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Effect of Application of EDTA and Delayed Light Activation on Bond Strength of Resin-Modified Glass Ionomer to Dentin

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ABSTRACT

The aim of the present study was to evaluate the effect of delayed light activation and the application of EDTA on bond strength between resin modified glass ionomer and dentin. Thirty permanent sound human posterior teeth were used. The crowns were separated from the roots 1mm below cervical line and then the crowns were cut in a mesio-distal direction to obtain two halves. Samples then were embedded in self cure acrylic resin and then trimmed to create flat dentinal surfaces. Samples were divided in to three groups of 20 each according to light activation (immediate, delayed or without). Each group was subdivided into two subgroups of 10 each according to EDTA application (conditioned or non-conditioned). The restorative material was applied to a cylindrical mold (2 mm diameter and a height of 1mm) fixed on the surfaces of conditioned and non-conditioned samples then subjected to light activation either immediate, delayed or without. Samples were stored for 24h at 37°C. Shear bond strength testing was done using universal testing machine. Two teeth for each group were prepared for SEM evaluation after being divided longitudinally within the center of the restoration and the interface was examined. The results showed that delaying light activation has significantly decreased shear bond between RMGI and dentin and that the application of EDTA resulted in increase in bond strength for all groups. The lowest shear bond strength was for the conventional type while the highest one was for the immediate light cured RMGI group. The interface as revealed by the SEM showed thicker and longer resin tags in the EDTA preconditioned specimens than without conditioning. It was concluded that the use of EDTA as dentin pre conditioning was beneficial to the bond strength of both RMGI and conventional GI to dentin and that RMGI provides better dentin bonding as compared to conventional GI.

KEYWORDS

EDTA, Shear bond strength, RMGI, delayed light activation.

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INTRODUCTION

Resin modified glass ionomer (RMGI) have been widely used due to their advantages such as the physiochemical bonding to tooth structure, fluoride release, biocompatibility and their coefficient of thermal expansion is similar to that of the tooth structure[1].

RMGI have dual setting reactions. One is a classic acid-base reaction of the conventional glass ionomer by the mixing of their two components, and the other is a polymerization of resin monomers by light irradiation. Based on the results of some recent studies the acid-base and photo-initiated free-radical reactions have a reciprocal inhibitory effect on each other, and photoactivation of RMGIs decreases the rate of the acid-base reaction [2,3].

Ethylene diamine tetra acetic acid (EDTA) is a gentle chelating agent at neutral pH that removes the smear layer and mildly demineralizes the dentin. Milder dentin demineralization achieved using EDTA may avoid the denaturation of collagenand improve the quality of the hybrid layer and its durabilitydue to the presence of more residual apatite crystallites left within the collagen matrixsubsequent to the dentine conditioning[5-7].

MATERIALS AND METHODS

Thirty extracted permanent sound human molars were used. The crowns of the teeth were separated from the roots 1mm below cervical line, roots were discarded and crowns were sectioned mesio-distally into buccal and lingual surfaces. The specimens were embedded in self-cure acrylic resin inside a prefabricated metallic cubic mold of 1.5 mm in a manner that the buccal and lingual surfaces were placed horizontally. Surfaces were trimmed until the dentin was exposed. Samples were divided into three groups of 20 each according to light activation (A_1: immediate light cured Photac Fil Quick Aplicap, A_2: delayed light cured Photac Fil Quick Aplicap or A_3: without light curing Ketac Fil Plus Aplicap). Each group was subdivided into two subgroups of 10 each according to EDTA application (E_1: conditioned or E_2 non-conditioned). 17% EDTA was applied on the surfaces of samples of subgroup E1 for 60 seconds, rinsed for 10 seconds and then gentle air dried.

Application of Photac Fil Quick Aplicap was done using cylindrical plastic mold with identical thickness (2 mm diameter and a height of 1mm) placed on the surfaces of the samples and light activation was performed for 20 s using LED light curing unit. For group A2 the material was allowed to set without the application of light for two minutes and then light activated for 20s. Ketac Fil Plus Aplicap was applied to the surfaces of group A3 and then allowed to set freely without the application of light for 5min.

Shear bond strength testing:

Samples were attached to the lower compartment of the Universal testing machine and then a compressive load was applied using a mono-beveled chisel shaped metallic rod so that the force of the shear was applied directly to the tooth- restoration interface. The load required for debonding was recorded in Newton and the data were recorded using computer software.

Scanning electron microscopic examination:

Two teeth from each group were used to examine the tooth- restoration interface. The occlusal enamel of each tooth was wet ground to expose a flat dentin surface. EDTA and the restorative materials were applied as mentioned previously for shear specimens, and then each tooth was sectioned mesio-distally to the level of the cervical line into two halves. Then, the two halves were separated by an additional horizontal cut. Samples were gold sputtered then scanned. The hybrid layer and the resin tags were viewed at magnification 1000x.

Statistical analysis

Description of quantitative variables was in the form of mean, standard deviation (SD). Data were explored for normality using Kolmogorov-Smirnov test of normality.

Comparison between quantitative variables was carried out by Student t-test of two independent samples. Tukey's post hoc test was performed when results of ANOVA test were significant.

RESULTS

Shear bond strength Table (1), Fig. (1)

Within the groups A_1 showed higher mean values than those of A_2 and A_3. Within each of subgroup EDTA showed higher mean values than without conditioning. The greatest shear bond strength was recorded in the immediate light cured Photac group with conditioning, whereas the lowest value was recorded in the Ketac group without conditioning.

Table (1) Mean shear bond strength, standard deviation and statistical analysis results as function of different interactions between tested variables

	Conventional		Immediate cured		Delayed cured		P value
	Mean	SD	Mean	SD	Mean	SD	
Non conditioned	8.33e	2.67	19.76b	1.83	17.45c	2.38	<0.0001***
Conditioned	9.37d	1.2	23.17a	3.40	20.84b	2.67	

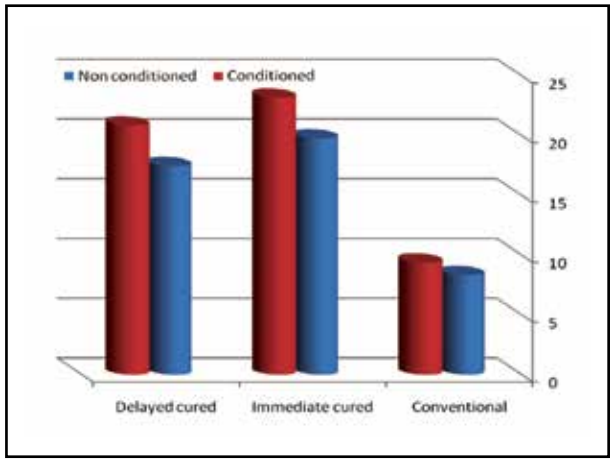
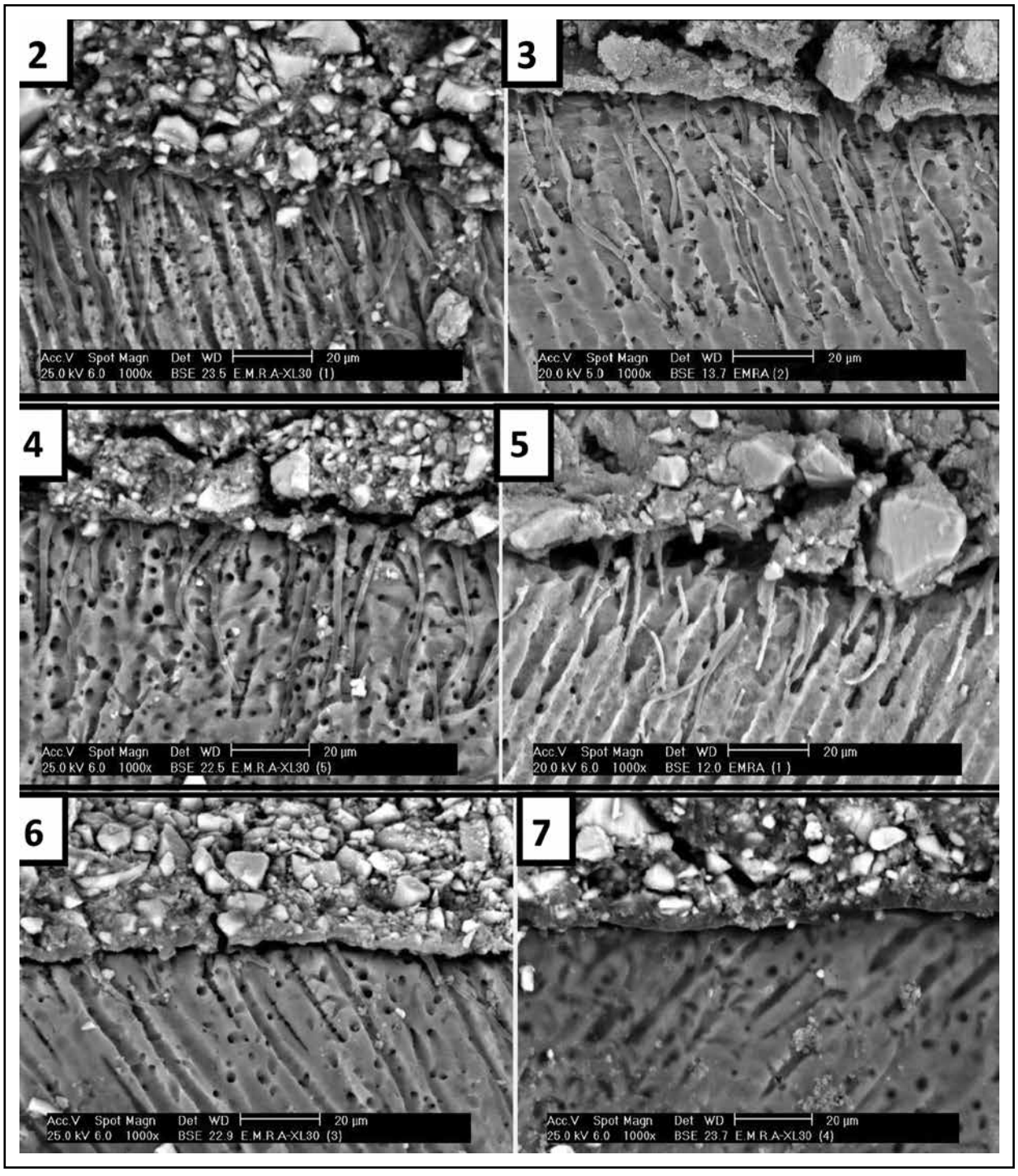


Fig. (1) Mean shear bond strength as function of the different interactions between the tested variables

Scanning Electron Microscopic Examination

SEM micrograph for glass ionomer-dentin interface revealed that in group A_1E_1: Numerous long, funnel-shaped resin tag extensions extending to long distance in dentin (Fig. 2) while in group A_1E_2: the resin tags were thinner (Fig.3). In group A_2E_1 resin tags were long and thick and penetrating the dentin layer (Fig. 4), however, in group A_2E_2 showed a gap between the restoration and the dentin (Fig. 5). Numerous resin tags which appear thinner and short were observed. In group A_3E_1 showed a gap between the restoration and the dentin. A few number of resin tags could be seen extending to short distance in dentin (Fig. 6), while in group A_3E_2 showed a gap between the restoration and the underlying dentin. Almost no resin tags were seen (Fig. 7).



DISCUSSION

The higher bond strength of Photac Fil Quick Aplicap may be attributed to the presence of HEMA which may have contributed to the micromechanical interlock as RMGI bond to dentin with two mechanisms, micro mechanical interlock and chemical interaction. The presence of HEMA could absorb water and form what is called an absorption layer which mediates better bonding of RMGI to dentin and functioning as a stress relieving layer to reduce stresses induced by shrinkage [(1)]. Also HEMA

content is thought to be an effective dentin wetting agent and therefore helps to develop an affinity between the material and dentin [2]. This was evident in SEM examination as it has revealed a prominent difference between the conventional glass ionomer and RMGI. The RMGI –dentin interface showed numerous and long resin tags while for the conventional type almost no resin tags were detected.

Delayed light activation has significantly decreased the bond strength of RMGI to dentin. When photo polymerization reaction is initiated the acid-base reaction is retarded for several reasons; part of the water in the liquid component is replaced by HEMA monomer. Ion formation would be retarded in the organic medium, which possesses a lower dielectric constant. In addition, the conformation of polyacrylic acid is affected by the presence of organic molecules, coiling up more tightly than it does in water. Finally, setting of the cement due to polymerization of the light curable component, results in a gel matrix in which diffusive processes occur at reduced rates[3].

On the other hand, the photochemical reaction is affected by the polar nature of the acid–base medium**.**The set material has interpenetrating matrices formed by the ionic matrix from the acid-base reaction and the polymerization matrix from the photochemical reaction[4].

Delayed light activation may have allowed the acid base reaction to occur rapidly forming network and as the reaction proceeded, the viscosity of the mixture increased and the mobility of network chain segments was reduced so the material set mainly by the acid- base reaction and the properties of the material was similar to that of the conventional type which suggest that VLC and polymerization reactions compete with and inhibit one another [5&6].

Also delaying the light-activation procedure and prewarming of the material helped to rapidly form poly-HEMA, increased the osmotic pressure and expelled fluids out of the dentinal tubules which produced a more hydrophilic dentin surface with lower surface energy that diluted the ions present on the surface for acid-base reaction, and finally lead to an inappropriate surface for the polymerization of free radicals [7]. The SEM examination revealed no significance difference between immediate and delayed light cured RMGI.

Comparing the effect of pre conditioning of the dentin by EDTA results showed that EDTA has significantly improved the bond strength of all groups. This may be the result of enhanced micromechanical retention due to improved removal of the smear layer and dentinal plugs which allowed resin monomer (HEMA) penetration into the dentinal tubules. Additionally, EDTA does not alter the fibrillar structure of collagen, allowing the mineral content of collagen to bond with the ionic component of RMGIs[8] and since the structural support by the mineral is not missing, resin infiltration may be facilitated [9].

EDTA did not aggressively decalcify the dentin surface or widely open the dentinal tubules, resulting in the formation of long and thin resin tags and a hybrid layer [10]. The formation of the hybrid layer and resin tag extensions was important to resist the acute de-bonding stresses that could occur during bond strength testing [11].

The SEM examination revealed slight difference between the preconditioned and non conditioned RMGI immediate and delayed groups. The resin tags were thicker and longer in the conditioned specimens than in the non conditioned groups. There was significant difference in the conventional glass ionomer group as the EDTA permitted a more intimate contact of the filling material with dentin and a slight penetration into the dentinal tubules.

CONCLUSIONS

Delaying light activation of RMGI has deleterious effects on the bond strength to dentin. The use of EDTA as dentin pre conditioning is beneficial to the bond strength of both RMGI and conventional GI to dentin. RMGI provides better dentin bonding as compared to conventional GI.

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