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Shear bond strength of resin modified glass ionomer with and without prior conditioning with sodium hypochlorite before conventional etching: ex vivo study

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Abstract

Introduction: Resin modified glass ionomers (RMGIs) provide an alternate to composite resins for bonding brackets in orthodontics. The aim of this study was to compare the mean shear bond strength (SBS) of RMGIs with and without prior conditioning with 5.25% sodium hypochlorite (NaOCl)
Material and Methods: 68 extracted human premolars were divided into two groups. In the experimental group, pre-conditioning with 5.25% NaOCl was performed followed by conventional etching whereas in the control group, conventional etching was performed only before bonding brackets with Fuji Ortho LC. All the brackets were stored in distilled water for 24 hours and debonded using universal testing machine. SBS values were recorded in megapascals. Mean and standard deviation for both the groups was evaluated and paired t-test was used to analyze the data using SPSS version 20.
Results: There was a significant difference in the SBS of the two groups ($p<0.05$). The mean SBS for the experimental group was 24.2+/-6.35MPa and for the control group was 9.68 +/-5.26 MPa.
Conclusion: Conventional etching of enamel surface before bonding brackets with RMGIs give adequate SBS value, whereas pre-conditioning with 5.25% NaOCl before etching gives a very high mean SBS value.
Key words: Shear bond strength; conventional acid etching; resin modified glass ionomers

Introduction

The bracket bonding procedures have traditionally used composite resins as the adhesive of choice to bond to enamel, since they provide adequate bond strength in clinical orthodontics.[1] Despite many advantages of composite resins, there are also some disadvantages associated with their use, white spot lesions (WSLs) being the most common.[2] A high prevalence of WSLs has been found in patients undergoing orthodontic therapy.[3,4] Factors predisposing the patients to develop WSLs are prolonged duration of the orthodontic treatment, inability of the patients to follow proper oral hygiene instructions and plaque retentive properties of the fixed appliances. Prevention of WSLs is very important because if left untreated can progress to carious cavitations and may cause esthetic problems.[5]

Various means have been employed by the researchers to reduce these WSLs which include daily mouth rinses with 0.05% sodium fluoride and fluoride varnish application.[6-8] Bracket adhesives that cause release of fluoride around the brackets is one such method to prevent WSLs since fluoride forms flouroapatite crystals that are more resistant to demineralization. Glass ionomer cements (GICs) were used initially to take advantage of their fluoride releasing properties but due to their unacceptable bond strength, they did not gain popularity.[9-11] Resins were added to the GICs to form resin modified glass ionomers (RMGICs) in order to increase their bond strengths.[12] RMGICs also release fluoride like GICs. They have the added advantage of being able to be bonded

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under moist conditions due to their hydrophilic nature, which is important for bonding second molars, because attachments usually fail due to salivary contamination.[13] Due to concerns regarding the bond strength of RMGIs, many clinicians do not use it routinely.

Numerous methods have been devised to increase the SBS of RMGIs so that they can be used in clinical practice for bonding brackets. These include application of 5.25% NaOCl, papain gel 10% and self etching primers etc.[14,15] Espinosa et al[16] showed that the quality of etch pattern could be improved by prior conditioning the enamel with 5.25% NaOCl before conventional etching.

Studies have shown that variable SBS values have been obtained for RMGIs both with and without prior conditioning and etching procedures.[13,17-19] Justus et al[13] have shown adequate SBS obtained with prior conditioning of 5.25% NaOCl before etching whereas Cacciafesta et al[17], Khoroushi et al[18] and Meehan et al[20] achieved adequate SBS value for RMGIs only by acid etching without prior conditioning. The aim of this study was to assess and compare the in-vitro SBS value of RMGIs by prior conditioning with and without 5.25% NaOCl before conventional etching so that it can be used for bonding in clinical orthodontics.

Materials and Methods

68 freshly extracted human premolars were collected from department of Oral Surgery (Sardar Begum Dental Hospital). Teeth with morphologically normal and intact buccal enamel were included. Fractured, hypoplastic, morphologically altered and teeth displaying moderate to severe tooth wear were not included. The teeth were disinfected by placing them in 2% gluteraldehyde solution for 10 minutes. They were then stored in thymol solution (antifungal agent) until they were ready to be bonded. The teeth were then polished with non-fluoridated pumice slurry using a rubber cup for 5-10 seconds, washed with water spray and air dried. The teeth were then randomly divided into two groups; Group A (experimental) and Group B (Control). In Group A, the teeth were first conditioned with freshly prepared 5.25% NaOCl (Haq Chemicals, Peshawar, Pakistan) for 1 min., washed with water spray and air dried, followed by etching with 37% phosphoric acid (Den Fil™, Vericom Co., Korea) for 30 seconds, washed and air dried. The surface of each tooth was moistened with wet cotton roll dipped in saline water. Premolar brackets (Ortho Organizer, U.K) with a mesh base of 11.92mm^2 were bonded with RMGIs (Fuji Ortho LC, GC Corporation, Tokyo, Japan) which was mixed according to manufacturer's instructions. Excess flash was removed and brackets light cured using LED (Coltolux cordless Coltene/Whaledent Inc., USA) for 40 seconds. The teeth in Group B were bonded with a similar procedure as in Group A except that the surfaces of teeth were not pre-conditioned with NaOCl. The sample was then stored in distilled water for 24 hours so that maximum strength of Fuji Ortho LC could be achieved.

The teeth were then mounted in a metal sleeve specially designed to be used with holder of the Universal testing machine (Schimadzu, Japan) at School of Chemical and Material Engineering (National University of Sciences and Technology, H-8 Islamabad, Pakistan, figure 1). Constant shearing force was applied by a blade that applied an occlusogingival force at the bracket/enamel interface until the bracket was debonded. The speed of the crosshead was 1mm/min. The SBS value was recorded in megapascals (MPa) by a computer attached to the universal testing machine. SPSS version 20 was used to analyze the data. Means, standard deviations, minimum values and maximum values were calculated. Paired t-test was used to analyze the differences in mean SBS values between the two groups. Differences indicated by P value, 5% were interpreted as significant.

Figure 1: Universal testing machine (Schimadzu, Japan)

Results

Mean, standard deviations, maximum and minimum SBS values were calculated (Table I). Figure 2 shows the difference in the mean SBS values of the two groups graphically. The mean difference between the SBS value of both the groups was statistically significant, at p= 0.000 (Table II)

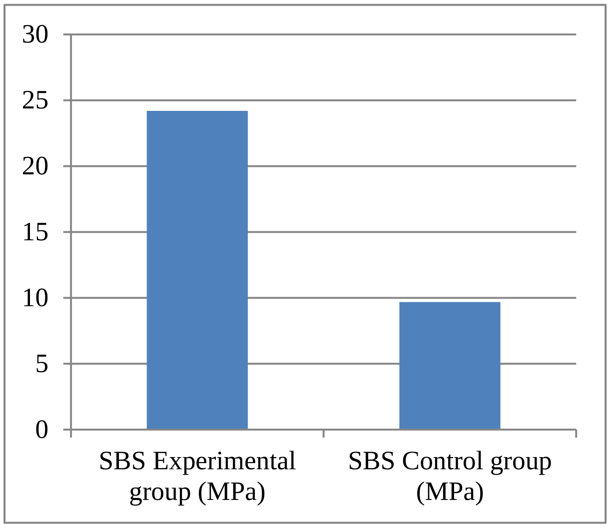

Figure 2: Graph showing the difference in the mean SBS values in MPa of both the groups.

Table I: Descriptive statistics in MPa of the Group A and B

	Group A (Experimental) n= 34	Group B (Control) n=34
Mean	24.284	9.688
SD	6.35	5.26
Range	12.7 (17.934-30.634)	10.52 (4.428-14.948)

Where n is the number of teeth in each group, SD standard deviation

Table II: Comparison of SBS values of the two groups.

Group	Mean SBS value (MPa)	SD of mean SBS values (MPa)	p-value
Group A (Experimental) **Group B** (Control)	24.842 9.688	24.284+/-6.35 9.688+/-5.26	0.000*

*Statistically significant, where SD is the standard deviation.

Discussion

In this study, RMGIs was used for bonding orthodontic brackets to the freshly extracted human premolars and NaOCl for pre-conditioning the enamel before conventional etching. Limited literature exists regarding the effect of NaOCl on the SBS of RMGIs.

NaOCl in a concentration of 5.25% is commonly employed as a bleaching agent but in dentistry it is being used to remove the smear layer in endodontics. When applied to enamel surface before acid etching, NaOCl gives type I and II etch pattern in which there is dissolution of prism heads and peripheries respectively, thus removing the organic layer of the enamel giving a better retention surface.[21] The adhesive is able to penetrate deeper into the enamel surface, thereby creating micromechanical interlocks and thus increasing the bond strength of the adhesive. Type III etch pattern is a comparatively random etching pattern in which adjacent areas of the enamel correspond to type I and II etch pattern. It is obtained after conventional etching only.[16]

In this study human premolars were chosen, since they have the advantage of simulating natural tooth structure, thus being close to the clinical reality. Bovine enamel has been used in various studies as a substitute for human enamel for bond testing, though differences in the bovine and human enamel have been reported by many researchers.[22, 23] Saleh et al[22] found a statistically significant difference between the SBS and tensile bond strengths of human and bovine enamel. Oesterle et al [23] also found that the bond strength value of the bonding agent to the bovine enamel was 21% to 44% weaker than to the human enamel.

In this study, it was found that human enamel when conditioned with 5.25% NaOCl, followed by conventional etching, the mean SBS of brackets bonded using Fuji Ortho LC was 24.2 +/-6.3 MPa. This was significantly higher than when the enamel was not conditioned with NaOCl and conventional only i.e SBS 9.68+/- 5.7 MPa. SBS value greatly exceeds the clinical recommendation of Reynolds[24] which is 5.9-7.8 MPa when NaOCl is used. The results of this study differ when compared to the study done by Justus et al[13] in which lower mean SBS of 5.7MPa was achieved without prior conditioning with NaOCl whereas optimal SBS value of 9.64+/-5.01 MPa was obtained in the group which was priorly conditioned with NaOCl. The net difference between our study and Justus et al's study in the mean SBS may be attributed to the method in which the SBS has been measured, since wire method was used for debonding the brackets as compared to our method of shearing blade.

Mojtahedzadeh et al[25] reported the difference in the two common methods of measuring SBS via a rectangular wire around the brackets and a shearing blade. They found out that significantly higher mean SBS value (24.8 MPa) was obtained with the wire loop compared with the shearing blade (17.12 MPa) which was significantly low.

The most common method used for debonding the brackets in the in-vitro is the SBS testing. In most of the studies, shearing blade has been used for debonding the brackets, whereas in other studies, wire loop method has been used. Studies have shown that wire loop method is not a true form of SBS testing, since there is also an element of tensile stress present in it when debonding brackets.[26] Difference in the designs of the blade can also affect the SBS testing.

Another factor that could contribute to the difference in the results between our study and Justus et al's study is that no thermocycling procedure was carried out after the bonding of brackets and the brackets were stored in distilled water only at room temperature. Thermocycling is a procedure used to simulate the clinical conditions. In the Justus et al's study, thermocycling of the brackets between 5°C and 55°C for 500 cycles was carried out for 25 seconds in each bath. Following thermocycling, they placed the sample in distilled controlled water bath at 37°C for 24 hours. Mohammed-Salih et al[27] studied the effect of thermocycling on the SBS of steel brackets and found a highly significant reduction in the SBS of brackets after thermocycling from 12.17 MPa to 6.52 MPa. Suckocuc[28] also found similar results with a significant reduction in the SBS of the groups after thermocycling. However, others have found no significant effect of thermocycling on the SBS of the adhesives.[29-31]

Control group in the present study, in which brackets were bonded just after conventional etching showed similar results to that of Summers et al[32] in which they reported that the SBS value of Fuji Ortho LC was in a clinically acceptable range just after etching at both 30 minutes (6.93MPa) and 24 hrs after bonding (9.56MPa). Similarly, the SBS value of Fuji Ortho LC was also obtained in vitro by Meehan et al[20] to be in a clinically acceptable range of 7.68 MPa just after acid etching. Clinically acceptable SBS values have been obtained for RMGIs just after the etching procedure by various researchers. [17, 33-36]

From previous studies along with the results of present study, it can be concluded that clinically adequate SBS value can be achieved after etching only, without any enamel pre-conditioning with NaOCl. Therefore, an additional step of prior conditioning with NaOCl seems questionable.

SBS testing determines the strength of the adhesive to the enamel in the in-vitro environment. However, the in-vitro studies have not been successful in predicting the efficacy of the material in the in-vivo because true simulation of the in-vivo conditions in the in-vitro is not entirely possible. Even though the in-vitro bond strength testing is important for initial screening and selection of the adhesives, they cannot be regarded as a substitute for in-vivo testing.[37] Due to the fluoride-releasing properties and the clinically acceptable SBS of RMGIs in the in-vitro studies, it is suggested that they should be tested in the in-vivo randomized clinical trials so that they may provide a suitable alternate to composite resins for successful bonding in orthodontics in the future.

Conclusions

- Pre-conditioning of the enamel with 5.25% NaOCl before conventional etching gives a very high mean SBS value.
- Etching of enamel surface with only conventional etching gives adequate SBS value, which is acceptable clinically.
- There is a statistically significant difference in the SBS values of the two groups.

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