ***- $p\leq0.001$ were significant and $p>0.05$ were non-significant (NS)							

Discussion

The samples in this study were divided into two groups, dry (Group D) and moist (Group M), depending upon the condition under which they were bonded. The samples in these two groups were further subdivided into four adhesive groups, the conventional system (control group), the self-etch primer system, the self-adhesive resin cement system and self-adhesive resin cement with adhesion boosters. Hence each condition, dry or wet, had four subgroups according to the adhesives used. The shear bond strength was not measured under oral conditions. Nevertheless, the in vitro SBS was found to be an acceptable methodology to determine future in vivo comparative condition.[8] The minimum bond strength required for bonding brackets has been suggested to range between 6 and 8 MPa.[8] While the maximum bond strength, should be less than the breaking strength of enamel, which is about 14 MPa.[9]

Inter-group comparison of Shear bond strength under dry condition

Under dry condition, the findings of our study concluded that the shear bond strength of the self-etch primer was highest. Then is the shear bond strength of conventional resin, followed by self-adhesive resin cement and least with the self-adhesive resin cement with adhesion boosters (Graph 1).

The shear bond strength of self-etch primer was higher than conventional resin, although the increase in shear bond strength was not significant, under dry condition. But both the systems could be used for routine clinical bonding procedure. The study conducted by Vilchis et al[10] on shear bond strength of orthodontic brackets bonded with different self-etching adhesives. The study concluded that the self-etching adhesives yielded shear bond strength values higher than the bond strength suggested for routine clinical bonding, indicating that orthodontic brackets can be successfully bonded with any of these self-etching adhesives. Another study conducted by Bishara SE et al[11] showed the effect of self-etch primer/adhesive on the shear bond strength of orthodontic brackets concluded that the shear bond strength of self-etch primer was significantly lower than the conventional resin but was clinically acceptable. The result of the present study, under dry condition, did not co-relate with this previous study.

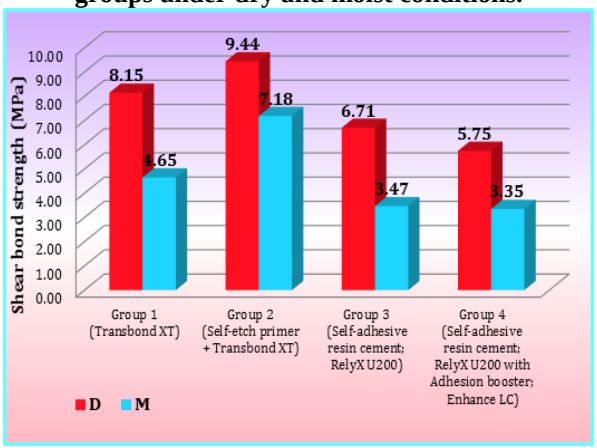
Under dry condition, a study conducted by Al-Saleh M et al[12] on bond strength of orthodontic brackets with new self-adhesive resin cements concluded that the SBS values of the brackets cemented with conventional resin were significantly higher than those of the 3 self-adhesive resin cements. The present study is in correlation to this study. The shear bond strength of self-adhesive resin cement (Rely-X U200), under dry condition, in the present study showed lower shear bond strength than the standard conventional group. But the shear bond strength obtained with self-adhesive resin cement was acceptable for routine clinical use.

Shear bond strength of self-adhesive resin cement when used with adhesion boosters (Enhance LC) under dry condition showed a decrease in the bond strength value compared to the standard group, Transbond XT. The decrease in shear bond strength of Rely-X U200 with adhesion boosters was below the level of clinical acceptance. No data has been being published till date regarding the use of adhesion boosters with self-adhesive resin cement. This could be attributed to the material specific quality of adhesion booster (Enhance LC) as concluded by Vicente A et al[13] in his study. Use of adhesive and adhesion booster produced and recommended by same manufacturer had shown to produce the greatest shear bond strength. Therefore it could be concluded that, the use of self-adhesive resin cement with adhesion boosters, of different manufacturer, could result in the shear bond strength below significant level of clinical acceptance. Further research regarding the use of self-adhesive resin cement with adhesion boosters should be carried out for conclusive results.

Inter-group comparison of shear bond strength under moist condition

Under moist condition this study concluded that the shear bond strength of self-etch primer was highest among all the other groups. The shear bond strength of conventional group was lower than the self-etch primer group, followed by the shear bond strength of self-adhesive resin cement. Least shear bond strength was noted for Self-adhesive resin cement with adhesion boosters. (Graph 1)

Graph 1: Shows the complete inter-group comparison of shear bond strength of the four groups under dry and moist conditions.



The shear bond strength of conventional group under moist condition was below the shear bond strength of self-etch primer. The shear bond strength of Transbond XT was so low that it could not be clinically used for bonding of molar tubes under moist condition. While the shear bond strength produced by self-etch primer + Transbond XT was estimated to be clinically acceptable for routine clinical bonding even when salivary contamination was present. A study conducted by Cacciafesta V et al[14] on the effect of water and salivary contamination on shear bond strength value of brackets bonded with conventional, hydrophilic and self-etching primers, showed that self-etch primer had higher strength values than either the hydrophilic or conventional primers. The self-etching primer was the least influenced by water and saliva contamination. This could also be attributed to the fact that self-etch primer has more hydrophilic solvent, which enhances its strength under moist condition.

The shear bond strength of self-adhesive resin cement, under moist condition, was found to be lower than the conventional resin. The shear bond strength of this material is below clinical acceptance. Thus despite the claim of manufacturer that self-adhesive resin cement can be used under moist condition, the results of the present study shows that it cannot be used for routine

clinical practice for orthodontic purpose. Thus, reducing the bonding procedure to a single step, by eliminating etching and priming, had not proved to be effective for orthodontic purpose. More research in this direction should be carried out in order to achieve shear bond strength of clinical acceptance with self-adhesive resin cement.

The shear bond strength of self-adhesive rein cement with adhesion booster showed the least shear bond strength, under moist condition. The present study showed that the bond strength of self-adhesive resin cement with adhesion boosters, under moist condition, was below the clinical significance level. Adhesion boosters were introduced with an aim to improve the bond strength under wet condition by incorporating the hydrophilic solvents. But when adhesion boosters were used with the self-adhesive resin cement, it decreased their bond strength. More studies on the performance of these material needs to be assessed prior to making a general recommendation for their clinical use.

Inter-group comparison of respective adhesive in dry and moist condition (Graph 1)

According to the present finding the shear bond strength of conventional resin, under dry condition exceeded the desirable standard of 6-8 MPa but under moist condition it was found to be below the desirable clinical standard. The study conducted by Nemeth BR et al,[15] on shear/peel bond strength of orthodontic attachments to moist and dry enamel concluded that bonding to moist and dry enamel appears to be material specific. Conventional resin; Transbond XT was found to have lower bond strength under moist condition compared to other conventional adhesive used. Thus, when bracket bonding is carried out with conventional system, it should always be ensured to have a non-contaminated surface. If contamination occurs at any step of bracket bonding, it should be made sure that the bonding procedure is repeated, as instructed by the manufacturer.

The results of the shear bond strength of self-etch primer in the present study showed the highest bond strength under both dry and moist condition. The bond strength of self-etch primer under dry condition was found to be higher than the bond strength under moist condition. But the shear bond strength of self-etch primer under moist condition exceeded the desirable clinical standard. Thus, the findings of our study suggest that self-etch primer was least influenced by saliva contamination. Since it is not possible to obtain a completely dry field in the buccal segment, use of self-etch primer for bracket bonding is advisable.

The shear bond strength of self-adhesive resin cement, in our study was found to be within the desired clinical standard of 6-8 MPa, under dry condition. But under moist condition the finding suggested that the use self-adhesive resin cement for orthodontic bonding it is not advisable. Vicente et al[4] showed the shear bond strength of 8.1 MPa for self-adhesive resin cement, which also suggested the use of self-adhesive resin cement under dry condition. The findings of our study suggest that self-adhesive resin cement cannot be used for orthodontic bonding under moist condition. Further research in this area is required prior to making a general recommendation for their use as limited data is published on self-adhesive resin cement.

The findings of shear bond strength of self-adhesive resin cement with adhesion booster were lower than the desired clinical standard, under dry and moist condition. Vicente A et al[13] in his study on the effects of three adhesion promoters on shear bond strength of orthodontic brackets concluded that Enhance LC (Reliance Ortho) produced the greatest shear bond strength when used with the material specific product Light Bond (reliance Ortho). Thus the low shear bond strength of self-etch primer when used with adhesion booster (Enhance LC) can be because of the difference in the manufacturer of the two products.

Conclusions

Bonding under dry condition showed better shear bond strength values than under moist condition for all the materials tested. Hence it is preferable to produce dry conditions during bonding procedure. Under moist condition, the self-etch primer showed the highest bond strength thus it could be concluded that Self-etch primer was least affected by salivary contamination.

The advantage with self-adhesive resin cement was that it combined all the steps of bonding into a single step. However its ease of use was negated by its decreased shear bond strength compared to the conventional system. Self-adhesive resin cement under moist condition showed the shear bond strength below clinical acceptance. This suggests that it is not advisable to use self-adhesive resin cement for bonding of molar tubes under moist condition. The self-adhesive resin cement when used with adhesion booster also did not improve the shear bond strength, under dry or moist condition.

References

1. Buonocore M G. A Simple Method of Increasing the Adhesion of Acrylic Filling Materials to Enamel Surfaces. J Dent Res 1955;34:849-853.
2. Keim RG, Gottlieb EL, Nelson AH, and Vogels DS. 2008 JCO study of orthodontic diagnosis and treatment procedures. Part 1: results and trends. J Clin Orthod 2008. 42:625–640.
3. Bishara SE, Olsen ME, Damon P, Jakobsen JR. Evaluation of a new light-cured orthodontic bonding adhesive. Am J Orthod Dentofacial Orthop 1998;114:243-247.
4. Vicente A, Bravo LA, Romero M, Ortiz AJ, Canteras M. A comparison of the shear bond strength of a resin cement and two orthodontic resin adhesive systems. Angle Orthod Dentofacial Orthop 2005;75:109-113.
5. Bishara SE, Ostby WA, Ajlouni R, Laffoon JF, Warren JJ. Early shear bond strength of a one-step self-adhesive o orthodontic brackets. Angle Orthod Dentofacial Orthop 2006;76:689-693.

6. Newman GV, Newman RA, Sun BI, Ha JJ, Ozsoylu SA. Adhesion promoters, their effect on the bond strength of metal brackets. Am J Orthod Dentofacial Orthop 1995;108:237-241.
7. Newman GV. Epoxy adhesives for orthodontic attachments. Am J Orthod Dentofacial Orthop 1965;51(12):901-912.
8. Reynolds IR. A review of direct orthodontic bonding. Br J Orthod 1979;6:171-178.
9. Zachrisson BU, Biiyiikyilmaz T. Bonding in orthodontics. In Graber TM, Vanarsdall RL, Vig KW, editors: Orthodontics: current principles and techniques, St Louis, 2005, Elsevier Health Sciences, pp 579-659.
10. Vilchis RJS, Yamamoto S, Kitai N, Yamamoto K. Shear bond strength of orthodontic brackets bonded with different self-etching adhesives. Am J Orthod Dentofacial Orthop 2009:136:425-430.
11. Bishara SE, VonWald L, Laffoon JF and 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.
12. Al-Saleh M, El-Mowafy O. Bond strength of orthodontic brackets with new self-adhesive resin cements. Am J Orthod Dentofacial Orthop 2010;137:528-533.
13. Vicente A, Bravo LA, Romero M, Ortiz AJ, Canteras M. Effects of 3 adhesion promoters on the shear bond strength of orthodontic brackets: an in-vitro study. Am J Orthod Dentofacial Orthop 2006;129:390-395.
14. Cacciafesta V, Sfondrini M, DeAngelis M, Scribante A, Klersy C. Effect of water and saliva contamination on shear bond strength of brackets bonded with conventional, hydrophilic, and self-etching primers. Am J Orthod Dentofacial Orthop 2003;123:633-640.
15. Nemeth BR, Wilthshire WA, Lavelle CLB. Shear bond strength of orthodontic attachments to moist and dry enamel. Am J Orthod Dentofacial Orthop 2006;129:396-401.