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PENETRATION OF AMALGAM CORRODED PRODUCTS INTO DENTIN AND ITS EFFECT ON BONDING USING SELF ETCH ADHESIVE SYSTEM VERSUS RESIN MODIFIED GLASS IONOMER

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ABSTRACT

Introduction: amalgam replacement by tooth-colored restorations has become a common procedure nowadays. Aim: this study was carried out to detect the effect of Penetration of amalgam corroded products into dentin on bonding of both self etch adhesives and resin modified glass ionomer (RMGI). Materials & method: 40 simple occlusal cavities were made in human extracted molars. Cavities were filled with amalgam, stored for one year then amalgam was removed and teeth were divided into two main groups (20 teeth each); group A; where amalgam was without any further increase in cavity depth. Group B; where amalgam was totally removed followed by further increase in cavity depth by 0.5 mm. each group was re divided according to the restorative material used to replace amalgam where group 1: resin composite with self etch adhesive, group 2: RMGI. Teeth were sliced and the interface was examined by scanning electron microscope coupled with EDAX. Results: amalgam remnants appeared at the interface of group A to interfere with bonding while it disappeared from the interface at group B. conclusion: increasing depth of the cavity by 0.5 mm after amalgam removal showed a more reliable interface for the subsequent tooth colored restoration.

INTRODUCTION

Since introduction of amalgam in the nineteenth century it has been used widely used worldwide and until now it has been the material of choice in many countries, this is partly due to patient preferences, availability of technology or cost. Like all other dental restorations amalgam restorations may also need to be repaired or replaced during the whole course of the restorative cycle. The main cause of failure of amalgam restoration is secondary caries, fracture and marginal deficiencies, depending on the size of the defect, it could be repaired but in many cases they still need to be replace (Major et al 2002, Nakjima et al 2000, Pereira et al 2006).

While material properties of resin composite for stress bearing areas of the oral cavity have improved, patients also became more demanding for esthetics. In contrast to amalgam, resin composite restoration

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can be adhesively bonded to enamel and dentin with the use of appropriate bonding systems. Accordingly, less invasive cavity designs are indicated for resin restoration. Moreover, other types of tooth colored restorative materials such as glass ionomer, resin modified glass ionomer and compomers have their own short comings such as inadequate wear characteristics and low fracture toughness. Thus they could not be substitute to resin composite restorations especially for restoration of posterior teeth, but still resin modified glass ionomer could be used as a base under resin composite restoration (Fusayma et al 1966, Ben-Amar et al 1995).

Continuous development in the field of adhesive resins has yielded in different types of simplified adhesives to meet the demand for more user-friendly adhesive techniques. The combination of primer and adhesive resin to one product still requires the application of several layers of adhesive resin but the number of bottles is reduced. In two step-self etch system, the acid conditioning and priming steps are combined. In such adhesive systems, the acidic primer dissolves smear layer and demineralizes superficial dentin, meanwhile, penetrating into dentin. After evaporation of solvents, the adhesive resin is applied onto the primed dentin that diffuses into the liquid priming without a rinsing step. The ultimate and most recent self-etch system, also called all-in-one adhesive, combining the conditioning, priming and bonding phases only in one step. At present, adhesives resins based on acidic functional monomers, such as 10-methacryloxy decyl dihydrogen phosphate (10MDP), carboxylic groups and copolymers are capable of chemical interaction with the mineral component of dentin. Most adhesion studies on dentin have been performed on sound or caries affected dentin. In case of replacement of restorations the underlying dentin exhibits a variety of micro-structural changes and considered as heterogeneous tissue, due to the penetration of corroded products into dentinal walls that will affect the adhesion of resin composite (Jensen et al 1982, Hals et al 1988).

Glass ionomer possess several beneficial properties, including physic-chemical adhesion to tooth structure and release of fluoride ions (Walls 1986). Glass ionomer have gained acceptance as liners, luting agents and core material, but their use as a restorative material has been less common (Reinhardt 1993). Compared with resin composite, the glass ionomer are relatively unesthetic and have poor physical properties, including low flexural strength and fracture toughness. Furthermore, they undergo a long and complex setting reaction and are easily damaged by excessive moisture and desiccation (Mount & Makinson 1991). In order to overcome these advantages, several manufacturers have recently developed resin modified glass ionomer restorative materials that are hybrid of conventional glass ionomer cements and visble light activated resin composite. They are more esthetic and less water sensitive than conventional glass ionomer, but they are still less esthetic and lower strength than resin composite. Several researches showed that resin modified glass ionomer have higher dentin bond strength than conventional glass ionomer (Burges & Burkett 1993).

Therefore, the objective of this study was to evaluate the influence stained dentin penetrated by corroded products on the formation of hybrid layer using self etch adhesive system with rein composite restorative material versus chemical bonding of rein modified glass ionomer.

MATERIALS AND METHOD

Materials:

Amalgam: Patterson® Admix Alloy Capsules - Patterson Dental Supply.

Adhesive: Adper Easy Bond Self-Etch Adhesive, 3M

Resin composite: 3M™ Filtek™ Z250 Universal Restorative.

Resin modified glass ionomer (RMGI): Photac™ Fil Quick Aplicap™ Light-Cured Glass Ionomer Restorative

Method:

- Teeth selection: 40 human sound molars extracted for periodontal reasons were selected and examined for cracks and flaws under steriomicroscope.
- Teeth preparation: simple occlusal cavities were made in each molar with a depth of 0.5 mm beyond the dentino-enamel junction. All cavities were filled with amalgam following the manufacturer instructions and the proper manipulation technique.
- Teeth storage: teeth were immersed in distilled water and stored in an incubator at 37°C for one year, were the distilled water was changed weekly.
- Teeth grouping: after storage teeth were divided into two main groups (20 teeth each); group A; where amalgam was removed by a high speed round bur till the last layer which was removed by a hand instrument without any further increase in cavity depth. Group B; where amalgam was totally removed by a high speed round bur followed by further increase in cavity depth by 0.5 mm using a high speed inverted cone bur.

Each group was sub divided into 2 groups (10 teeth each) according to the restorative material used in re-filling the cavities where:

- Group A1 cavities re-filled using self etch adhesive and resin composite.
- Group A2 cavities re-filled using RMGI
- Group B1 cavities re-filled using self etch adhesive and resin composite.
- Group B2 cavities re-filled using RMGI.
- Teeth examination: slicing of teeth was done using a microtome, slices were examined at the tooth-restoration interface using scanning electron microscope coupled with EDAX, results were calculated and images of the interface were taken.

RESULTS

The mean and standard deviation values were calculated for each group in each test. Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests. Data showed parametric (normal) distribution.

Independent sample t-test was used to compare between two groups in nonrelated samples.

The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

TABLE (1) The mean, standard deviation (SD) values of Silver of different groups.

Variables	Silver				
	Self-etch Composite		Glass ionmer		*p-value*
	Mean	SD	Mean	SD	
0.5mm removed	0.00 ^{aA}	0.00	0.00 ^{aA}	0.00	1ns
0.5mm remained	0.41 ^{bA}	0.38	1.69 ^{bB}	0.67	0.005*
p-value	**0.017***		**0.001***		

Superscripts with different small letters indicate statistically significance difference within the same column. Superscripts with different capital letters indicate statistically significance difference within the same row. *; significant (p≤ 0.05) ns; non-significant (p>0.05)

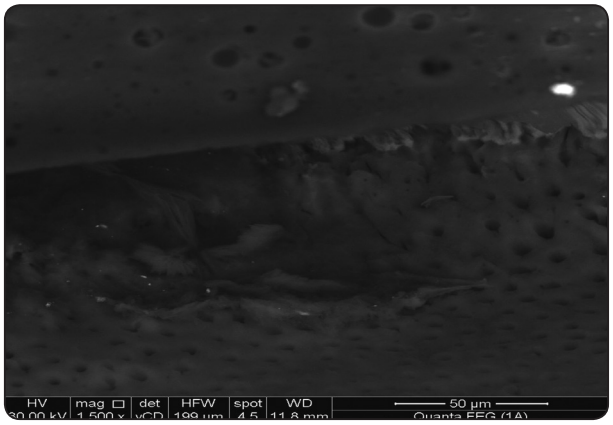

Image (1): Scanning electron microscope image after composite application using self etch adhesive where the previous amalgam is removed and the cavity depth is increased by 0.5 mm; showing uniform, almost gap free hybrid layer with traces of remaining amalgam debris.

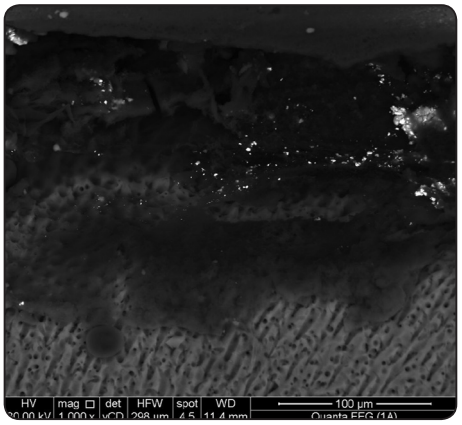

Image (2): scanning electron microscope image after composite application using self etch adhesive following the removal of amalgam without any further increase in cavity depth; showing a detached intermittent hybrid layer with more amalgam remnants that seem to interfere with adhesion.

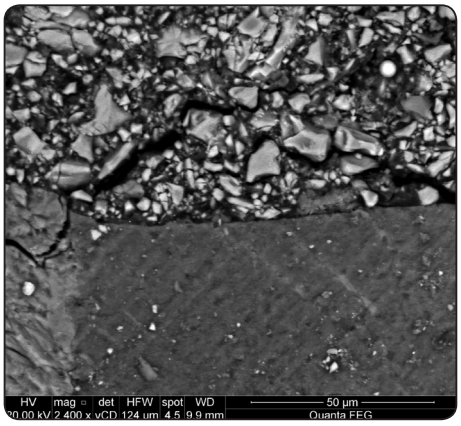

Image (3): scanning electron microscope image after RMGI application. The previous amalgam is removed and the cavity depth is increased by 0.5 mm; showing intact, almost gap free interface.

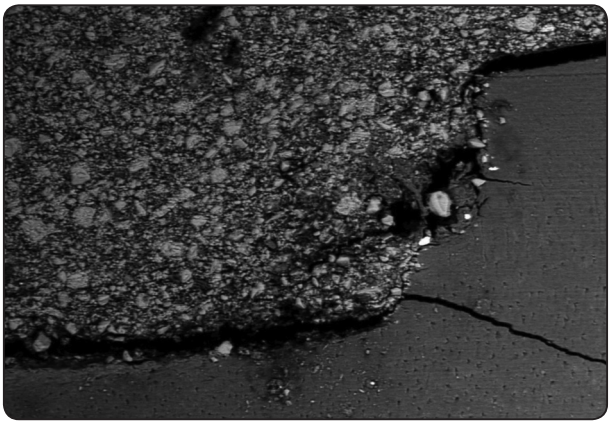

Image (4): scanning electron microscope image after RMGI application following the removal of amalgam without any further increase in cavity depth; showing an interfacial gap, yet more intact than composite applied without increase in cavity depth.

Silver results

Effect of presence and absence of last 0.5mm on adhesion within each Restorative material:

a) Self-etch Composite groups:

A statistically significant difference was found between (0.5mm removed) and (0.5 mm remained) groups where (p=0.017).

The highest mean value was found in (0.5 mm remained) (0.41 ± 0.38), the lowest mean value was found in (0.5mm removed) (0.00 ± 0.00).

b) Glass ionomer groups:

A statistically significant difference was found between (0.5mm removed) and (0.5 mm remained) groups where (p=0.001).

The highest mean value was found in (0.5 mm remained) (1.69 ± 0.67), the lowest mean value was found in (0.5mm removed) (0.00 ± 0.00).

Relation between restorative material in the presence and absence of last 0.5mm:

a) Removed last 0.5mm groups:

No statistically significant difference was found between (Self-etch

Composite) and (Glass ionomer) groups where (p=1).

Both groups showed no silver (0.00 ± 0.00).

b) Remained last 0.5mm groups:

A statistically significant difference was found between (Self-etch

Composite) and (Glass ionomer) groups where (p=0.005).

The highest mean value was found in (Glass ionomer) (1.69 ± 0.67), the lowest mean value was found in (Self-etch Composite) (0.41 ± 0.38). lowest mean value was found in (5mm removed) (0.00 ± 0.00).

DISCUSSION

The aim of this study was to compare one step self etch adhesive system in bonding to stained dentin through evaluation of the hybrid layer formed using scanning electron microscope, versus resin modified glass ionomer chemical bonding to stained dentin after removal of amalgam restoration.

Corrosion of amalgam is destructive phenomenon, which is not limited to the external surfaces, or amalgam-tooth interface where it is evident, but also affects the bulk of the restoration. Over a period of time corrosion progresses from interface toward the center of the restoration, reducing its hardness and affecting the matrix structure by molecular disintegration of Cu6Sn5 phase. Chloride ions in saliva, food constituents and drinks play an essential role in the corrosion process and the deposition of metallic ions. If amalgam is removed carefully during clinical procedures, at first a thin granular layer of corrosion products is exposed. This layer covers both enamel and dentin cavity walls and cannot be removed by etching with phosphoric acid gels. After removal of these corrosion products commonly stained dentin is found in the remaining dentin, which in many cases superficially softened (Scholtanus etal 2009).

Almost three decades ago, resin composite materials have been regarded as not suitable for restoration of posterior teeth, especially in cases of extensive loss of tooth structure. Main points of concern were wear, marginal integrity, and adhesion to dentin, radio-opacity, dimensional stability and compressive strength (Roulet JF 1988). However, with the advances in filler and polymer technologies and adhesive resins for enamel and dentin, composites progressed and became predictable materials even for use in stress bearing situations (Demarco etal 2012, Lynch CD etal 2014). Also resin-modified glass ionomer cements were developed to overcome the high solubility of glass ionomers. These cements bond to the inorganic dentin via a link to the calcium ion in the dentin. As with glass ionomers, this is an acid-base reaction that occurs in an aqueous environment. By combining the advantages of glass ionomer and resin, these materials also release fluoride, have an increased resistance to microleakage, adhere to tooth structure, and are less soluble than a conventional glass ionomer. These materials have a longer working time than traditional glass ionomers. it also has advantage of being able to directly bond to resin composite. They produce a catalyst rich-air inhibited layer, which can polymerize with resin composite, making them useful in glass ionomer/ composite laminate restoration(Wilson AD 1990, Burges etal 1993).

It has been demonstrated in our study that with using one step self etch adhesive system, there was failure in the formation of hybrid layer with leakage at the interface between resin composite and dentin, also it was observed the penetration of corroded

products as silver, copper and tin within the hybrid layer. Meanwhile, when removing stained dentin by increasing the depth by 0.5mm, there were no corroded products observed and higher quality of hybrid layer was observed under scanning electron microscope, this was in agreement with scholtanus JD etal results, which showed lower bond strength with the one step self etch adhesive system when compared with three step adhesive system when bonding with stained dentin.

The reason for lower bond strength using one step self etch adhesive system to the discolored dentin was not due to morphological and physical changes of the dentin substrate. It might be due to the precipitation of plasma protein in dentinal fluid by corrosion products that may be reduce the permeability of the dentin and interfere with the infiltration of the resin monomer. Another explanation was that the metal elements from the corrosion products of amalgam were found to bound on the surfaces of collagen fibrils (Ellender etal 1979). These metallic elements might affect polymerization of the resin monomer. it was reported that the particles of copper, zinc and tin could initiate the polymerization of UDMA-based monomer at room temperature in absence of tertiary amine when moistened with small amount of water. The reason is that a small amount of the released metal ions acts as reductant redox polymerization (Miyagawa etal 2000). However, the initiation mechanism might depend on the amount of metal particles used, since it was reported that high amount of zinc ions tend to retard the setting reaction of the resin monomer (Wanichacheva etal 2000). A third explanation is that these heavy metals reduced the acid solubility of smear layers, making them less etchable than normal smear layers (Harnirattisai etal 2007).

On using resin modified glass ionomer there was no difference in the chemical bonding between stained and unstained dentin, both showed higher quality of bonding when compared to one step self etch adhesive system. Resin modified glass ionomer bond to the inorganic dentin via hydrogen bond between the carboxyl groups of the poly acrylic acid and calcium in the tooth structure forming the ion enriched zone. As mentioned before the morphological and physical structure of dentin was not changed, so it would not affect the chemical bonding of the resin modified glass ionomer.

CONCLUSION

1. On removal of amalgam restorations without further increase in cavity depth; remnants of amalgam and corrosive products are deposited and infiltrated into the underlying dentin.
2. Remnants of amalgam and corrosive products interfere with the adhesion of successive restorations when using self etch adhesives or RMGI.
3. RMGI seems to be less affected by amalgam remnants than self etch adhesive composite.
4. Increasing the depth of the cavity by 0.5 mm after removal of amalgam showed complete removal of amalgam remnants and both self etch adhesive composite and RMGI showed a reliable interface.

RECOMMENDATION

When an old amalgam is replaced, it is recommended to increase the depth by 0.5mm to remove the layer penetrated by corroded products. If it is not available, it is recommended to use resin modified glass ionomer as a base under resin composite restoration when using self etch adhesives.

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