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Original Article

Evaluation of shear bond strength of amalgam restorations repaired with composite resin by different surface treatments

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Abstract

Aim: Repairing amalgam restorations with composite resins is a clinical practice with many advantages. An effective adhesion is achieved between amalgam and composite by applied different surface treatment on amalgam surface. In this study, the effect of adhesive systems applied on amalgam surface on composite-amalgam connection was investigated.
Methodology: Standard cavities were opened in 70 acrylic molds that had completed their polymerization and amalgams were placed in these cavities. Seven groups were randomly assigned to different surface treatments on amalgam. In group 1 only roughening with diamond bur, in group 2 acid etch, in group 3 acid application after roughening with diamond bur, in group 4 roughening with diamond bur and silane, in group 5 acid etch and silane, in group 6 roughening with diamond bur and Alloy Primer and finally 7. acid etch and Alloy Primer was applied in the samples. After the application of clearfil universal bond to all groups, composite resins were placed and polymerized. Shear bond strengths were tested with a Universal testing machine. Obtained data were evaluated by one way ANOVA and Tukey B tests.
Results: In the statistical evaluation of the groups, the highest shear bond strength between amalgam-composite was seen in the 3rd group where both roughening with diamond bur and acid were applied together, and the lowest shear bond strength was seen in the first group with only roughening with diamond bur. The differences between the groups were statistically significant ($p<0.05$).
Conclusions: The roughening of the amalgam surface affects the shear bond strength between amalgam and composite resin. These results obtained in vitro conditions should be supported with clinical studies.

Keywords: Amalgam, composite, shear bond strength

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Introduction

Dental amalgam is a material used in dentistry since 1800s (1). It is still preferred in posterior teeth due to its strong physical properties, high durability and abrasion resistance, cheapness, and increase in cavity edge coating of the corrosion products (2). The most important reason for the repairing of existing amalgam restorations is secondary caries (3). Another problem with amalgam restorations is complete or partial fractures (4). 41% of the causes of amalgam restorations fail were secondary caries and 22% were restoration fractures. Secondary caries are difficult to diagnose and cause change the entire restoration (5).

Defective dental amalgam restorations are usually treated by replacing with new amalgam or other restorative materials. The restoration of only defective areas is a much more protective method than detract whole material. As a viable protective technique, the repair of defective areas has been proposed many times because it is simple, fast and economical (5-7). Repair of the defective restoration results in less iatrogenic damage than is completely removal and reconstructed, and is therefore preferred. Amalgam restorations can be repaired with composite resin (with an adhesive) or amalgam, but the repaired restoration is less powerful than the one-piece restoration (7). However, it protects the tooth because it is impossible to removal the restoration without injured some dental hard tissue. Thus, damage to the healthy tooth tissue is prevented during removal of the old restorative material (8). The cavity walls do not become thin and weak, and the risk of damage to the pulp is also minimized. Less damage to dental tissues occurs, reduced risk of been broken teeth against masticatory forces and extended life. During removal of the material at the base of the cavity, the dentin in the area close to the pulp is protected, thus decrease the possibility of need endodontic treatment of the tooth. When the restorations are repaired, there is minimal treat to the tooth structure and the repair is more cost-effective than removaled of the whole restoration. In addition, the chair time during the procedure is reduced (3,4). Studies have shown that the cavity size decreases by at least 0.2-0.5 mm during the removal of the amalgam (9,10). By removing only the defective parts, unnecessary enamel-dentin removal is prevented. It is reported that the tooth is stronger, maintains its strength and increases its life (11,12). For these reasons, repair is the most preventive treatment option. The findings of the studies support repair instead of replacing amalgam restorations with localized defects (5,6).

Nowadays, with the gain popularity of minimally invasive techniques, many different adhesive systems are used in the repair of amalgam restorations with composite resins (4). Studies have shown that adhesive systems have bonding features with metal alloys and therefore can be used in amalgam repair. In this study, the effect of different adhesive systems used in the repair of amalgam restorations with composite resin on bond strength was investigated.

In the repair of amalgam restorations with composite resins, the surface of the amalgam must be roughened and a bonding agent must be used between the materials (13-15). In our study, the bonding strength at the amalgam-composite interface was evaluated in the restoration of amalgam exposed to different surface treatments with composite resins.

Materials and Methods

In our study, acrylic (Meliodent, Bayer Dental, England) was placed in 3 cm diameter and 5 cm height plastic molds and 70 molds were prepared. 5 mm in diameter and 2 mm in depth cavities were opened into the molds which had completed their polymerization. The amalgam prepared in the amalgamator in 8 seconds was condensed into the cavities and the surfaces were smoothed and burnished with burnisher. Subsequently, it was kept in the oven at 37°C for 48 hours in a 100% humid environment. Then the amalgam surfaces were sanded in aqueous medium. The samples were randomly divided into 7 groups with 10 samples in each group. Each group was subjected to different surface treatments and made suitable for bonding with composite resin.

In our study, spherical particle capsule amalgam (Megalloy EZ Capsule Amalgam, Dentsply Detrey GmbH Konstanz, Germany) and a light curing composite resin (Estelite Posterior Quick, Tokuyama, Japan) were used. The brand, manufacturer and chemical composition of the materials used in this study are listed in Table 1.

In Group 1, the amalgam surface was prepared with diamond bur (Diatech Dental Ag, Heerbrugg, Switzerland). This was performed for 3 seconds for each treated group under water cooling. In every five samples one used bur was renewed.

In Group 2, 37% orthophosphoric (Scotchbond, 3M ESPE, USA) acid was applied. In each group treated with acid etch, the acid was applied on the amalgam surface for 20 seconds followed by washing for 20 seconds.

In Group 3, 37% orthophosphoric acid was applied after the preparation of amalgam surface with diamond bur.

In Group 4, after the amalgam surface was prepared with diamond bur, silane was applied according to the manufacturer's instructions.

In Group 5, 37% orthophosphoric acid was applied to the amalgam surface and silane was applied according to the manufacturer's instructions.

In Group 6, after the amalgam surface was prapared with diamond bur, Alloy Primer (Alloy Primer, Kuraray, Japan) was applied to the surface and allowed to dry.

In Group 7, after applying 37% orthophosphoric acid to the surface of the amalgam, Alloy Primer was applied to the surface and was allowed to dry as group 6.

Table 1. Brand, manufacturer and chemical composition of the materials used

Product name	Chemical composition	Company
PMMA Acrylic	Polymethylmethacrylate	Palapress, Vario, Hereaus Kulzer, Hanau, Germany
Megalloy EZ Capsule Amalgam	Silver, Tin, Copper	Dentsply Detrey GmbH Konstanz, Germany
Estelite Posterior Quick	Bis-GMA, TEGDMA, Bis-MPEPP, ZrO_2-SiO_2	Tokuyama, Japan
Scotchbond Universal Etchant	Orthophosphoric acid 37%	3M ESPE AG, Seefeld, Germany
ESPE Sil	Etanol, silan	3M ESPE, Germany
Alloybond	Aceetone, 10-MDP, 6VBATDT	Kuraray Co, Ltd, Tokyo, Japan
CLEARFIL Universal Bond	BOND, 10-Methacryloyloxydecyl dihydrogen phosphate (MDP), Bisphenol A diglycidylmethacrylate (Bis-GMA), 2-Hydroxyethyl methacrylate (HEMA), Hydrophilic amide monomers, Colloidal silica, Silane coupling agent, Sodium fluoride, dl-Camphorquinone, Ethanol, Water	Kuraray Co, Ltd, Tokyo, Japan

As a final step for each group, the 7th generation bonding system (Clearfil Universal Bond, Kuraray Co, Ltd, Tokyo, Japan) was applied according to the manufacturer's instructions. The adhesive was applied to the surface for 20 seconds and cured with LED light for 20 seconds. The experimental groups, the number of samples and the procedures applied are presented schematically in Table 2 and Table 3.

Table 2. Experimental groups and applied procedures

Groups		
Group 1	Roughening with diamond bur	Bond
Group 2	Acid etch	Bond
Group 3	Roughening with diamond bur + Acid etch	Bond
Group 4	Roughening with diamond bur	Silane + Bond
Group 5	Acid etch	Silane + Bond
Group 6	Roughening with diamond bur	Alloy Primer + Bond
Group 7	Acid etch	Alloy Primer + Bond

Table 3. Experimental groups and applied procedures

	Roughening with diamond bur	Acid etch	Silane	Alloy Primer	Bond
Group 1	+				+
Group 2		+			+
Group 3	+	+			+
Group 4	+		+		+
Group 5		+	+		+
Group 6	+			+	+
Group 7		+		+	+

Resin composites were bonded to amalgam using semi-transparent polyethylene molds (inner diameter: 4 mm and height: 2 mm). The composite resins, which were carefully condensed on to the amalgam, were polymerized by LED light device for 40 seconds.

Shear bond strength of the samples was measured with the Universal Test Device (Shimadzu, Japan). Each sample was placed in the instrument with the blade edge parallel to the sample surface. The knife-ege test tip was applied with a force of 1 mm / min and the bond strength of composite resins to the amalgam surface was measured as Megapascal (MPa).

Statistical Analysis

Statistical analyses were carried out using the SPSS 21.0 software (SPSS, Chicago, IL, USA). Obtained data were evaluated by one way ANOVA and Tukey B tests.

Results

In the statistical evaluation of the groups, the highest bonding strength between amalgam composite was found in the 3rd group in which the bur and acid etch were applied together, and the lowest bnding strength was seen in the first group which had only roughening with bur. According to the one-way ANOVA, the average values of the results in MPa are shown in Table 4. The differences between the groups were statistically significant (p<0.05).

While the average MPa value of the group 2 treated with acid etch was 4.23, in group 5 treated with acid etch and silane, this value was 3.41 and in group 7 treated with acid and alloy primers, it was 2.74. This shows that in terms of bonding strength, the application of acid alone or after bur roughening is more effective than the combination with silane and alloy primer.

In group 4, the bonding strength was 2.85 in the silane application after bur roughening, and in alloy primer application after bur roughening in the 6th group, this value was found 3.56. This can be explained that alloy primer application after bur roughening is more effective on bonding strength than silane application.

Table 5 shows the statistical differences in pairwise comparisons between the groups according to the Tukey Ba test (Table 5).

Table 4. Mean and standard deviation values of the groups

		N	Mean	Std. Deviation	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum	
Mpa	Group 1	10	2,4240	1,07998	1,6514	3,1966	1,12	4,16	One way ANOVA
	Group 2	10	4,2310	1,08350	3,4559	5,0061	2,79	6,08	
	Group 3	10	4,9220	2,00377	3,4886	6,3554	2,91	8,80	
	Group 4	10	2,8580	1,17931	2,0144	3,7016	1,53	5,24	
	Group 5	10	3,4100	1,18222	2,5643	4,2557	2,31	5,91	
	Group 6	10	3,5620	1,36378	2,5864	4,5376	1,43	5,92	
	Group 7	10	2,7490	,80604	2,1724	3,3256	1,15	3,78	
	Total	70	3,4509	1,48292	3,0973	3,8044	1,12	8,80	F=4,69 P=0,001 Significant

Table 5. Comparisons between groups according to Tukey B test

Tukey B[a]				
Gruplar	N	Subset for alpha = 0.05		
		1	2	3
Group 1	10	2,4240		
Group 7	10	2,7490	2,7490	
Group 4	10	2,8580	2,8580	
Group 5	10	3,4100	3,4100	3,4100
Group 6	10	3,5620	3,5620	3,5620
Group 2	10		4,2310	4,2310
Group 3	10			4,9220

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 10,000.

Discussion

Amalgam restorations are replaced or repaired for different reasons. Minimally invasive treatment approaches have been proposed to restore amalgam with composite resins with superior physical and aesthetic properties. This is due to the loss of substance in the dental tissue during amalgam replacement and the possibility of damage to the pulp. Since the repairing of amalgam restorations with amalgam is not a reliable option, the necessity of an adhesive approach has been advocated (16,17). With the development of composite resins, these resins have been used in order to strong bonding in the repair of defective parts of amalgam restorations. Composite resins were applied in two different techniques: mechanical and chemical. Different adhesive systems have been used in the chemical technique. There is often controversy that these systems form ionic bonds with the metallic structure of amalgam. In the mechanical technique, the surface of the amalgam was roughened and grooves were formed in order to increase the retention (16,18,19).

Lacy et al in their study to repair amalgam restorations found that the bonding strength obtained from amalgam-composite resin samples are higher than amalgam-amalgam samples (20).

In the study of the bonding strength of amalgam resin-composite restorations by Ergücü et al., it was found that the mean value of 4.41 MPa obtained from Scotchbond Multi Purpose Plus group, was lower than all other groups. Similarly, in our study, only bur roughened specimens showed the lowest bonding value among the other groups (2).

Hadavi et al. in their study they evaluated the microleakage between amalgam-composite. they found that application acid after bur roughening affected the bonding between amalgam-composite negatively. The reason for this is explained by the authors as the deterioration of reactions that may affect the adhesion between the metallic structure of the amalgam and the bonding agent (21). In another study in which Hadavi et al. examined shear bond strength between amalgam-composite, it was found that applying acid to amalgam surface reduced 45% the bonding strength by removing the oxide layer (22). In our study, on the contrary, it was concluded that acid application after bur roughening had a positive effect on bonding strength.

Balkaya et al in the study of the effect of universal adhesives on the bonding strength of amalgam repair using and without using an alloy primer, stated that alloy primer increases the binding strength (23). In another study conducted by Blum et al in order to evaluate the effect of surface treatment on amalgam binding strength of composite resin, alloy primer and Panavia 21 system were used together and acquired high binding streight between amalgam-composite (24). In our study, the bonding strength of the specimens treated with alloy primer and bond was high, especially after roughening with bur. In a study by Özcan et al., it was reported that the use of silane after CoJet-sand application increased the bonding strength between amalgam- composite. In this study, we found that silane application after acid roughening had a positive effect on bonding strength (16).

Conclusions

As a result, roughening processes on the amalgam surface affect the shear bond strength between amalgam and composite resin. The results that only roughening with bur does not contribute much to the bonding, but also that acid etch, alloy primer and silane applications increase the bonding need to be supported by clinical practice.

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