Evaluation of shear bond strength of composite to newly condensed and set amalgam by using two adhesive systems

Ahmmed Hammed, B.D.S, M.Sc.*
Inas Al-Rawi, B.D.S, M.Sc.**

Abstract:

The introduction of adhesives has created a new opportunity to bond composite resin to existing amalgam restoration on aesthetically disturbing surfaces. Further more, the composite laminate would probably improve the restoration.

This in vitro study was conducted to evaluate the shear bond strength of composite resin to fresh and set amalgam by the use of two adhesive systems and to study the effect of water storage time on the shear bond strength of composite resin to fresh and set amalgam

One hundred and eighty cylindrical specimens, 5mm high x 5 mm in diameter, composed of 3 mm of amalgam and 2 mm of composite with a layer of bonding material in between were prepared. Syntac Sc, Excite, control (non bonding) used to bond composite resin (Tetric) to the amalgam bases in three groups I, II and III (each one composed of 60 amalgam bases). Each group divided into two minor groups each of 30 amalgam bases one for fresh amalgam bases referred (F) and the other one for set amalgam bases referred (S), each minor group, F and S subdivided into 3 subgroups according to water immersion period into 48hrs, 1month, 3months,stored at 37 ^{0}C for scheduled period of time.

Specimens were thermocycled and subjected to shear bond strength testing, and the mode of failure whether adhesive, mixed cohesive were recorded also. Results expressed very highly statistically significant difference in shear bond strength values among the all three groups with the highest shear bond strength mean values (SBS) for the control group III (without bonding agent) with the greatest SBS values to set amalgam subgroups. While for group I and II (Syntac SC, Excite) showed the highest SBS mean values to fresh amalgam .The Syntac SC bonding agent shows higher SBS mean than excite bonding agent to either fresh or set amalgam. In conclusion, for both types of bonding agents, Syntac SC performed better in bonding composite resin to amalgam than Excite and the water immersion period has an effect on the SBS mean values and on the type of mode of failure.

Keywords:

Shear bond strength, adhesive systems, composite, set amalgam.

Introduction:

As the incidence of caries has decreased over the past decade, patients have become increasingly more concerned about their appearance, therefore, the clinical practice of operative dentistry has been an ever changing field as a result of new knowledge generated from both the

*Assistant Lecturer in the Department of Conservative, College of Dentistry, University of Baghdad.
**Assistant Professor in the Department of Conservative, College of Dentistry, University of Baghdad.

basic and clinical science, and so, our understanding of patient treatment has been enhanced [1,2].

In attempt to over come the shortcomings of both amalgam and composite resin, a combined amalgam composite resin restoration was introduced in the mid 1980s, and later in the early 1990s was more developed [3].

Composite veneered amalgam restoration is a method of treatment primarily aimed at the visible areas in the mouth, incorporating both the desired mechanical properties of amalgam and the aesthetic qualities of composites [4]. This procedure can be accomplished in one or two sessions.

In the one session procedure, retention is obtained from freshly mixed amalgam immediately after condensation. In the two-session procedure, retention is obtained from set amalgam. Retention can be provided by mechanical and/or micro mechanical means or chemical means [5].

For chemical means, multipurpose adhesive materials are used that bond to amalgam, composite, and tooth structures.

The common dominant to amalgam composite systems or amalgam dentin system that impair the bond strength is the bond between the adhesive material and the amalgam. The existence of a "true" chemical bond between amalgam and adhesive material was not verified. Micro mechanical retention is now considered the most likely mechanism of resin amalgam bonding. Previous studies that evaluated SBS of composite amalgam by multipurpose adhesive materials did not examine the impact of prolonged aging in water. The possible impairment of resin amalgam interface after long-term immersion in water should thus be investigated.

Material and methods:

One hundred and eighty plastic molds prepared with dimensions of 5 x 5 mm of cylindrical geometry, close fitting acrylic piston of dimension 5 mm diameter x 2 mm height (Cylindrical) prepared from cold cure acrylic that fit in a hole of the mold to create a cavity of 5 mm x 3mm for condensation creation of amalgam bases (Good cap500 NG2, OGUSSA, Germany).

Syntac Sc, Excite, control (non-bonding) used to bond composite resin (Tetric) to the amalgam bases in three groups I, II and III respectively (each one composed of 60 amalgam bases). Each group divided into two minor groups each of 30 amalgam bases one for newly condensed (fresh) amalgam bases referred (F) and the other one for set amalgam bases referred (S), each minor group, F and S subdivided into 3 subgroups according to water immersion period into 48hrs, 1month, 3months,stored at 37 0C for scheduled period of time, as shown in table (1).

Samples were therm ocycled for 500 cycles between (5-55) C and then tested for shear bond strength by Zwick testing machine. The specimens were stressed to failure and the shear bond strength calculated in MPa .

The mode of failure whether adhesive, mixed or cohesive were recorded using stereomicroscopy and because all the debonded composite surfaces were completely covered by bonding agent, failure analysis were performed on the debonded amalgam disk also the composite surfaces have been checked.

Statistical Analysis:

The statistical methods were used to analyze and assess the results, these include Analysis of variance (ANOVA) test for difference in one criterion, and least significant difference (LSD) to examine the difference between groups.

Table (1): The distribution of samples for each group

Group	No. Of samples	Subgroup	Technique	Immersion periods
I	10	F_1	Fresh amalgam +Syntac SC + tetri	48hrs
	10	F_2	Fresh amalgam +Syntac SC + tetric	1 month
	10	F_3	Fresh amalgam +Syntac SC + tetric	3 months
	10	S_1	Set amalgam +syntac SC + tetric	48hrs
	10	S_2	Set amalgam + syntac SC + tetric	1 month
	10	S_3	Set amalgam + syntac SC + tetric	3 months
II	10	F_1	Fresh amalgam + excite + tetric	48hrs
	10	F_2	Fresh amalgam + excite + tetric	1 month
	10	F_3	Fresh amalgam + excite + tetric	3 months
	10	S_1	Set amalgam + excite + tetric	48hrs
	10	S_2	Set amalgam + excite + tetric	1 month
	10	S_3	Set amalgam + excite + tetric	3 months
III	10	F_1	Fresh amalgam + tetric	48hrs
	10	F_2	Fresh amalgam + tetric	1 month
	10	F_3	Fresh amalgam + tetric	3 months
	10	S_1	Set amalgam + tetric	48hrs
	10	S_2	Set amalgam + tetric	1 month
	10	S_3	Set amalgam + tetric	3 months

Results:

The mean shear bond strength (SBS) of all groups at different water storage time is presented in Fig (1). It is clear that the highest shear bond strength mean values for the control group III (without bonding agent) with the greatest SBS values to set amalgam subgroups. While for group I and II (Syntac SC, Excite) showed the highest SBS mean values to fresh amalgam except for Syntac SC at 48 hrs immersion period time show higher SBS mean value to set amalgam rather than fresh amalgam All groups exhibited deterioration of the SBS as a function of water immersion time.

The statistical analysis of SBS values for all three groups using ANOVA test showed very highly significant difference ($p<0.001$) among all the three tested groups. Table (2)

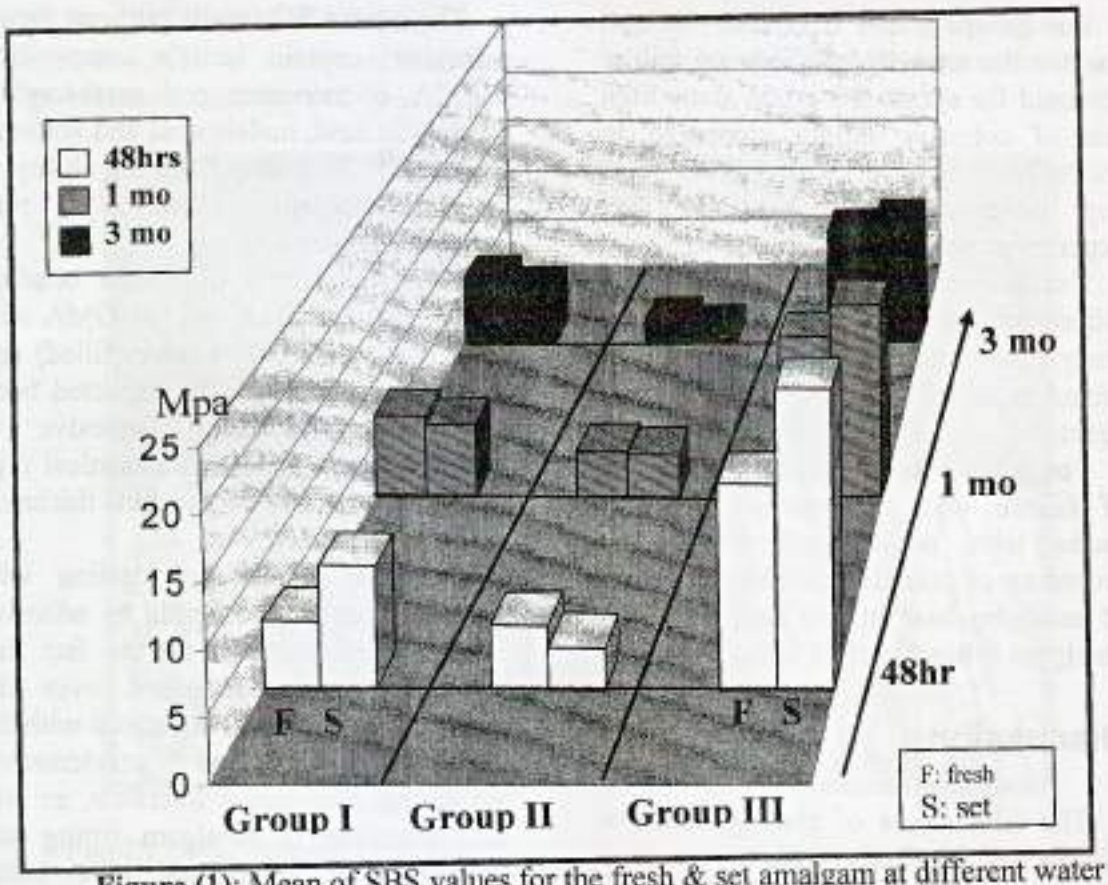


Figure (1): Mean of SBS values for the fresh & set amalgam at different water storage times. (Arranged according to time intervals).

Table (2): Analysis of Variance (ANOVA) / between all groups

ANOVA	Sum of square	d.f	Mean square	F value	Sig.
Between Groups	794.919	2	397.459	881.34	***
Within Groups	12.176	27	0.451		
Total	807.095	29			

*** Very highly significant difference at level 0.001.

Further analysis of all data is needed to examine the difference between groups, so least significant difference (LSD) test showed very highly significant difference between each pairs of groups as shown in table (3).

Table (3): LSD TEST between all groups

GROUP1	GROUP2	GROUP3
***		
	***	
***		

For groups I and II (syntac SC and Excite) the analysis of mode of failure obtained for syntac SC group show high rate of cohesive failure compared to Excite bonding agent, which didn't show any cohesive failure through the experiment period.

Excite maintain adhesive mode of failure through out the 3 months of the study with slight gradual increase in mixed mode of failure for both bonding agents.

For group III maintain adhesive mode of failure with decrease of cohesive mode with passing of time. Also recording of complete cohesive fracture of amalgam base in two samples at set amalgam subgroup of 48 hours (S1).

Discussion:

The advantages of placing adhesive system on amalgam surfaces prior to placing composite resin were assessed clinically by providing more retention by adhesion of adhesive and composite resin to the enamel surface around the amalgam restoration. [6] Also decreasing the microleakage at the junction of amalgam and composite resin. [7]

In general all groups yielded mean SBS values in the range (1.35-23.25) Mpa (within the all immersion times 48 hours, 1 months, 3 months) with very highly statistically significant difference between them. Under the conditions Of this invitro study it's clear that the Syntac Sc bonding agent has higher mean SBS values than the Excite bonding agent, this can be explained mainly on the fact that there's great chemical difference in the compositions of both bonding agents that affect their ability to adhere to amalgam consequently affect the mean SBS values of both.

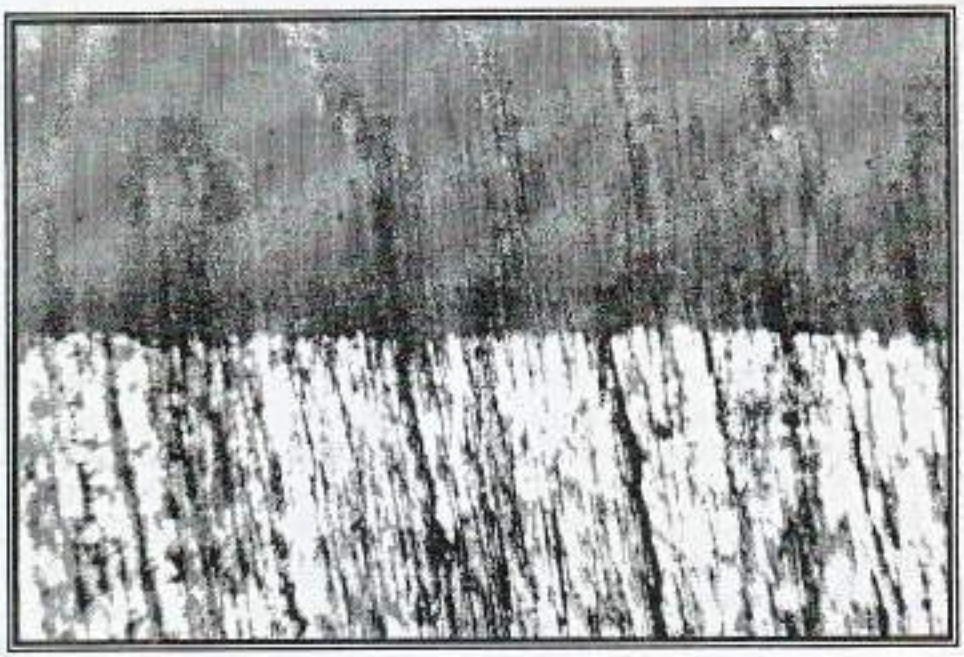
The syntac SC (multi purpose dental adhesive) contain in it's composition HEMA co-monomer and methacrylate polycrylic acid, maleic acid and water as solvent [8]. So it may have the ability to bond amalgam chemically plus micromechanically.

The composition of Excite bonding composed of HEMA and Bis-GMA with highly dispersed silica (nano filled) and ethanol as solvent [8], the expected bond mechanism for such adhesive to amalgam may be micromechanical type only that depends on the film thickness of the adhesive.

Previous studies that dealing with amalgam bonding to dentin by adhesive agent were conducted on the fact that when amalgam condensed over the bonded dentin, It will be mixed with the fluid resin during condensation providing mechanical interlock, so will add retention to amalgam fitting and reinforce the tooth and give better marginal adaptation, the degree to which these advantages are realized is directly proportional to strength and longevity of the adhesive bond. The SBS of amalgam bonded to tooth range from (3-10) Mpa, at this value, the advantages listed above are not fully realized [9]. While in case of bonding composite to existing newly condensed or set amalgam the bonding agent will penetrate into the micro mechanical feature of amalgam depending on the wettability and chemical affinity of bonding agent to the amalgam, so micro mechanical retention is now considered the most likely mechanism of resin-amalgam [10].

Examination of interface between composite resin and amalgam under stereomicroscopy (40X) as shown in fig (2) reveled that the two materials are close intimately adapted with rough sharp interface, this agree with Franchi

et al 1994 [11], also the examination of composite-adhesive amalgam interface under stereomicroscopy (40X) as shown in fig. (3) reveled intimate adaptation of all three materials with smooth interface.



Fig(2): Composite-amalgam interface(vertical section) under magnification at 40X.

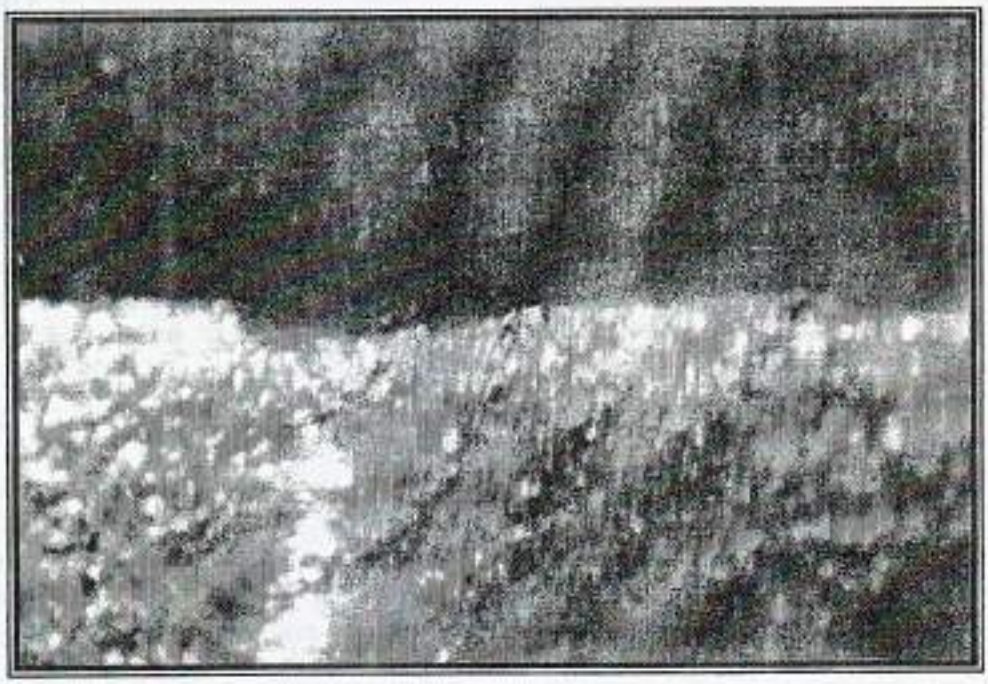


Fig (3): Composite-bonding agent-amalgam interface (vertical section) under magnification at 40X

So the idea of the presence of the adhesive agent as a weak point in the junction can be accepted depending on the mechanical properties of composite resin and adhesive agent.

As general view under the conditions of this in vitro study, there's a significant decrease in the mean SBS values of groups after 1 and 3 months periods of water immersion. These results in fact agree with Bichacho et al [12], which found hydrolytic degradation of the bond during 100 days of immersion in water . Also agree with Pilo et al 1996, who found decrease of mean SBS values of adhesive after 3 and 6 months period of water immersion [10] and agree with Ruse ND et al 1995, found sharp drop of SBS values for Scotch bond multi purpose over 30 days of water immersion [13].

These findings could be explained on the fact that the water filling the voids within the molecular structure of matrix or causing sample to swell concomitantly with degradation of filler-matrix interface [10]. The water absorbed by the polymeric matrix could cause filler-matrix debonding or even hydrolytic degradation of the filler [14]. An observation of the effect of water immersion period on the mean SBS value of the groups that in Syntac SC group the water storage has high detrimental effect on the mean SBS value at 1st one month period by presence of highly significant difference between F1 and F2, S1 and S2 and then the statistical difference decrease with passing of time this give idea that there is rapid initial water up take within first month with minimal gain after ward, this agree with Diaz- Arnold et al 1994[15]. The mean SBS values of composite resin to set amalgam (in group III) higher than that to newly condensed amalgam (with highly statistically significant difference at 48 hours, statistically significant difference at 1 month period, and non statistically significant difference at 3 months period) this can be explained on the fact of absence of free unreacted mercury enable greater microscopic mechanical interlocking to occur into set amalgam compared to newly condensed amalgam, this result agree with Miller et al 1992 [16].

In group I and II the mean SBS values of Syntac SC and Excite bonding agents were higher to newly condensed amalgam than set amalgam (except for syntac SC at 48 hr, the SBS to set amalgam were higher than that to newly condensed amalgam) this disagree with Fruits et al [17], who suggest that the resin composite should be added after the amalgam has had adequate time to set.

The Syntac SC maintain high rate of cohesive failure with little deterioration of SBS values. While the Excite maintain high rate of adhesive failure with high deterioration of SBS values and both bonding agents exhibited a gradual increase in mixed mode of failure. These results can be explained by the postulated mechanism of interaction with water either washing away or hydrolysis of bonding agent.

In-group III the mode of bond failure confined to be either adhesive or cohesive modes without mixed mode (because there's no bonding agent in this group). So in this group composite – amalgam failure type maintain mainly adhesive mode o f failure also some decrease of cohesive mode of failure with passing of time this can explained by effect of water storage on composite resin by passing of time by affecting the post curing polymerization. There's complete cohesive failure in amalgam bases in subgroup S1, (48 hrs) this is

concomitant with the high mean SBS values for this subgroup.

References:

1.Sturdevant CM: The art and Science of operative dentistry. 2nd ed, 1985; Chapter 9: 11 PP 213-311.

2.Craig RG: Restorative dental materials.7th ed, C V Mosby Co 1989; Chapter 9: PP 214-247.

3.Cardash HS, Bichacho N, Imber S, Liberman R: A Combined amalgam and composite resin restoration. Fixed prosthodontics and operative dentistry 1990; 63:502-505.

4.R Pilo, T Brosh, E Shapinko, H dodiuk: Long term durability of adhesive system bonded to fresh amalgam. J Prosth Dent 1996; 76(4): 431-436.

5.Hadavi F, Hey JH, Ambrose ER: Shear bond strength of composite resin to amalgam an experiment in vitro using different bonding systems. Oper Dent 1991; 16:2-5.

6.Zalkind M, Rehany R, Revah A, Stern N: A composite resin bonded to dental materials. J Prosth Dent 1981; 46:300 –330.

7.Ghulaam MK, AL- Rawi I: In vitro study of reinforcement of undermined cusps with composite resin in amalgam restorations. 2002 (M.Sc. Thesis collage of dentistry, Baghdad University).

8.Personal Communication with Vivadent ,Ets ,Liechnisteinsu , 1998.

9.Belcher MA, Stewart GP: Two years clinical evaluation of an amalgam adhesive. J Am Dent Assoc 1997; 128: 309-314.

10.Pilo R, Brosh T, Shapinko E, DodiukH: Long term durability of adhesive system bonded to fresh amalgam. J Prosth Dent 1996; 76(4): 431-436.

11.Franchi M, Trisi P, Montanri G, Piattelli A: Composite resin amalgam compound restoration. Quintessence Int. 1994; 25(8): 577-82. (Abstract).

12.Bichacho N, Pilo R, Brosh T, Berkovich M, Helft M: Shear bond strength of composite resin to fresh amalgam. Oper Dent 1995; 20(2): 68-73. (Abstract).

13.Ruse ND, Sekimoto RT, Feduik D: The effect of amalgam surface preparation on the shear bond strength between composite and amalgam. Oper Dent 1995; 20(5): 180-185.

14.El –Hejazi AA: Water sorption and solubility of hybrid and micro fine resin composite filling materials. Saudi Dent journal 2001; 13(3): 139–142.

15.Diaz Arnold AM, Arnold AM, Williams VD: Measurements of water sorption by resin composite adhesive with near infrared spectroscopy. Cited by Pilo et al , J Prosth Dent 1996; 76(4) :431-436.

16.Miller BH, Arita K, Tamura N, Nishimo M, Guo I, Okabe T: Bond strength of various materials to dentin using amalgam bond. Am J Dent 1992; 5: 272-276.

17.Fruits TJ, Duncanson MG, Coury TL: Interfacial bond strengths of amalgam bonded to amalgam and resin composite bonded to amalgam. Quintessence Int 1998; 29(s): 327-334.