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Research Paper: Investigating the effect of amalgam restoration on shear bond strength of orthodontic tubes

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ABSTRACT

Introduction: Adult patients who require orthodontic treatment usually have amalgam restorations at the buccal surface of the posterior teeth. Research has shown that bond strength to amalgam is less than the bond strength to enamel.The aim of this study is to determine the effect of amalgam restorations extension on shear bond strength of orthodontic tubes.

Materials and Methods: The 70 extracted molar teeth were randomly divided into 7 groups of 10 and orthodontic tubes of specimens were bonded by Transbond XT Adhesive Paste and Single Universal Bonding and/or by Transbond XT Adhesive Bond. The specimens were subjected to 1000 thermo cycles between 10 - 50 ° C, and then the shear bond strength was measured by the Universal Testing Machine.

Results: The results showed that the mean shear bond strength of bonded orthodontic tubes on amalgam restoration is lower than the shear bond strength on the enamel. The results indicated that when Single Bond Universal and Transbond XT Adhesive paste were used for bonding of orthodontic tubes the mean shear bond strength of increased, compared to when, only the transbond XT adhesive was used, thought this increase was not statistically significant.

Conclusion: The amount of enamel around amalgam restorations is one of the most important factors in the degree of bond strength of orthodontic attachments. As the amount of bonding surface on the enamel margin is higher than that of the amalgam bond, we can expect more bond strength.

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Introduction

The introduction of the acid etching method by Buonocore (1) allowed for direct bonding of orthodontic brackets to the teeth, which made it easier for orthodontic treatments, reduced gum irritations, improved oral and dental hygiene, Beauty was improved and the duration of orthodontic visits decreased (2) . Improvements in orthodontic bonding techniques also reduced the banding of posterior teeth (3). However the band resists the debonding forces, but prones the teeth to the periodontal diseases (4). However, with the increase in adult patients seeking orthodontic treatment, attachment bindings to teeth that has amalgam or porcelain veneers is a problem that can challenge orthodontic treatment (3) the available bonding for proper bond to amalgam and porcelain require additional primers, therefore needs more time and money to create proper bonding to amalgam and porcelain. This clinical problem has led to new research on the bond to amalgam and porcelain (5). The adult patients who require orthodontic treatment usually have amalgam restorations at the buccal surface of the posterior teeth (6). Researches have shown that bond strength to amalgam is lower than bond strength to enamel (7), (8). Some orthodontic patients have restorations at the buccal surface of their posterior teeth, but these restorations are not so extensive that the entire surface of the orthodontic tube bonds on the amalgam. The class I restorations that involve only Pit buccal and/or Pit and Buccal grooves and the small class V restorations may create a position that is, part of the bond surface on enamel and part of it on amalgam. The aim of this study was to measure the shear bond strength of bonded orthodontic tubes on different sizes of class I amalgam restorations, when it involves the pit cavity and buccal groove of the tooth, thereby part of the bonding surface covered with amalgam and a part with the enamel. And Transbond XT Adhesive Paste along with Single Bond Universal, which contains 10-MDP monomer, used for bonding of tubes and compare it to that ,the Transbond XT Adhesive used for the bond of tube to tooth .

Materials and Methods

This is in- vitro experimental study.This study was performed on 70 first mandibular molars without structural defects, extracted due to periodontal problems .The specimens were divided into 7 groups of 10, and at the buccal surface of the specimens a class I cavity or groove was carved to a depth of 1.5 mm with the following specifications:

Groups 1 and 2 with a 1.75 mm cavity width on the buccal surface in a way that, 25% of the bonding surface on the amalgam and 75% on the enamel.

Group 3 and 4 with a cavity width of 3.5 mm on the buccal surface, in a way, that, 50% of the bonding surface on the amalgam and 50% on the enamel.

Group 5 and 6 with a cavity width of 5.25 mm on the buccal, in a way, 75% of the bonding surface on amalgam and 25% on the enamel.

Group 7 samples as control, and remained intact.

Since we did not find any study on the comparison of the orthodontic shear bond strength by reviewing of the relevant literatures, this investigation seems to be the first of its kind. Due to the problem of access to the specimens, 10 teeth in each group were selected for the study. These teeth were autoclaved to prevent the bacterial contamination, then stored in distilled water (9).

All Class 1 cavities were carved by a turbine mounted flat cylindrical diamond bur (Jota, Ruthi, Switzerland). The cavities were measured by a digital colis (Digimatic caliper; Mitutoyo CD-6, Tokyo, Japan) in order to confirm the dimensions of the carved cavities. An admix capsular amalgam (SDI, GS 80, Bayswater, Victoria, Australia) was condensed by a condenser activator inside the prepared cavities, and then manually burnished.

After 24 hours, the specimens were polished for 20 seconds with sandblasting (G2, NAIS, Bulgaria)(10). Each specimen was cleaned ultrasonically for 10 min in distilled water to eliminate any residue.

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The buccal surface of the specimens was polished with non- Fluoride pumice (Kimia, Iran) for 15 seconds, and dried with oil free and water free air. Then, the amalgam surfaces were sandblasted using 50 µ aluminum oxide particles under 7 Kg / cm 2 air pressure from 10 mm distance for 3 seconds (Basic Classic, Renfert; Hilzingen, Germany) .In these seven groups, teeth were etched with 37% phosphoric acid (FineEtch 37; Spident Co, Korea) for 25 seconds ,washed for 20 seconds and dried with oil free air, till the chalky appearance of the orthodontic enamel. Orthodontic tubes (American Orthodontic Corporation, low profile non-convertible tube, Sheboygan, Wis, United States) were bonded to the buccal surface of specimens. For bonding in groups 1, 3, 5 and 7, the Transbond XT primers (3M Unitek, Monrovia, California, USA) was used and in groups 2, 4, and 6 the universal bonding(Single Bond Universal; 3M, Monrovia, California, USA) and Transbond XT primers were used.

All specimens were light cured for 40 seconds using a light curing unit (Woodpecker LED Curing Light; Gulin Woodpecker Medical Instrument Co., Ltd., Guangxi, China). The specimens were subjected to T1000Th thermal cycles between 10 - 50 ° C, and then the teeth were placed to CEJ in acrylic block (Pyrax; Pyrax Polymer, Roorkee, India). Specimens were mounted in a universal testing machine, where the device's power cutter was perpendicular to the flat surface of the orthodontic tube. The shear force was applied using a universal testing machine (STM-20; SANTAM Design & Manufacturing Co., Iran) with a 50 kg load cell and a crosshead speed (crosshead speed) of 1 mm/min on the specimens to detach the orthodontic tubes [11] .The force was measured and recorded in Newton, then the shear bond strength was calculated by the formula: bond strength (Mpa) = force (N) /area of bracket base (mm^2). Finally, the collected data were checked in SPSS software version 18. Normal distribution of quantitative variables was assessed using the Shapiro-Wilk test. One-way ANOVA and Kruskal-Wallis test were used to compare the shear bond strengths in terms of the extent of orthodontic tooth restoration. In these cases, when the results of the test were found to be significant, the pairwise comparison of the groups was done by the Bonferroni Correction test using Turkey's and Mann Whitney's multiple comparison tests, respectively. Comparison of shear bond strength in two conditions with and without universal bonding was performed by the independent t-test and Mann Whitney test.

Results

Results of table 1 show a significant difference between the mean shear bond strength of the orthodontic tubes on the 25%, 50% and 75% of the amalgam surface in the 6 groups and the control group ($p < 0.001$)(table1)

Table 1: Comparison of the shear bond strength of orthodontic tubes (MPa) in 7 groups

Group	Number	Minimum	Maximum	Median (range)	SD± Mean	P-value*
1 (25%)	10	17/9	80/15	(38/13-94/9) 59/11	21/2±a**88/11	
2 (25%)	10	84/9	76/15	(08/14-72/10) 49/12	93/1±ad**49/12	
3 (50%)	10	56/6	41/13	(20/10-62/7) 175/9	95/1±^{b}25/9	
4 (50%)	10	03/7	14/03	(09/12-86/8) 14/10	08/2±^{cd}25/10	<0.001
5 (75%)	10	85/3	98/9	(8-91/4) 57/6	90/1±^{c}51/6	
6 (75%)	10	17/6	67/9	(44/8-83/8) 80/7	18/2±^{bc}11/8	
7 Control	10	43/10	12/17	(99/14-13/13) 99/14	92/1±^{a}52/14	

The small letters indicate insignificant statistical difference in the Tukey double comparison test.The results of Table 1 show that between the shear bond strength of the orthodontic tubes in the 6 groups that , 25%, 50% and 75% of the amalgam bonding surface were bonded by primer and universal bonding, and the control group was statistically significant ($0.001 > p$). However, the pairwise comparison of the groups showed only a statistically significant difference between group 2 and 6, 4 and 7, also between 6 and 7 ($p < 0.001$).

Based on the results of Table 2, the mean

shear bond strength of the orthodontic tubes on the 25% surface of the amalgam restoration, is higher in the group , where the orthodontic tubes were bonded by primer and binding universal to the group that orthodontic tubes were bonded only by primer. However, this difference is statistically insignificant (p = 0.52) (table2)

Table 2: Comparison of the shear bond strength of orthodontic tubes (MPa)

Group	Number	Minimum	Maximum	Median (range)	SD±Mean	P-value* Independent T Test *
1 (25%)	10	17/9	80/15	(38/13-94/9) 59/11	21/2±88/11	520/0
2 (25%U)	10	84/9	76/15	(08/14-72/10) 49/12	93/1± 49/12	

Based on the results of Table 3, the mean shear bond strength of the orthodontic tubes on 50% surface of the amalgam restoration is higher in the group where the orthodontic tubes, were bonded by primer and universal bonding, than in the group, the orthodontic tubes were only bonded by primer. However, this difference is statistically insignificant (p = 0.286). (table3)

Table 3: Comparison of the shear bond strength of orthodontic tubes (MPa)

Group	Number	Minimum	Maximum	Median (range)	SD±Mean	P-value*
3(50%)	10	56/6	41/31	(20/10-62/7) 175/9	95/1±25/9	280/0
4(50%U)	10	03/7	03/14	(09/12-86/8) 14/10	08/2±25/10	

Based on the results of Table 4, the mean shear bond strength of the orthodontic tubes on the 75% bonding surface of the amalgam restoration , is higher in the group where the orthodontic tubes were bonded by primer and universal bonding, than in the group where orthodontic tubes were only bonded by primer. However, this difference is statistically insignificant (p = 0.075). (table4)

Table 4: Comparison of the shear bond strength of orthodontic tubes (MPa)

Group	Number	Minimum	Maximum	Median (range)	SD± Mean	P-value*
5(75%)	10	85/3	98/9	(8-91/4) 57/6	90/1±51/6	0/075
6 (75%U)	10	17/6	67/9	(44/8-83/8) 80/7	18/2±11/8	

Based on the results of Table 5, the mean shear bond strength of the orthodontic tubes in groups using Single Bond Universal (groups 2, 4 and 6) was higher than in the group not using single Bond Universal (Groups 1, 3 and 5), however, this difference was statistically insignificant (p = 0.148).

Table 5: Comparison of the shear strength of orthodontic tubes (MPa) in 2 groups with and without universal bonding

Group	Number	Minimum	Maximum	Median (range)	SD± Mean	P-value*
Without universal bonding	30	85/3	80/15	(11-94/6) 21/9	97/2±21/9	148/0
With universal bonding	30	17/6	76/15	(30/12-89/7) 14/10	70/2±28/10	

Discussion

Bonding orthodontic attachments on tooth surfaces restoration is often challenging and usually requires modified bonding techniques. As suggested by many researchers, such as Zachrisson et al and Gross et al., in this study, samples were sandblasted immediately before the orthodontic tube bonding by 50 µ aluminum oxide particles to increase adhesion of the attachments to the sample surfaces(6),(12). Like many other studies, samples were subjected to sandblasting for 3 seconds (13), (11), and (5). Jost-Brinkmann et al., believe that sand blasting for more than 4 seconds to increase adhesion is unnecessary (14). According to Graber et al., bonding on amalgam restorations requires surface roughening by sandblasting or diamond bur (15). Study of Zachrisson et al., indicates that sandblasting by aluminum oxide particles leads to a greater adhesion to roughening by diamond bur (6). With regard to the size of aluminum oxide particles, study of Buyukyilmaz and Zachrisson revealed that there is no significant difference between particles with a size of 50 µ and 90 µ (1) . In this study, crosshead speed in the universal testing machine similar to other studies was 1mm/min (13, 7, 6).

The obtained data of this study showed that the shear bond strength of the orthodontic tubes varies, when bonded by Adhesive Transbond XT on the different size of amalgam restoration

(Table 4-1). The orthodontic tube shear bond strength, when bonded by Adhesive Transbond XT, and the bond surface 25% on amalgam ,was 2.21 ± 11.88 MPa; 50% on amalgam, was 1.95 ± 9.25 MPa ;and 75% on amalgam found to be 1.91 ± 6.51 MPa, which significantly indicates that bond strength decreases with increasing bonding surface on amalgam .Also, the shear bond strength of the orthodontic tubes varied when bonded on different sizes of amalgam restoration by Transbond XT Adhesive Paste and Single Bond Universal (Table 4-1).

The orthodontic tube shear bond strength, when bonded by Transbond XT Adhesive Paste and Single Bond Universal, while 25 % bond surface on amalgam was 1.93 ± 12.49 MPa; 50% on amalgam, 2.08 ± 10.25 MPa; and 75% on amalgam, 8.11 ± 2.18 MPa, which significantly indicates that bond strength decreases with increasing bonding on amalgam. These results indicate that the most important factor in the bonding strength of the orthodontic attachments, other than the adhesive type and applied bonding, is the degree of healthy enamel ridge around the dental restorations.

In this study, the mean shear bond strength of bonded orthodontic tubes on amalgam restoration was compared with the mean shear bond strength of bonded orthodontic tubes on etched enamel. According to Table 4-1, the mean shear bond strength to enamel was measured 14.52 ± 1.92 MPa. In the study of Guiraldo et al. (2016) and Hellak et al. (2016), the mean shear bond strength of the bracket to etched enamel bonded by Transbond XT Adhesive was 12.57 and 15.51 MPa, respectively (16, 17) .This miner difference of bond strength to the enamel is due to the morphology and amount of the teeth surface fluoride used.

In this study, all of the specimens bonded to amalgam, the shear bond strength was lower than the shear bond strength of tube bonded to the enamel. It corresponding the data of the relevant studies (18,12, 6) . According to the study of Zachrisson et al., the clinically acceptance of bond strength is 5 to 8 MPa (6). Almost all of our study groups have this bond strength.

From the view of compatibility of the clinical findings of Zachrisson and Buyukyilmaz, with our data, it can be concluded that, if 25% of the bond surface is placed on the acid etched enamel edge, it is likely that the bond strength is clinically acceptable and there is minor probability of bond failure during treatment.

Based on this study, prejudice cannot be made where the bonding surface is more than 75% on amalgam, which requires further studies. Pairwise Comparison on the shear bond strength of the orthodontic tubes in terms of the extent of the restoration under tube in the groups that used Transbond XT Adhesive with the groups using transbond XT Adhesive Paste and Single Bond Universal Bonding (Table 4-2, 4-3, 4-4, 4-5)revealed that the use of Single Bond Universal in all three statuses of 25%, 50% and 75% bonding surface on the amalgam increased bond strength, which is statistically insignificant.

The findings showed that there is a significant difference between groups 4 with 7 and 6 with 7, but there is no statistically significant difference between groups 2 and 7. This suggests that the shear bond strength of the orthodontic tubes when 25% bond surface placed on amalgam, and the Buccal tubes bonded with Transbond XT Adhesive Paste together and single Bond Universal bonding, is similar to the shear bond strength of the orthodontic tube bonded by Transbond XT Adhesive on enamel. But a new comparison from the perspective of demineralization is done by Almeida et al. they came to conclusion that universal adhesive system may be used for bonding metal backets If the orthodontist wants to maintain dental enamel health. And transbond plus SEP presented high demineralization of enamel when compared with universal adhesive system. Although there was no difference in the shear bond strength between them (19).

Conclusion

According to the results of this study, the amount of healthy enamel margin around the buccal surfaces of amalgam restorations is one of the most important factors in the bond strength of orthodontic attachment bonded to

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the buccal surfaces of the teeth, so that when the degree of the surface bond on the enamel margin is higher than the bond surface to amalgam, we can expect more bond strength. Based on the results of this study and the findings of previous studies, there is a need for at least 5 to 8 MPa bond strength to be clinically acceptable, when a healthy enamel margin around amalgam restoration is present, and be able to embed at least 25% of the attachment bonding surface on it. Then this bond could be clinically accepted .The results showed that the use of Single Bond Universal did not increase the bond strength significantly .Therefore ,due to the high cost of bonding universal, spending to achieve more bond strengths on amalgam restorations is not rational .

Conflicts of interest

There are no conflicts of interest

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