IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 6 Issue 5, May 2019
ISSN (Online) 2348 – 7968
www.ijiset.com

Effect of Amalgam Corroded Products on Quality of Hybrid Layer Using Etch and Rinse and Self-etch Adhesive Systems

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Abstract:
Amalgam and resin composite are two commonly used restorations in dental practice. Nowadays replacing the silver colored dental amalgam with the tooth colored composite has become a routine procedure. Amalgam ages in the oral environment leaving corrosive products that infiltrates into tooth structure and might interfere with bonding of resin composite to tooth on replacing amalgam with composite. In this study 40 molars were selected, cavities were made in each molar and filled with amalgam. Teeth were stored in distilled water for one year. After storage teeth were divided into two main groups; group A; where amalgam was removed 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 sub divided into 2 groups according to the adhesive system used in re-filling the cavities where sub group 1; cavities re-filled using self-etch adhesive and resin composite. Group 2 cavities re-filled with etch and rinse adhesive and resin composite ·Teeth examination: slicing of teeth was done, slices were examined using scanning electron microscope coupled with EDAX. The results of this study demonstrated that amalgam corrosive products interfered with bonding and that removal of 0.5 mm showed no corrosive remnants and allowed better adhesion for both adhesive systems used.
Keywords: amalgam replacement, resin composite, self etch adhesive, etch and rinse adhesive.

1. Introduction:

In the oral environment dental restorations are exposed to a variety of mechanical and chemical challenges and consequently they are often prone to failure due to secondary caries and/or fracture. Therefore replacement of restorations constitutes a substantial part of all restorative treatment in clinical dentistry (1). In some cases of failed amalgam restorations, the corrosion products penetrate deeply into dentinal walls and appear as small to large areas over the cavity floors. The discolored dentin occurs as a two-way exchange of materials between the restoration and the surrounding tooth structure. An early study reported that amalgam discolored, but did not noticeably soften the dentin (5). The dentin structure remained intact, with a normal tubular structure. However, other studies have suggested that corrosion in the gap between an amalgam and the cavity wall results in the formation of a chemical solution of highly acidic, highly concentrated dissolved metallic ions. This condition was thought to cause localized demineralization of tooth structure and precipitation of metal ions.

The precipitation of amalgam elements, mainly tin and zinc, found to be accumulated in the superficial part of demineralized dentin. The tin and zinc might diffuse forming calcium-phosphate-tin or calcium-phosphate-tin-zinc complexes, which were formed at the tooth-amalgam interface and on the cavity floor in the dentin. The amount of tin and zinc were found between the range of 5 and 10% in the tubular areas of discolored dentin. However, for high copper amalgam, copper and zinc were found to have higher amount than tin (12).

At present, the use of resin composite materials in conjunction with dental adhesive is emerging of choice for replacement of existing amalgam restorations. The dentinal tubules of the discolored dentin were found to be open with more precipitation of plasma protein from dentinal fluids adjacent to corrosion products might reduce the permeability of the dentin and interfere with the infiltration of resin monomer. Therefore discolored dentin must be considered as a different substrate for clinical procedures when compared with sound, unaltered dentin (4).

For the success of such adhesive replacement restorations, reliable adhesion to the remaining tooth is of major importance. The aim of this study is to analyze the metal elements in the dentin deposited by amalgam corrosion products after one year old amalgam placement, and the quality of the hybrid layer, after replacement with resin composite restoration using etch and rinse and the self etch adhesive systems.

2. 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. Adhesive: Scotchbond™ Universal Adhesive, etch and rinse approach 3M Resin composite: 3M™ Filtek™ Z250 Universal Restorative. Method: · Teeth selection: 40 human sound molars extracted for periodontal reasons were selected and examined for cracks and flaws under sterio-microscope. · 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 with etch and rinse adhesive and resin composite · Group B1 cavities re-filled using self etch adhesive and resin composite. · Group B2 cavities re-filled with etch and rinse adhesive and resin composite · 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.

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

Silver results:

Effect of presence and absence of last 0.5mm on adhesion within each Restorative material: Etch and Rinse Composite groups:A statistically significant difference was found between (A2) and (B2) groupswhere (p=0.029). The highest mean value was found in (A2) (0.42 ± 0.29), the lowest mean value was found in (B2 groups) (0.00 ± 0.00). Self-etch Composite groups:A statistically significant difference was found between (A1) and (B1) groupswhere (p=0.017). The highest mean value was found in (A1) (0.41 ± 0.38), the lowest mean value was found in (B1) (0.00 ± 0.00)

Relation between restorative material in the presence and absence of last 0.5mm: Removed last 0.5mm groups:No statistically significant difference was found between (B1) and (B2) groupswhere (p=1). Both groups showed no silver (0.00 ± 0.00).

Remained last 0.5mm groups:No statistically significant difference was found between (A1) and (A2) groupswhere (p=0.804). The highest mean value was found in (A2) (0.42 ± 0.29), the lowest mean value was found in (A1) (0.41 ± 0.38).

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

Variables	**Silver**				
	Self-etch adhesive (1)		**Etch and rinse adhesive (2)**		***p-value***
	Mean	**SD**	**Mean**	**SD**	
0.5mm remained (A)	0.41^{bA}	0.38	0.42^{bA}	0.29	0.804ns
0.5mm removed (B)	0.00^{aA}	0.00	0.00^{aA}	0.00	1ns
p-value	**0.017***		**0.029***		

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 ($p \leq 0.05$) ns; non-significant ($p>0.05$)

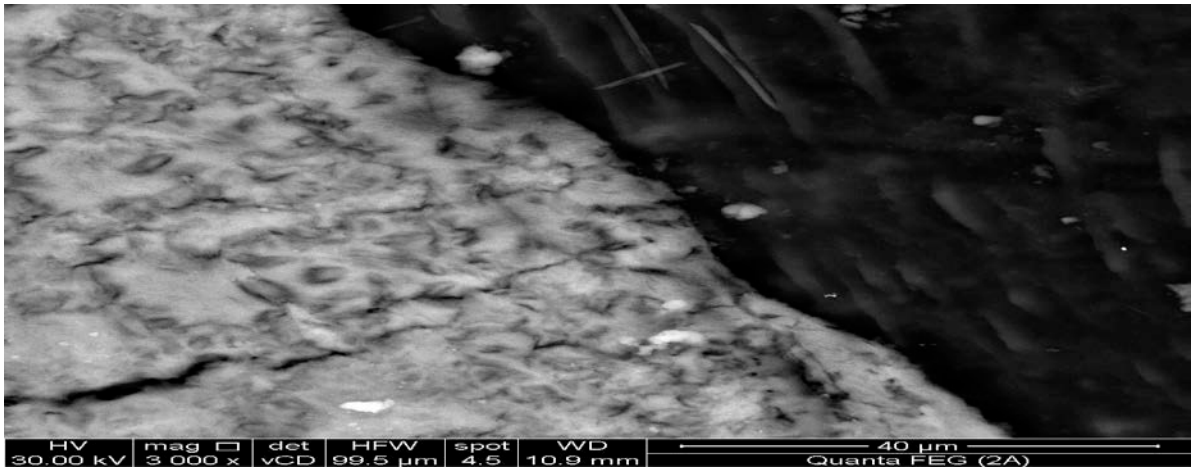

Fig (1) showing group A1 with poor quality bonding between resin composite and tooth with amalgam silver remnants dispersed along the hybrid layer.

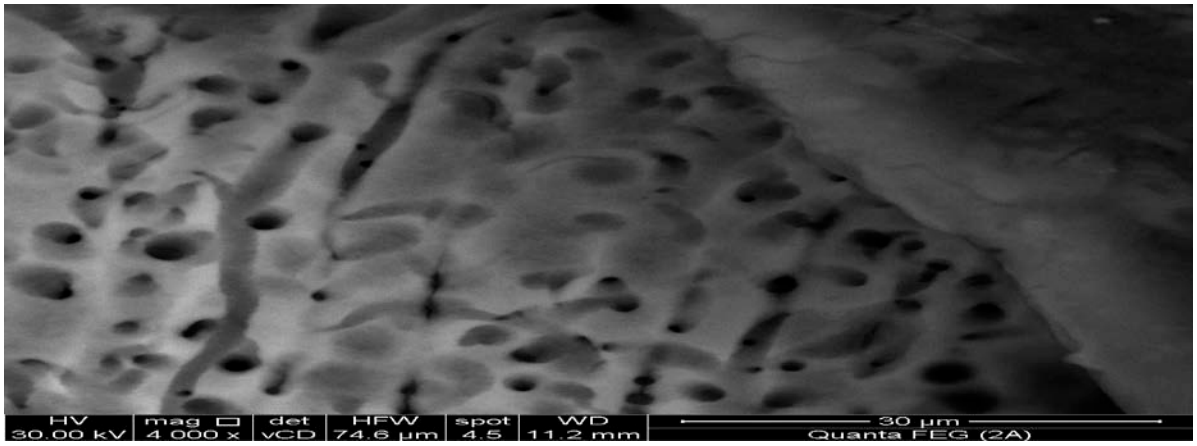

Fig (2) showing group A2 with intimate contact between resin composite and tooth with no traced amalgam remnants.

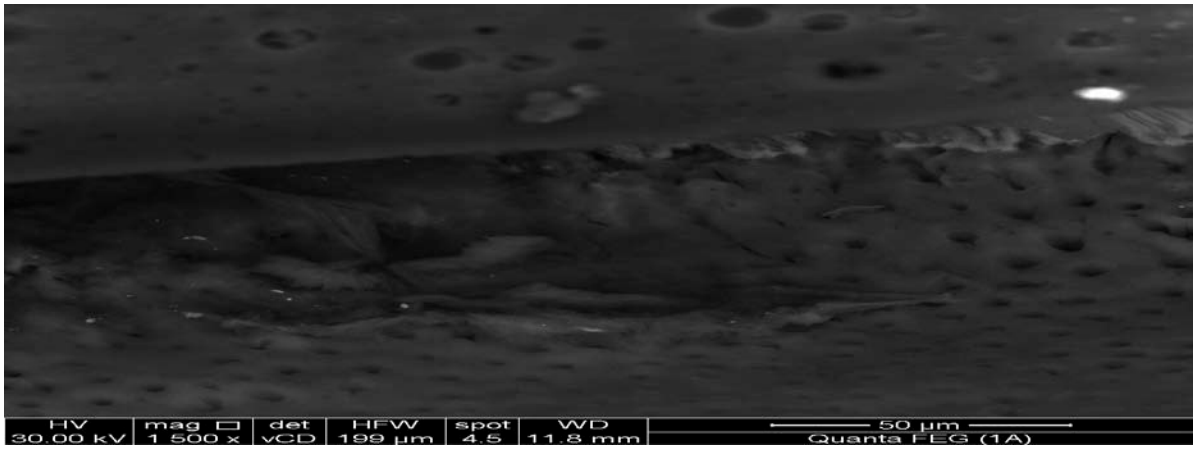

Fig (3) showing group B1 with a wide interfacial gap between resin composite and tooth containing amalgam remnants.

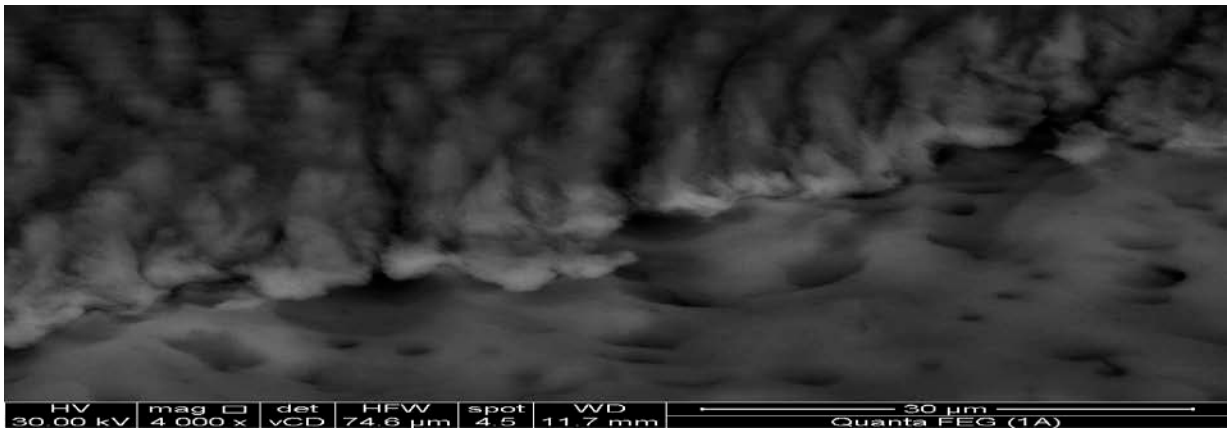

Fig (4) showing group B2 with full resin infiltration into tooth structure and no appearance of amalgam remnants.

4. Discussion:

The aim of this study was to compare etch and rinse adhesive system with self etch adhesive system in formation of hybrid layer of stained dentin after removal of old amalgam restoration. Stained dentin is characterized by extensive black discoloration, which caused by penetration of silver and mercury ions and deposition of metal sulfides.

Amalgam restoration does not adhere chemically to cavity walls, which leave marginal micro-gap between amalgam, and cavity walls, which facilitates transport of fluids, ions, molecules and possibly bacteria and their toxins. Due to the difference in thermal expansion between amalgam and tooth structure, intra-oral temperature changes result in intermitting opening and closing of the gap thus creating inward and outward transport of the fluid along the amalgam tooth interface (3)

Exposure of amalgam to aggressive oral environment results in complex of physical and chemical challenges that causes alterations of structure and property as time, temperature changes, mechanical forces, chemical interactions with oral fluids and galvanic phenomena. All these factors either act continuously or intermittingly (3). In our study, we used the time factor by storing the specimens in saline in an incubator at 37°C for 9 months, saline was used because chloride concentration causes an aggressive environment that enables invitro testing in shorter period of time than intraorally. The results of this study demonstrated that the hybrid layer formed with both etch and rinse and the self etch adhesive systems were not penetrated by corroded products while bonding with unstained dentin by increasing the pulpal floor cavity depth by 0.5mm after removal of amalgam restoration. Meanwhile, application of resin composite directly on stained dentin showed penetration of the hybrid layer with high quantity of silver ions and lower quantities of copper, zinc and tin. There were also remnants of mercury which affected the quality of the hybrid layer formation and uncompleted resin tag formation for both etch and rinse and the self etch adhesive systems. Moreover, etch and rinse adhesive system showed better adaptation than the self etches adhesive system, which showed more leakage at the interface.

Scholtanuset et al found that discolored dentin adjacent to amalgam restoration contain amalgam corrosion products that can penetrate deeply in dentinal walls. It has been suggested that there is a relation between ion penetration, discoloration and demineralization. In addition, the result of scanning electron microscope study showed that most dentinal tubules in discolored dentin were open, but the perception of plasma protein in dentinal fluid in dentinal fluid adjacent to the corrosion products may reduce that permeability of the dentin and interfere with the infiltration of resin monomer. Therefore, discolored dentin must be considered as a different substrate for clinical procedure when compared with sound unaltered dentin.

Harnirattisia et al found no difference between self-etch and total etch adhesives with regard to bonding to discolored dentin, these results were contradicted with our results, as in our study bonding with total etch adhesive showed improved bonding and improved quality of the hybrid layer than with self-etch adhesives. Nakajima M et al results showed that bond strength to darkened dentin was lower than that of intact dentin. Ghavamnasiri et al showed that after amalgam removal by 0.5mm extension of cavity walls of non-dicolored dentin could improve the dentinal marginal seal to replicate that of the initially placed composite restoration.

Scholtanus et al results showed that corrosion of amalgam plays a major role in the efflux of metal ions, they found that gamma 2 phase (Sn8Hg) in conventional amalgam and the eta phase (Cu6Sn5) in high copper amalgam are the phases that are most easily corroded. Corrosive attack from Cu6Sn5 in high copper amalgam tin is released with copper, which is available to form relatively soluble complexes of chlorides and sulfides on the amalgam. Also Ghavamnasir et al revealed the presence of elements such as copper and silver in dentin, while mercury did not penetrated into dentinal tubules, this was in contrast with the findings of Soremark et al and Ayuz et al whose results showed traces of mercury and this was in agreement with our results but in contrast with Kurosaki and Fusayama who stated that mercury could not be found inside dentinal tubules, but rather it returns to the amalgam structure and reacts with the unreacted alloy core.

Marjaneh et al and Ghavamnasiri et al demonstrated that no need to extend the depth of the pulpal floor of the prepared cavity by 0.5mm or more when replacing amalgam restoration with resin composite as they obtained the same level of the bond strength without increasing the depth. These results were contradicted with our results as increasing the depth increased the quality of the hybrid layer formation than with stained discolored dentin. Scholtanus et al results were in agreement with our results that darkly discolored dentin found beneath amalgam restoration contains amalgam corrosion products and is demineralized, therefore, it should be considered as a different substrate for clinical procedures than sound dentin.

5. Conclusion:

On the basis of this in-vitro study extension of the pulpal floor by 0.5mm after amalgam removal and replacement with resin composite using either self-etch or etch and rinse adhesive systems will give better hybrid layer formation than dealing with stained dentin penetrated by corroded products. In dealing with stained dentin etch and rinse adhesive system gives better hybrid layer formation with less micro leakage than with self-etch adhesive system.

6. Recommendation:

When amalgam restoration is to be replaced with resin composite restoration we should extend 0.5mm beyond the discolored dentin, and if it is not possible it’s better to use etch and rinse adhesive system.

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