ORIGINAL ARTICLE

# Evaluation of the Integrity of Amalgam-Composite Interface with Two Resin Based Intermediate Materials

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**ABSTRACT:**

**Objective:** To evaluate the effect of intermediate materials at Amalgam-Composite interface.

**Methodology:** This *in-vitro* study was conducted at IRCM COMSATS Lahore**.**100 High copper-Spherical amalgam (Aristalloy) specimen were stored in deionized water for two weeks. They were randomly assigned to one of the following groups after being polished. Control Group comprised of fifty bars of Amalgam bonded to Hybrid composite(SolareXGC) with Amalgam bonding agent (Framingdale NY-USA). Experimental group comprised fifty bars of Amalgam bonded to composite with resin modified glass ionomer cement (GC Fuji).The shear bond strengths were tested using the Universal testing machine at acrosshead speed of 0.5mm/min.

All the collected data was entered in SPSS version 19.0. ANOVA was used to determine the mean SBS (Shear Bond strength) values of control and experimental groups**.**

**Results**: On comparison, there was no significant difference in the bond strength of Amalgam-Composite interface with Amalgam Bonding Agent and Resin Modified glass Ionomer cement.

**Conclusion:** There is less significant effect of type of the adhesive on interfacial integrity, rather it is based more on the adhesive's thickness, method of application and other manipulative variables.

**Keywords:** Amalgam, Composite, Interface, Shear Bond strength, Resin Modified Glass ionomer Cement, Amalgam Bonding agent.

## INTRODUCTION:

Dental amalgam is known as the reliable and durable restorative material for more than a century.[1]Good mechanical properties, wear resistance, sealing ability, ease of handling and cost effectiveness,[2] make it an important part of dental care plan in the developing nations where there is a lack of funded health policy for dental diseases.[2,3]

The grey or the metallic color of restoration gives unaesthetic look to the tooth. The other reasons behind replacement of Amalgam restorations include; secondary carries, marginal fracture, wear, and loss of anatomic contours.[4,5] These factors may be compounded by the presence of undermined enamel.[6] Therefore total replacement of defective and unaesthetic amalgam restorations represents a major part of restorative treatment. Dentistry's attempts to compensate these issues are the development of composite resins and bonding agents.[7,8]

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Composite resin provides an esthetic alternative to the dental amalgam. Its adhesion to the tooth structure is facilitated by dentine bonding agent which forms an effective bond at the tooth-composite interface and strengthens tooth structure by minimal intervention during placement.[2] With a variety of shades, translucencies, effects, opacities, and innovative placement techniques, today's composites allow simple reproduction of dynamic properties of natural dentition.[9] Concerns of bonding breakdown due to polymerization shrinkage and low strength in large restoration, still favor the placement of dental amalgam.[10] Bonding agents originally developed for composites only, are now being formulated to improve the bond strength at the tooth-amalgam interface. Reduction of microleakage is another benefit. The reason is their adherence with hydrophobic amalgam and the hydrophilic enamel of tooth. Their sealing ability reduces secondary caries, staining and sensitivity.[3,7] Various generations of bonding agents are available.[11] Combined amalgam composite or "Amalcomp" could be a solution to the problems related with both materials. The blend of esthetics of the composite with good mechanical properties of amalgam improves microleakage at the interface. Better marginal adaptation results due to sealing by an intermediate material. Composite reinforcement of the weakened tooth increases fracture resistance due to minimal invasion.[2] This is an alternative option for treatment of defective and old amalgam restorations. Repair involves removal of defective tissue adjacent to the defective area and restoration of the prepared site. This procedure allows preservation of sound tooth structure and allows only minimal intervention. Multiple factors influence Bond strength values such as type and age of tooth, mineralized content of dentin, and type of test and storage media.[5,12] Amalgam bonding systems and resin modified glass ionomer are used to bond amalgam to the composites.

They form a micromechanical bond between amalgam and composite resin. They are composed principally of 4-META (4-Methacryloxytrimellitic Anhydride) like other dental adhesives, but with additional Poly-methyl-methacrylate (PMMA).[2,7]

Resin modified glass ionomer is applied as a thin intermediate layer between the two materials.[7] It serves multipurpose functions; to mask the restoration by opacifying amalgam background,[13] it provides adhesion between amalgam and composite and, also prevents microleakage.[14]

If the existing amalgam is repaired, it will also save time taken otherwise to remove the restoration, and cost of complete resin restoration.[15,16] Bond strength values are determined by tensile analysis and shear analysis. Shear Mode of analysis can detect local bonding conditions and provide accurate results.[17] Less shaping of the specimen reduces risk of early failure and high coefficient of variation.[18] The durability of bond strength between composite resin and amalgam is still controversial and little is known about it.[7] Therefor, there is a need for further studies to be conducted to elaborate this subject.

**METHODOLOGY:**

This *in-vitro* study was conducted at IRCM COMSATS Lahore. 100 specimens were taken, which were divided into 2 groups. Group A (Control group) Amalgam bonding agent and Group B (Experimental group) Resin modified glass (low).

**Preparation of Amalgam-Composite samples:**

Specimens consisting of amalgam and resin composite bars with a thin layer of intermediary material between them were fabricated as follows:

100 bar samples of High copper spherical Amalgam Alloy-31% copper (Aristalloy, cookson Birmingham, UK) were prepared using PTFE split (Poly tetra Flouro-ethylene) molds (fig-1.1). Pre-proportioned Amalgam capsules were triturated in an SDS Kerr 4000 amalgamator (Kerr Hawe) according to the manufacturer's instructions and condensed into the mold space (2x4x2) to serve as matrix. In all the samples, amalgam was condensed using a serrated round condenser with a diameter of 1mm by a single operator to ensure standardization. The alloy samples were allowed to set for 30 minutes prior to mold removal.

In control group, surfaces of amalgam samples were treated with amalgam bonding agent (Parkell, Farmingdale, New York). All samples were etched with 37% Phosphoric acid and rinsed with air water syringe and air dried after 15 seconds. Amalgam Bonding agent was then light cured through the mold for 20 seconds with a 500mw/cm.$^2$ output hand-held curing light (Belle glass, Orange, CA, USA). Surfaces of the samples in experimental group were treated with Resin modified glass ionomer cement (luting-GC Fuji Corporation.). Manufacturer's instructions were followed accordingly. Finally the samples were Photo activated for 20 seconds with a curing lamp.

The samples (fig-1.2) were allowed to set for 24 hours at room temperature and then subsequently abraded with 400 grit Silicon Carbide burrs to eliminate possible contaminants and cause surface roughness for the retention of the adhesive systems. All specimens were then air dried for 24 hours and subsequently stored in deionized water for 1 week at 37$^o$C in drying oven (WiseVen WOF-15509525003). Fractured, broken or samples with varied dimension were excluded from the study. They were divided randomly into control and experimental groups.

The amalgam-composite slabs were stored in deionized water for one week to simulate aging, prior to their assembling on PMMA Base. PMMA (Poly-methyl-methacrylate) l discs were prepared manually with a recess of 4x4x4 in the center for fixation of amalgam-resin samples. The whole assembly was allowed to polymerize sufficiently at room temperature for 24 hours.

**Shear Bond Strength Testing:** The samples were examined under digital microscope (Optika-B-600 MET) at 50X magnification with digital camera (Optikam-PRO 5-Model-4083.12 LT) to ensure the inclusion criteria (Fig-2.2). The specimens were checked for the presence of cracks, asperities and interfacial gaps to avoid pre-test failures.

The sample Assembly (fig-2.1) was locked in a fixture attached to the compression load cell of an Instron testing machine (fig-2.3: Instron Corp, Canton MA, USA, Model, 1195) with 1KN load cell moving at a cross head speed of 0.5mm/min until fracture. Magnifying glass was used before the application of load to determine the focus of load cell on the interface. The shear forces were recorded in MPa and were obtained directly from Instron computer software.

**RESULTS:**

Table-2 shows the descriptive analysis and comparison of control and experimental group. Using ANOVA (table-3), it was also concluded that there was no statistical difference in the mean of all four study groups (p-value = 0.971).

The mean SBS (Shear Bond Strength) value in Amalgam-composite samples with ABA as an intermediate material (Control group) was 3.02 ± 0.84 whereas, in Amalgam-Composite samples with RMGIC as an intermediate material (Experimental group) the mean SBS was 2.93 ± 0.

Table: 1
Intraoral adhesive systems used in the study

| Material | Material Description | Composition | Manufacturer |
|---|---|---|---|
| Control group Amalgam bond plus (ABA) | Light cured etch and rinse system | 4-META(4-Methacryloxyethyl trimellitic Anhydride), Bisphenoldimethacrylate, HEMA(hydroxyethyl Methacrylate, tri-ethylene glycol methacry late, silver filler | Parkellfarmingdale, NY.USA |
| Experimental group RMGIC | Light cure | Flouroaluminosilicate glass and poly-acid modified liquid with HEMA and water | Luting-GC Fuji |

Table: 2
Descriptive analysis and comparison of SBS in Control (Amalgam bonding agent) and Experimental groups (Resin modified glass)

| | Amalgam bonding agent Control group | Resin modified glass ionomer Experimental group |
|---|---|---|
| N | 25 | 25 |
| Mean | 3.02 | 2.93 |
| Std. Deviation | 0.84 | 0.65 |
| Std. Error | 0.17 | 0.13 |
| 95% C.I for Lower | 2.67 | 2.67 |
| Mean Upper | 3.37 | 3.20 |
| Minimum | 1.40 | 1.60 |
| Maximum | 4.40 | 4.30 |

Table: 3
ANOVA

| | Sum of Squares | Df | Mean Square | F | P-value |
|---|---|---|---|---|---|
| Between Groups | 0.143 | 3 | 0.048 | 0.079 | 0.971 |

Figure: 1.1
PTFE Mold used for specimen preparations

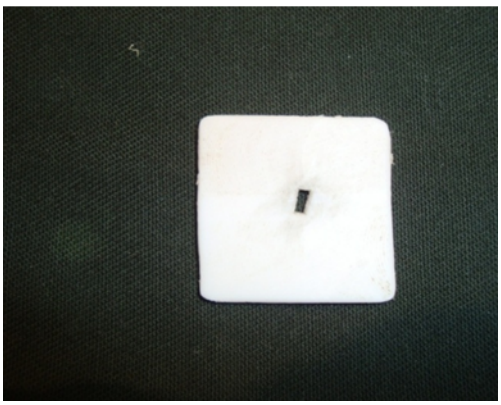

Figure: 1.2
Amalgam composite samples

Figure: 2.1
Amalgam-Composite Specimen

Figure: 2.2
Microscopic image of Amalgam-composite interface
Mounted on the PMMA Base

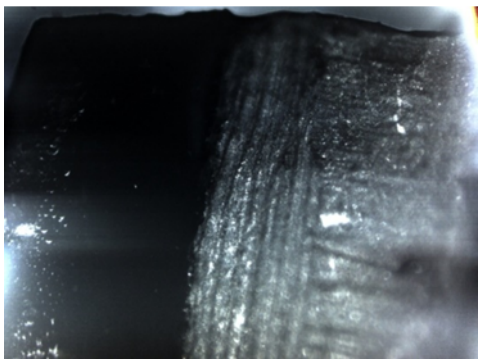

Figure: 2.3
Sample Assembly fixed in Instron
(Universal Testing Machine)

**DISCUSSION:**

Suggested techniques used for amalgam repair or veneering are based on mechanical or chemical procedures. Mechanical techniques include roughening the amalgam with undercuts and grooves through burrs. Chemical techniques include use of multipurpose adhesives.[14,20,21]

The present study was based on the concept of reinforced Amalcomp restorations by using adhesive/intermediate material. Adhesives are used due to their ability to bond porcelain, resin composite, alloy and amalgam to enamel and dentin. Further, they have been used in the similar studies on amalgam bonding.[19, 20] They seal dentin and reduce microleakage and consequently the pulpal sensitivity. That is why they are known to increase interfacial bond strength in combined amalgam-composite restorations.[22]

Enhanced bond strength values demonstrate good interfacial integrity, along with reduction in marginal leakage and associated issues like sensitivity, pulpal changes and the development of secondary caries , the most common reason for failure of amalgam restorations.[23,24]

The ultimate objective of determination of bonding capacity is the prognosis of deterioration of the interfacial bond with time as function of environmental conditions.[25] Mode of bond strength testing has few limitations as shear stress is not evenly distributed and focused on true interface.[26, 27] But less aggressive specimen preparations reduces the risk of early failure and high coefficient of variation therefore shear analysis is usually preferrred.[18]

Adhesives used in the current study included Amalgam bonding agent and Resin Modified Glass ionomer cement (RMGIC). The choice of these materials was based on the fact that they perform well in terms of interfacial strength. Amalgam bonding agent is recommended by the manufacturer for critical situations, where mechanical retention is deficient and additional bonding is required. The powder consists of Poly-methyl-methacrylate fibers, which improve bond strength through mechanical union between amalgam and the composite.[28, 29]

Evidences have been reported by the studies that adhesives with 4-META and PMMA powder produced significantly higher Shear bond strength.[19,21,30,31] But still the existence of true chemical bond is controversial and bond strength studies have contradictory results.[1,14,32]

The other adhesive used in this study was RMGIC. The

choice of material was based on the demonstrated use of certain glass ionomer formulations as an adhesive with amalgam.[23,33] Available data suggested 4-META/HEMA based bonding agents.[23,33,34] could be beneficial for composite veneering of amalgam, if preceded by intermediates like adhesives or RMGIC.[21] RMGIC as a liner reinforces the interface of amalgam and composite.[35] It has been observed as an effective esthetic material and adhesive than resin bonding systems for combined restorations.[22,36]

It has been suggested that glass ionomer during its initial reaction phase adheres chemically to the base metals, especially silver and tin. This ensures marginal sealing and reduced marginal leakage in the clinical cases.[35] The basis of selection of RMGIC in this study[37] was its association with increase in fracture resistance of teeth with combined restorations.[38,39,40] Mechanically RMGIC showed substantial plastic deformation in compression, due to its polymeric nature overcoming the shortcomings of crazing on dehydration, brittleness and low fracture resistance in conventional GIC.[37]

One limitation of this veneering technique was the production of an additional amalgam-composite interface apart from the tooth amalgam-interface, because there was no chemical interaction between the two. RMGIC filled the interface with a compatible material.[2,13,41] The mean values of Shear Bond Strength in control group (Amalgam bonding agent) and experimental group (RMGIC) showed no statistical difference between the two groups. The reason could be the variation in the mechanical properties of the luting agent (RMGIC) and shorter storage time of samples which resulted in lack of complete curing of the samples and affected mechanical strength.[37]

Additionally, presence of HEMA in RMGIC although improved bonding, but it could cause cross-linking of polyacid chains too far apart, which effected the integrity of material.[37] Therefore manipulative variables have been proved to have more detrimental effect on SBS values than the chemistry only.

## CONCLUSION:

Adhesive bonding at Amalgam-composite depended more on manipulative variables. They included factors based on adhesive's manipulation, which encompassed water-powder ratio (RMGIC), thickness of adhesive and mode of curing; and factors based on the bonding substrates, which comprised sample geometry, dimensions, preparation methods, surface abrasion and duration of aging. Storage in water caused hydrophilic degradation of the interface while short term aging just gave the baseline values.

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