The effect of amalgam condensation techniques on the tensile bond strength using different dentin adhesives (in vitro study)

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ABSTRACT

Background: The purpose of this in vitro study was to assess the effect of the condensation techniques of the amalgam on the tensile bond strength of the amalgam to dentin.

Materials and Methods: The occlusal enamel surfaces of the teeth were ground flat to exposed the dentin surfaces, and polished with 600-grit SiC papers. The dentin surfaces were treated with one of the combinations of dentin bonding agents and condensation techniques. The tensile bond strengths were determined with a Zwick Universal Testing Machine.

Results: Statistical analysis of the result revealed that for the Scotchbond Multi-Purpose adhesive and the control groups, hand condensation was better and the difference was highly significant ($p<0.01$) while for the Syntac single-component adhesive group , the mechanical condensation performed better and the difference was highly significant ($p < 0.01$) . For both types of condensation techniques, the Syntac single-component showed higher tensile bond strength values than that of both Scotchbond Multi-Purpose and control groups ($p < 0.01$) . The Scotchbond Multi-Purpose showed higher tensile bond strength values than that on the control groups and the difference was highly significant ($p<0.01$).

Conclusions: For both types of condensation techniques, Syntac single-component performed the best in bonding the amalgam to dentin. The two types of condensation techniques had different effect on the tensile bond strengths of the amalgam to dentin using the dentin bonding agents.

Keywords: Amalgam, tensile bond, dentin. (J Bagh Coll Dentistry 2009; 21(1):33-37)

INTRODUCTION

Although silver amalgam is the only self-sealing restorative material [(1),] until recently it was not bondable. The concept and indications for bonded amalgam were proposed by several authors [(2-4)] Advantages of bond amalgams over their unbonded counterparts are: increased fracture resistance of restored teeth [(5),] reduced marginal microleakage [(6),] and decreased or eliminated postoperative sensitivity [(7)].

Proper amalgam condensation is essential to obtain optimal physical properties of the amalgam restoration [(8)] with high-copper spherical amalgam, a vertical and lateral condensation with vibration is recommended [(9).] This step of amalgam condensation can be produced with either hand or mechanical condensation.

For hand condensation, when a given force is applied, the smaller the condenser is the greater is the pressure exerted on the amalgam [(8)]. If the condenser tip is too large, the operator can not generate sufficient pressure to adequately condense the amalgam and force it into retentive areas [(9).]

The procedure and principles of mechanical condensation are the same as those for hand condensation, including the need to use small amalgam increments [(10).] The only difference is that mechanical condensation is done by an automatic device.

One advantage of mechanical condensation is the capability of applying a consistent force. This prevents lamination of amalgam, as successive increments are condensed by forcing excess mercury to the surface [(10)]. Different condensation techniques may affect tensile strength of amalgam bonded with adhesive resins.

MATERIALS AND METHODS

Samples preparation.. Sixty freshly extracted intact human lower premolars were utilized in this study. Immediately after extraction, the teeth were placed in distilled water at room temperature throughout the experiment. Then the teeth were embedded in auto-polymerized methylmethacrylate. The crowns and 1.0 mm of the roots below the cemento-enamel junctions were left exposed. The occlusal enamel surfaces were ground with diamond cutting discs using low-speed handpiece to expose flat peripheral dentin surfaces and each disc was changed after being used for 15 specimens. The occlusal surfaces were ground with fine stone disc using lathe with water cooling system to remove any remnant enamel until exposing the peripheral dentin surfaces.

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The teeth were wet-polished with 600-grit silicone carbide abrasive papers manually to create a uniform smear layer. Specimens were stored in distilled water at room temperature for 48 hours before bonding to prevent dentin dehydration.

After that, the coronal diameter of each specimen was measured by a measure in ribbon, and the radius of each specimen was calculated to find the interfaced surface area in square millimeters (mm^2).

Sample Grouping. The dentin bonding systems were used:

1. A dual-cure Scotchbond Multi-Purpose system "4th generation".
2. A light-cure Syntac "single-component, multi-use" system "5th generation".

All specimens were randomly assigned to six groups of ten each to receive one of the following treatment combinations:

Group 1) Scotchbond Multi-Purpose and hand condensation.

Group 2) Scotchbond Multi-Purpose and mechanical condensation.

Group 3) Syntac and hand condensation.

Group 4) Syntac and mechanical condensation.

Group 5) without bonding agent and hand condensation (control).

Group 6) without bonding agent and mechanical condensation (control).

The Adhesives Application. Before dentin conditioning, the dentin surface was repolished with 600-grit SiC paper to produce a fresh smear layer, rinsed and gently air dried. Dentin bonding agents were used according to the manufacture's instructions.

For the Scotchbond Multi-Purpose, the Scotchbond etchant (35% phosphoric acid) was applied to enamel and dentin, waiting for 15 seconds, then rinsed for 15 seconds and dried for 2 seconds. Copper bands of different sizes according to the different diameters of the specimens were then attached to each specimen and of 6.0 mm height and coated with vaseline from the inner sides for easy removal after amalgam hardening. The copper bands were tightly fitted to the outer surfaces of the teeth without any displacement. After that, Scotchbond Multi-Purpose primer was applied to all etched surfaces using brush and dried gently for 5 seconds. Scotchbond Multi-Purpose adhesive was applied as one drop on each primed surface and light-cured with a visible light-cure unit of 400 MW/Cm^2 for 10 seconds.

High-copper spherical amalgam capsules were triturated for 5 seconds with a mechanical amalgamator. The amalgam was carried with an amalgam carrier and condensed into the mold. Each specimen received one capsule.

For the Syntac, acid etchant (35% phosphoric acid) was applied by brush to enamel and dentin, waiting for 15 seconds, then rinsed for 15 seconds and dried for seconds.

Syntac "single-component" (primer and adhesive in one bottle) was applied to all etched surfaces as first layer and air blown to a thin layer for 2 seconds and light-cured for 10 seconds. The copper bands then were attached to the specimens. A second layer of Syntac then was applied with the brush and again air blown to a thin layer for 2 seconds and light-cured for 10 seconds. The same type of amalgam was used and condensed into the mold.

Amalgam Condensation. The condensation techniques used were:

1. Hand condensation using a modified single-end amalgam condenser of 2.5 mm diameter serrated condensation face. This condenser was sectioned with diamond cutting disc using high-speed handpiece with water cooling system and the shaft was drilled to receive a spring that withstands 3.0 Kg. Pressure load and the other part of the condenser "i.e. the shank and the condensing tip" was slided in this hollow within soldered cylinder . The spring was soldered to the shank so that when the exact pressure that corresponded to 3.0 Kg. was exerted, a contact occurred between two projections; one attached to the shaft and the other attached to the movable sliding shank and condensing point. This modification was done to have a standardized hand condensation pressure during the condensation of the amalgam. The condensation was started from the center of the amalgam mass toward its peripheries. The condensation frequency after each increment of amalgam was 8 thrusts for 5 seconds, and the filling of the amalgam cylinderical mold took 3 minutes. After that, the amalgam was condensed for 15 seconds with 20 thrusts.
2. Mechanical condensation using mechanical condenser point that was adapted to an ultra-sound handpiece that was connected to an ultra-sound generator of 25000-32000 H_z straight-line oscillations per second. The condensing tip was of 2.5 mm diameter and the condensing pressure was of 3.0 Kg. Each increment of amalgam was condensed from its center toward its periphery for 5 seconds, and took 3 minutes to fill the mold with amalgam. After that, the amalgam was condensed for 15 seconds. Then, the amalgam were carefully carved and burnished with amalgam carver and burnisher. The mechanically-condensed amalgams were burnished with mechanical burnisher tip.

Fifteen minutes after condensation, the copper bands were carefully dislodged and removed.

Samples Testing. After storage in distilled water at room temperature for 48 hours, the specimens were tested for tensile bond strengths between amalgam cylinders and dentin using a Zwick Universal Testing Machine with a loop attached to amalgam at cross head speed of 5 mm/minute until the amalgam separated from the tooth under the vertical retraction that was exerted on the bulk of the amalgam cylinders. The failure loads were in kilogram and transferred into Newtons by multiplying the value by 9.8 and divided it into the corresponding interface surface area in (mm^2) to get the tensile bond strengths in Mega Pascal (Mpa).

RESULTS

Tensile Bond Strength Values. The mean values and the standard deviations of the tensile bond strength (TBS) of each group are presented in table 1. By using the student-test for the Scotchbond Multi-Purpose group; the SBS mean value of hand condensation of amalgam was higher than that of mechanical condensation and the difference was highly significant (p<0.01).

For the Syntac group, there was highly significant difference (p<0.01) also while the mechanical condensation had higher TBS mean value compared with hand condensation.

For the control group, hand condensation exhibited higher TBS mean value than mechanical condensation and the difference was highly significant (p<0.01).

Table 1: student t-test for comparison between two types of condensation techniques for each group of dentin treatment

Groups	Hand ondensation			Mechanical condensation			(t-test)
	Statistics			Statistics			
	M	SD	V%	M	SD	CV%	
I+H (Scotchbond)	2.69	0.24	8.92	2.31	0.26	11.34	H.S. (3.36)
III+IV (syntec)	6.58	0.421	6.39	9.22	1.64	17.81	H.S. (-4.92)
V+VI (control)	0.59	0.28	48.25	0.27	0.112	40.3	H.S. (4.22)

For both condensation techniques and by using One-Way ANOVA test and the Least Significant Difference (LSD) test, there was highly significant difference between the adhesives used and the control group and also between the two dentin bonding agents used. The Syntac showed a greater TBS mean value than the Scotchbond Multi-Purpose and the control groups. Also, the Scotchbond Multi-Purpose had significantly higher TBS mean value than the control group (p<0.01).

Effect of condensation techniques. Under the circumstances of this study, there was no significant difference in tensile bond strengths between the two types of condensation techniques for all the groups together. This result is in agreement with that of Ratananakin et a1[11]. This may be attributed to the relatively similar conditions between the two types of condensation techniques (i.e. similar diameter of the condensing face, similar pressure load, and similar amalgam condensation method although there is difference in the frequency of the condensation thrusts).

However, the mechanical condensation had higher average of tensile bond strength although the difference was not significant. This result coincides with that of chapman & Crim [12] who found that the mechanical condensation had better bonding and adaptability than that of hand condensation using spherical type of amalgam. This may be attributed to the findings which stated that with spherical alloy, vibratory type of condensation with ultra-sound devices performed better than other techniques of condensation. In addition, there are evidences which indicate that mechanical condensation is superior to hand condensation in terms of fulfilling the objectives of condensation [10]. One of these objectives is the intimate bond of the amalgam to tooth structure [13].

For each type of dentin bonding treatment and the controls, the results were completely different and there was highly significant difference between the two types of condensation techniques affecting the bonding of amalgam to dentin. Both the Scotchbond Multi-Purpose and the control groups, showed better performance of the hand condensation while for the Syntac group, the mechanical condensation performed better than hand condensation. These results disagree with that of Ratananakin et a1[11] . These findings may be attributed primarily to the modality of the dentin treatment with or without bonding agents and the different types of amalgam adhesives used. This attribution is due to the fact that there was on significant difference between both types of condensation techniques at all groups together but the difference appeared at each dentin treatment group separately from the others.

Scotchbond Multi-Purpose adhesive and / or primer does not contain in its chemical composition 4-META co-monomer, so there will be no chemical union between the adhesive resin and the amalgam. Therefore, the expected bond mechanism for such adhesive to amalgam is micro-mechanical type that depends on the film thickness of the adhesive. Hand condensation effect may be more obvious than the mechanical condensation under these circumstances. Similarly, for the control groups, there was no bonding mechanism between the amalgam and dentin just the micro-mechanical adaptation enhanced by heavy hand condensation. This attribution is supported by the classic studies and recent reports about the hand condensation effects and the bonding mechanism of recent dentin bonding agents to amalgam [14]. Sweeney[15], Jorgensen[16], and Mjor[17] contributed to such researches. Some of them found that the hand condensation performed better in reducing porosities at amalgam / dentin interface and it had better adaptability. Others reported that there were some kinds of mechanical interlocking between amalgam particles and dentin irregularities even that the self-sealing criteria of amalgam was not started yet .

The Syntac adhesive / primer has 4-META and HEMA co-monomers that may bond the amalgam chemically and micro-mechanically. This “real” bonding may show the obvious effect of mechanical condensation to enhance the bonding of amalgam to dentin. This explanation is supported by the findings of Chapman & Crim[12], which had already mentioned.

The Use of Dentin Bonding Agents. For both types of condensation techniques and under the conditions of this study, there was highly significant difference between the different types of adhesives used on the one hand, and between the groups with the bonding treatment and that without bonding treatment (controls) on the other. These results are in agreement with several studies. Zardiackas & Stoner[2], Shimizu et a1[3], and Varga et a1[4] showed that the bonding of amalgam to tooth structure was possible under laboratory conditions with higher over the unbonded one .

In addition, numerous clinical studies had reported favorable results, which were obtained when using amalgam bonding approach. Those studies were done by Summitt et a1[18], Setcos et a1[19], and Belcher & Stewart[35]. These results support the finding obtained by this about the bonding of amalgam to dentin by using dentin adhesive systems and with higher TBS than that of the controls.

The differences in the bond strengths different generations of dentin binding agents have been shown in various studies.

Under the circumstances of this study, the Syntac adhesive showed higher TBS to dentin than the Scotchbond Multi-Purpose. This finding is in agreement with that of Retief et a1[14], although the TBS values were higher than those of this study. However, Chappell & Eick[22] and Holtan et a1[23] found that the Scotchbond Multi-Purpose had significantly better bond strength between the amalgam and dentin than the Syntac and Scotchbond Multi-Purpose may be due to the different chemistries of these bonding systems , although some similarities do exist. The similarity found in the pretreatment procedure in using the same chemical composition etchants 9355 phosphoric acid). The Scotchbond Multi-Purpose primer contains HEMA and polyalkenoata co-polymer and the adhesive contains BIS-GMA and HEMA[14]. The Syntac-one bottle-contains 4-META and HEMA[24]. Examinations with an electron microscope have shown that the hydrophilic monomers connect with both organic dental hard tissue by forming ion complexes with calcium ions of enamel and dentin and hydrogen bridges with collagen fibers of dentin[25] . This complicated connection may be the reason for such higher TBS values obtained in this study over the Scotchbond Multi-Purpose.

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