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An in Vitro Study to Compare the Bond Strength with Dentin Tissues between PQ Amalgam and Excite

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Abstract **Original Research Article**

Background and Aim*:** One of the important disadvantages of amalgam restorations is its disability of bonding to tooth substance that necessitates over preparation of the tooth to produce mechanical retention for the filling material. Thus, several materials were marked to bond Amalgam to tooth structure. ***Material and Methods: 20 extracted human premolars were flattened occlusally to expose dentin. The teeth where mounted in phenolic rings with acrylic resin. Split Teflon mold was applied over the dentin surface contains a holed cylinder with a diameter of 2 mm and a height of 2 mm works as a matrix for applying the filling material. The teeth were divided into 2 equal groups according to the restorative and bonding materials used: (PQ Amalgam-Amalgam, Excite-Estilite), Specimens were thermo cycled (500 cycles between 5°C and 55°C). The fracture surfaces were then observed by a stereomicroscope. ***Results:*** Data was subjected to a T student, statistical studies revealed that shear bond strengths of the Excite-Estilite group were greater than the PQ Amalgam-Amalgam group ($p<0.05$). ***Conclusions:*** This study showed, Bonding amalgam to dentin using its special bonding material did not increase the bond strength between amalgam and dentin.

Keywords: Shear bond strength - bonding amalgam restorations - PQ Amalgam - bonding composite.

INTRODUCTION

Dental amalgam is one of the widely used materials in restorative dental treatment, with its ease of use and low cost, but one of the drawbacks to amalgam restorations is its inability to bond to dental structures, and this requires additional removal of these tissues to secure mechanical fixation and thus weakening the tooth structure [1]. As a result of the great development that occurred in the dentin bonding systems in recent times, many amalgam bonding materials appeared, as an auxiliary solution to increase stability with a more conservative preparation [2].

As the amalgam is attached to the preparation surfaces by covering the walls of the hole prepared cavity to receive the amalgam restorations with a thin layer of zinc phosphate cement and thickening the amalgam directly towards this surface, which led to a slight improvement in both the sealing and stability of the amalgam restorations [3].

A material has been developed (Selective Interfacial Amalgamation) for application under the amalgam filling by mixing each of the polycarboxylate cement with the particles of the amalgam alloy [4] in order to achieve a kind of homogeneity, the bonding strength of this material reached 3.5 MPa [5], and the amalgam restorations were attached to the etched enamel using resin-mineral cements (Panavia and Super Bond) Which was developed for the bonding of fixed partial denture in the Maryland bridge technique, where this technique contributed to preventing marginal leakage, and the bonding force reached (17.7 MPa) when using Super Bond with etched enamel, while the bonding forces of Panavia with dentin were about (3.2±0.4) MPa [6].

Some also mentioned the possibility of using traditional dentin bonding systems under amalgam restorations, especially systems containing monomers with hydrophilic ends and hydrophobic ends at the same time, taking into consideration that amalgam is a highly hydrophobic substance, while the dentin is considered as a hydrophilic material [7].

Amalgam Bond is appeared; it is one of the bonding materials for dentin that was specially manufactured to bond amalgam restorations. For the mechanism of bonding amalgam when using these materials, it depends on the oxygen inhibitor layer. When the bonding material hardens, the bottom layer of the bonding resin hardens too, while the surface layer remains non-polarized due to the presence of the oxygen (oxygen-inhibitor layer) [8]. Once the amalgam is condensed into this layer the oxygen is expelled and microscopic wedges are inserted from the hardening amalgam allowing the resin to fully polymerize almost completely mechanically bound to the amalgam [9]. Many studies was done about the effectiveness of these materials in bonding amalgam restorations and comparing the amalgam bonding strength with the bond strength of resin with dentine tissue which in turn is clinically accepted.

Bonding of the resin with the dentinal tissues: It depends on the bonding of the bonding materials with the composite resin on the one hand and with the dentin tissues on the other hand. When the bonding material is applied to the surface of the etched dentin, tags of bonding material extend into the spaces in the network collagen fibers (as a result of acid etching) with a thickness of 1-5 microns forming the hybrid layer in addition to the extension of the tags of the bonding material within the open dentinal tubes leading to a microscopic mechanical bonding with the dentin tissues, on the other hand, the bonding material is interact with the composite chemically [7], and microchemically.

Dentin bonding systems have developed continuously to obtain a system that achieves higher bond strength and ease of application, until the bonding system of single bottle and separate etching appeared. The bond strength with dentine tissue can reach tell 25 MPA [10]. But the question is could amalgam bonded restorations reach the bonding strength of composite restorations.

AIM OF STUDY

It is a laboratory study to evaluate the bonding strength of amalgam restorations with dentin tissues when using amalgam bonding materials “PQ Amalgam” and compared it with the bonding strengths of composite resin restorations with dentin tissue when using a bonding system with separate etchant.

MATERIALS AND METHODS

The Study Sample

Twenty newly extracted permanent human premolars free of caries were collected from the extraction department at the Faculty of Dentistry at the University of Damascus and kept in physiological serum at room temperature after they were cleaned and washed well, in order to replace fluids until use, then occlusal enamel was cut (by using a Diamond disc) , down to 1/2 mm below the junction of the dentinal enamel toward the dentin surface, and the samples were placed in an acryl molds for ease of handling and transportation. A cleaved Teflon mold, 2 cm long and 2 cm wide, contains a cylinder with a diameter of 2 mm and a height of 2 mm serving as a matrix for applying the restorative materials over dentin. After the samples were prepared, they were divided into two equal groups, the first group: PQ Amalgam as a bonding agent was applied and restored by amalgam (Fig. 5) as following : Ultra-Etch etching acid it contains phosphorous acid at a concentration of 35% which is related to PQ Amalgam system was applied to the dentin surface for 15 seconds, according to manufacturer instruction, after which the dentin surface was washed with water and dried with a gentle stream of air while maintaining the moisture of the dentin, then the Teflon mold was fixed on the surface of the dentin using adhesive wax (Fig. 3) and a celluloid tape was applied inside it (Fig. 4), then the bonding material was applied, and a light air stream was applied for 5-10 seconds until the bonding material loose its milky appearance according to the manufacturer’s instructions, then it was hardened by light curing device for 20 seconds, then amalgam was applied immediately after mixing it with the amalgamator for 15 seconds by the amalgam condenser and was well condensed (Fig.7) The second group: Excite bonding material and Estelite composite resin were applied, where the surface of the dentin was etched by 37% phosphoric acid for 15 seconds, then the dentin surface was washed with water and dried with a gentle air stream, while maintaining the moisture of the dentin. Then the bonding Excite was applied by a special brush and a light air stream was applied for 3 seconds to brush the bonding, then it was hardened by a light-curing device for 20 seconds, after that composite Esteilite was applied within the Teflon mold in one batch, with a thickness of 2 mm, then hardened by a light-curing device for 30 seconds, Then the Teflon mold and celluloid tape were removed, and thermal cycles were operated to the samples.

The Study of Bonding Strength

Application of thermal cycles: All samples were kept in physiological serum in a special incubator at a temperature of 37 ° C for 7 days, during that time they were subjected to 500 thermal cycles ranging from 5-55 ° C according to (standard 19941145ISO TR 11) (The duration of each cycle is 15 seconds for each degree, and the transfer time from one degree to another is approximately 8 seconds, using the Memmert thermal cycle device), after that shear bond strength tests were conducted.

Shear Bond Strength Tests

Shear bond strengths were tested by a mechanical testing device located in the Faculty of Mechanical Engineering at Damascus University INSTRON 1195)) (Fig. 9), where the samples to be

tested were placed within a metal mold in the middle of the work table of the device, then the head of the applicator a blade, was lowered contacting the bonding surface (Fig. 10), The forces were applied at a speed of 5 mm/min until the sound of failure occurred, and the results were read from the device panel that recorded the highest value reached by the sample at the moment of the failure, and these results were recorded in a research form.

Examination of the Bonding Surface under Magnification

After applying the shear forces tests by the device INSTRON The bonding surface was examined under magnification with a magnification of 400 times to find out the type of failure that occurred in the bonding surface according to the following criteria [12]

Adhesive failure: a failure between the bonding material and the restored material, and Cohesive failure: a failure within the restored material, and Mixed failure: some of the restored material remained on the surface of the bonding material.

Statistical Study

The statistical analytical study was conducted, the results were written down, and they were treated statistically using a program SPSS version 13.0, and based on a test T Student to study the effect of the curing method on the shear bond strength in the two study groups (PQ - Amalgam group and Excite - Estilite group) after the estimated arithmetic mean values of the shear strength which expressing the bonding forces of the two previous groups were calculated, and a chi-square test was conducted to study the effect of the treating method in the two groups Study on the frequency of fracture types (types of failure) resulting from testing shear bond strength in the studied samples.

RESULTS

Description of the research sample: The research sample consists of 20 human premolars, after preparing their smooth occlusal dentin surfaces, various restoration materials were applied to them according to the accompanying bonding material. They were divided into two equal groups (according to the bonding and repair materials used) table No. (1) that each group included 10 teeth The shear bond strength test was conducted to assess the bonding forces of these restored materials, and the surface of the samples was examined after applying the shear forces under magnification to find out where the bond failure occurred. The results showed the following:

The results of the first group: the average shear bond strength was reached when applying the amalgam restoration material and the bonding material PQ Amalgam (MPa 1.85) and failure of the bonding occurred between the bonding and the restoration.

The results of the second group: the average shear bond strength were reached when applying the restoration material Excite and bonding material Estilite (12.96) MPa as shown in Table No. (1), and the frequency of bonding failures was distributed as follows: 30% bonding failure within the restoration material, 30% bonding failure part of the restoration material remaining on the surface of the bonding material, and 40% failure between the bonding material and the used restoration, as it is shown in Diagram No. (2).

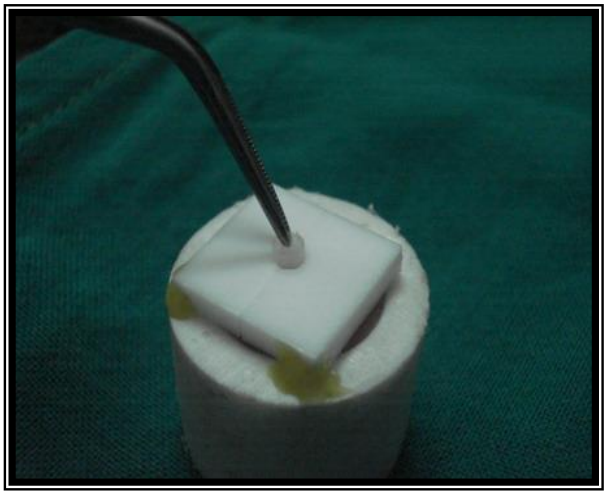
The Results of the Statistical Study of the Differences between the Groups

Test T students between PQ - Amalgam group and Excite - Estilite group Table No. (2) Shows the presence of a statistically significant difference ($P < 0.05$) in the average shear bond strength, and that the values of bond strength in the PQ - Amalgam group were smaller than the values of the bond strength in the Excite group - Estilite, and the chi-square test Table No. (3) shows that there are statistically significant differences ($P<0.05$) in the frequency of the type of failure between the PQ - Amalgam group and the Excite - Estilite group in the research sample, as the failure rate within the restoration material (Cohesive) And the incidence of mixed failure, which contains part of the restoration material on the surface of the bonding in the PQ-Amalgam group was smaller than the rate of its occurrence in the Excite-Estilite group in the research sample.

(Fig. 1) The Composite Resin

(Fig. 2) The Amalgam Restoration

(Fig.3) Applying the Teflon Mold to the Sample Surface



(Fig.4) Applying the Datum Tape

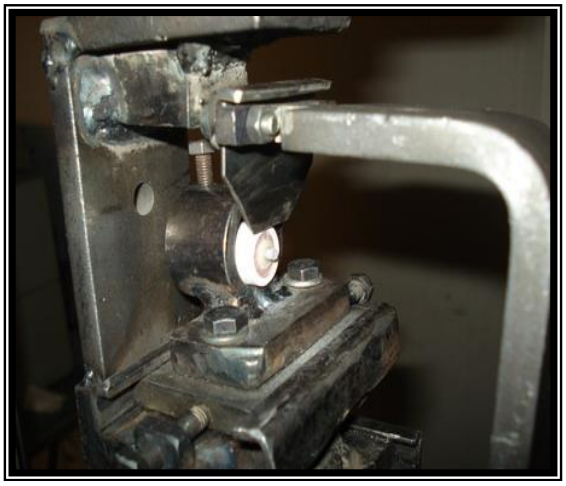
(Fig. 5) Amalgam Bonding MaterialPQ Amalgam

(Fig. 6) Application of Amalgam Bonding Material

(Fig. 7) The Sample after Compaction of the Amalgam

(Fig. 8) The Sample of the Associated amalgam

(fig. 9) Application Shear Tests



(Fig. 10) the Sample on a Device INSTRON

Table No 1: Shows the Arithmetic Mean, Standard Deviation, Standard Error, Minimum and Maximum Shear Forces (In Megapascals) in the Research Sample According To the Studied Group

The studied variable	The studied group	number of teeth	SMA	standard deviation	standard error	minimum	the highest rate
Shear forces (in MPa)	PQ - amalgam	10	1.85	1.30	0.41	0.32	4.46
	Excite - Estilite	10	12.96	7.99	2.53	1.59	24.84

Table No 2: Shows the Test Resultst Student for Independent Samples to Study the Significance of the Differences in the Average Shear Forces (In Megapascals) between the PQ - Amalgam Group and the Excite - Estilite Group in the Research Sample

The studied variable	Values calculated t	degrees of freedom	The difference between the two averages	standard error of the difference	Significance level value	The significance of the differences
Shear forces (in MPa)	-4.342	18	-11.11	2.56	0.000	There are significant differences

Table No 3 Shows the Results of the Chi-Square Test to Study the Significance of the Differences in the Frequency of the Type of Failure between A Group pq - Amalgam and Excite - Estilite Group in the Research Sample

The two variables studied = the studied group x the type of failure that occurred				
number of teeth	Chi-square value	degrees of freedom	Estimated significance level value	The significance of the differences
20	8.571	2	0.014	There are significant differences

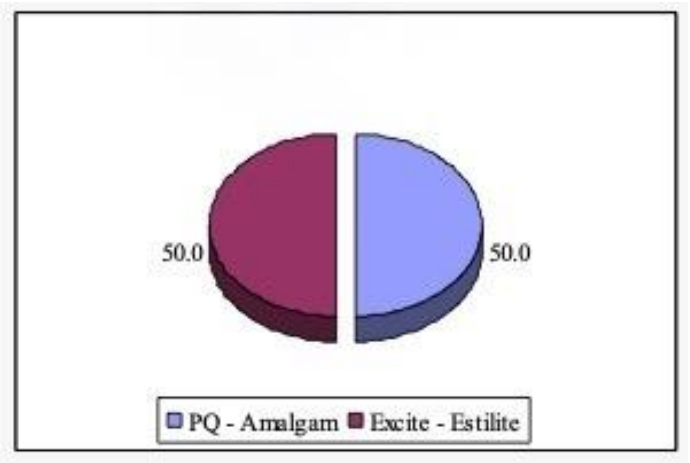


Diagram No 1: Represents the Percentage of the Distribution of the Research Sample According To the Studied Group

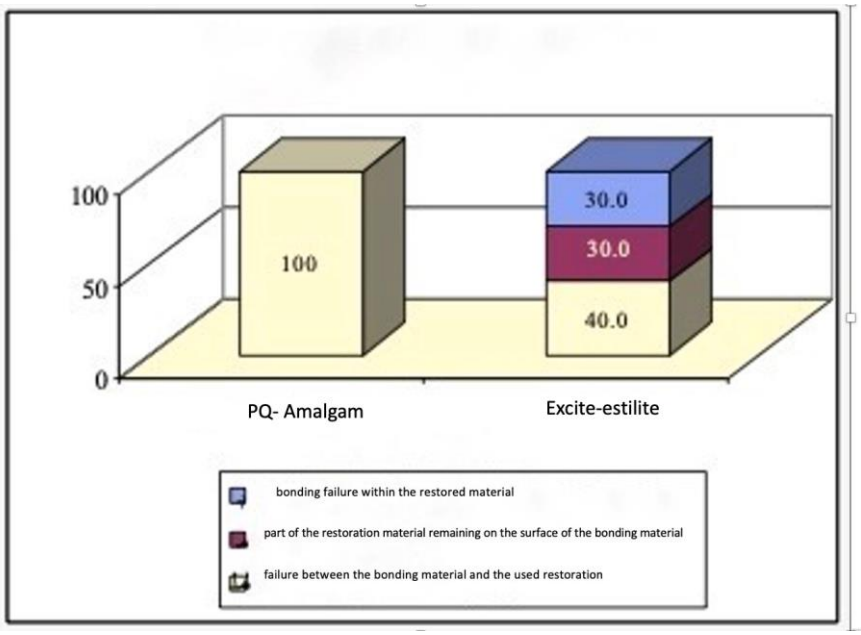


Diagram No 2: Represents the Percentage of the Type of Failure in the Research Sample According to the Studied Group

DISCUSSION

The shear bond strength test, which expresses the bonding forces, was used because it is one of the most widely used tests to evaluate the bonding strength [7]. The average bond strength of amalgam restorations with the dentin tissues in this study was (MPa 1,85) which is consistent with the results of Olmez study who found that the bonding strengths of amalgam restorations with dentin when using Amalgam specialized bond agent is (2.95+/-0.92MPa), and similar to the results of Hasagawa [14] where the bonding strengths of amalgam restorations when applying special materials for amalgam bonding reached (5.1 +/- 1.73 MPa), and the results of our study differed with the results of the study of Mcomb [15], which showed that the bonding strengths of amalgam restorations with dentin tissue when using special materials of amalgam bonding, it ranges between (3-10 MPa) and this difference between studies is due to the fact that the recorded results depend largely on the working conditions and the conditions of the experiment (such as the type of amalgam used, the type of bonding materia, the condition of the examining device, the place of application and the depth of dentin to which the sample is applied, and Thermal cycle procedures) [7].

The study showed that the bond strengths of composite resin restorations with dentinal tissues (12,96 Mpa), When using the restorative material Excite and Estilite bonding agent, while Olmez [13] study showed that the bonding strengths of composite resin restorations with dental tissues are estimated (6.40 +/- 2.17 MPa), and Hasegawa [14] study showed that the bonding strengths of composite resin restorations with dentin is equal to (17) 09 +/- MPa). The difference in the results of studies of the bonding strength of composite resin restorations with dentinal tissues is due to several reasons in addition to what was previously mentioned, and the composition of resin bonding system and the kind of composite used which affects the bonding strength.

The study showed that the bonding strengths of composite resin restorations with dentinal tissues are higher than the bonding strengths of dental amalgam restorations with dentinal tissues in each of the two study groups. This is due to the compatibility between the restored composite resin and the bonding material in terms of composition, while the composition of the amalgam differs from the composition of the bonding, and therefore the nature of the link between the composite and the bonding material is consist of union of monomers, that is means it is a chemical bonding in addition to micromechanical link, which is different from The nature of the bonding between the amalgam and the bonding material, which is only a micromechanical bonding caused by the amalgam's interaction with the oxygen-inhibited layer, repelling the oxygen and allowing it to be harden [16].

The results of this study agreed with the results of a study conducted by Baghdadi[11] and with the results of the study of La Torre[14] and his colleagues in and Olmez [13], where they found that the bonding strengths of composite resin restorations with dentinal tissues are significantly higher than the bonding strengths of dental amalgam restorations with dentin.

The results of the current study differed with the results of a study conducted by Moon, Covey [18], and with the results of a study conducted by Kawakami [19], where the shear forces of the composite resin bonded to dentin were close to the shear forces of the dental amalgam bonded to the dentin tissue, and this is due to the difference in the type of materials used where researchers used with amalgam bonding materials

Cement-based, in that we used light-hardening resin bonding materials, and the difference is also due to the different working conditions and conditions of the experiment. No thermal cycles were applied in the previous two studies, as thermal cycles accelerate the chemical dissolution of the interfaces or bonding surfaces, leading to a clear important deficiency in the bonding strength [20]. As for the frequency of fracture type, the Estilite-Excite group was characterized by the highest frequency of mixed fracture with the remnants of a restorative material and the greater frequency of failure within the restored material due to the strong micro retention of the bonded restoration inside the opened dentin tubes causing high bonding strength.

CONCLUSIONS

Within the limitation of this laboratory study, we conclude the following:

The bonding strengths of composite resin restorations with dentinal tissues were higher than the bonding strengths of amalgam restorations with dentinal tissues, and the bonding forces of amalgam restorations with dentinal tissues were low when applying materials for bonding amalgam, and thus we recommend to prepare optimal cavity for amalgam restoration according to Black's principles.

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