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Effect of Prewarming and/or Delayed Light Activation on Resin-Modified Glass Ionomer Bond Strength to Tooth Structures

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Clinical Relevance

Bond strength might improve by delaying the light activation procedure when a cavity conditioner is used for bonding RMGI to enamel. Conversely, delaying the light activation and/or prewarming of RMGI compromises bond strength to dentin and should be avoided.

SUMMARY

Introduction: Recent research shows that the acid-base reaction and light-activated polymerization in resin-modified glass ionomers (RMGI) compete with and inhibit one another. In addition, extrinsic energy would improve some properties of RMGI. This in vitro study evaluated the effect of prewarming and/or delayed light activation on bond strength of RMGI to tooth structure.

Materials and Methods: Ninety-six flat enamel and dentin surfaces of human molars were ground with sequentially finer abrasives to 600-grit silicon carbide paper. Each surface was treated with a cavity conditioner for 10 seconds, rinsed, and gently air-dried (n=12). RMGI was applied to tooth substrates according to the following protocols: group 1) according to manufacturer's instructions; group 2) a delay of two minutes in light activation; group 3) prewarming of the encapsulated material (90 seconds, 40°C); group 4) prewarming plus a delay of two minutes in light activation. After 24 hours of storage at 37°C and 500 rounds of thermocycling, the samples were tested for shear bond strength and analyzed using two-

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way analysis of variance and Tukey HSD test (α=0.05).

Results: Significant differences were observed between study groups ($p<0.05$). The highest enamel bond strength was recorded in group 2. Regarding dentin groups, the highest bond strength was recorded in group 1.

Conclusion: Within the limitations of the present study, delaying light activation might improve bond strength of RMGI to enamel; however, the standard procedure recommended by the manufacturer is the best procedure for bonding of RMGI to dentin. More investigations are necessary.

INTRODUCTION

Polyalkenoate (glass ionomer) cements (GICs) have widespread clinical uses as temporary or permanent restorations, as cavity liners or fissure sealants, or as luting agents for indirect restorations and orthodontic brackets. GICs are unique in their ability to bond to enamel and dentin and to base metals,[1] release fluoride,[2] inhibit potential caries,[3] and exhibit antibacterial activity due to their low setting pH value.[4]

Resin-modified glass ionomers (RMGIs) are composed of an acid-degradable glass and aqueous solutions of polyacid and monomeric components, including 2-hydroxyethyl methacrylate (HEMA). The setting reaction of the cement is triggered immediately after mixing in the form an acid-base reaction. Free-radical polymerization of the monomeric components is then initiated by irradiation with visible light. Each acrylate group is capable of independently participating in the chain reaction, but the final outcome is the formation of a covalently cross-linked three-dimensional network. The set cement is composed of interpenetrating networks of, say, poly (HEMA) and polyacrylate salts. This photochemical reaction reduces the moisture sensitivity and the dehydration associated with the initial stages of GIC acid-base setting reaction.[5]

As a result, the setting reaction of RMGIs is mediated by at least two different mechanisms that depend on reactant diffusion before gelation. The kinetics and setting mechanisms of each reaction might depend on and/or compete with the other.[6] Necessarily, one reaction replaces part of the other; however, the chemistry indicates that the formation of each network would separately inhibit diffusion and thus the other reaction. Immediate light activation might limit the acid-base reaction and give rise to different structural properties.[6] On the other hand, delayed irradiation might limit the polymerization of resin.[6,7]

In the same context, a study recently showed that the polymerization behavior of RMGIs is under the influence of the power density of the curing unit.[8] Yelamanchili and Darvell[9] made an attempt to answer the question whether interference occurs between the components of an resin-modified glass ionomer cement (RMGIC) by changing the light-activation protocol. They reported a competitive phenomenon between network-forming reactions, leading to a sensitive balance between the two, and a critically optimum light-activation protocol: too much irradiation might be detrimental, as is delay. They recommended that the manufacturer's instructions regarding the duration of irradiation should be followed so that an optimal result would be achieved.

On the other hand, recent data show that a moderate increase in composite resin temperature increases its flowability, which is advantageous in composite resin placement, leading to better adaptation with cavity walls and outline.[10–14] Furthermore, recent research indicates that there is a higher degree of composite resin conversion[11] when it is cured at slightly higher temperatures. One study[15] showed that prewarming of composite resin might have a detrimental effect on restoration margins as it increases polymerization shrinkage. Conversely, the results of a recent study by Fróes-Salgado and others[16] showed that prewarming of composite resins before light activation in clinical situations does not alter their mechanical properties and monomer conversion but enhances composite resin adaptation to cavity walls. A more recent study by Deb and others[17] revealed that prewarming of dental composite resins enhances their flowability and conversion degree. The linear polymerization shrinkage increases parallel with an increase in conversion degree; however, the flexural strengths remain unchanged. They reported that prewarming of composite resins might have clinical advantages during placement and adaptation of the material to the cavity walls.

Regarding prewarming protocols of GICs and RMGIs, an earlier study has shown that accelerated setting reaction in RMGI by means of heat or ultrasound waves shortens the setting reaction time of RMGI and significantly increases the bond strength to enamel.[7] According to O'Brein and others,[18] application of an external energy source by prewarming the capsules, by exposing the surface to a high-irradiance light-curing unit, or by ultra-

Table 1: *Materials Used in the Study, Their Compositions, and Mode of Their Applications According to the Manufacturer Instructions*

Material name and manufacturer	Manufacturers' instructions	Material composition
Cavity Conditioner (GC, Tokyo, Japan)	Apply with a brush for 10 s, rinse thoroughly.	Polyacrylic acid (20%), aluminum chloride (3%), distilled water
Fuji II LC (Improved version) (GC, Tokyo, Japan)	Shake the capsule, push the plunger until it is flush with main body, place the capsule into a metal GC capsule applier and click the lever once, set the capsule in a mixer and mix for 10 s, load it into the applier, and inject in the prepared cavity and cure for 20 s.	Powder: fluoro alumino-silicate glass; liquid: polyacrylic acid (20%-25%); 2-hydroxyl ethyl methacrylate (30%-35%); proprietary ingredient (5%-15%); 2,2,4,trimethyl hexa methylene dicarbonate (1%-5%); powder/liquid: 0/33g/0/085 mL

sonic scaler treatment significantly improves surface hardness at initial stages of glass ionomer cement setting reaction.

RMGIs are a hybrid of glass ionomers and composite resins. It seems that no study to date has attempted to evaluate and measure the effect of delaying light-activation and prewarming on RMGIs bond strength. Therefore, the aim of the present study was to investigate the effect of a delayed light activation technique and/or prewarming of an RMGI on bond strength to tooth structures. The specific hypothesis tested in this study was that delaying light activation and/or prewarming do not influence the bond strength of an RMGI to tooth structures.

MATERIALS AND METHODS

Shear Bond Strength Evaluation

Forty-eight sound human third molars were used for the purpose of the present study. The teeth were stored in 0.2% thymol solution at 4°C and used within two months after extraction following informed patient consent, as approved by the Medical Ethics Committee of Isfahan University of Medical Sciences. The crowns of the teeth were separated from the roots, sectioned mesiodistally, and embedded in flat cylindrical acrylic resin molds in a manner that the buccal and lingual surfaces were placed horizontally. Buccal and lingual surfaces were used for enamel and dentin groups, respectively. Forty-eight buccal surfaces were ground at the vestibular enamel surface on wet silicon carbide papers up to grit 600 to achieve a flat surface. Lingual surfaces were trimmed until the dentin was exposed and then were ground on wet silicon carbide papers up to grit 600 to create flat dentinal surfaces. After preparing 96 flat enamel and dentin surfaces, the surfaces of the specimens in each group were conditioned with 20% aqueous polyalkenoic acid cavity conditioner (GC, Tokyo, Japan; Table 1) prior to the application of the restorative material. Cylindrical plastic molds with identical thicknesses (2 mm of internal diameter and a height of 1 mm; Orthorings, Ortho Organizers Inc, Carlsbad , CA, USA) were fixed on the surfaces at room temperature (22 ± 1°C). Fuji II LC RMGIC was used in the present investigation (GC Improved Version, Tokyo, Japan; Table 1), supplied in capsules and mixed according to manufacturer's instructions for 10 seconds in a mechanical mixer (CapMix 1, 3M ESPE, St Paul, MN, USA). For enamel and dentin groups, sample subgroups (n=12) were prepared as follows:

1. Control. The material was mixed, injected into the mold, and then light activated according to manufacturer's instructions.
2. Delayed light activation. The material was mixed, injected in the mold, formed, and then allowed to set without the application of light for two minutes and then light activated according to manufacturer's instructions.
3. Prewarming. RMGIC capsules were immersed in a water bath at 40 ± 1°C for 90 seconds prior to activation, mixing, and injection into the cylindrical mold.
4. Prewarming and delayed light activation. RMGIC capsules were prewarmed similar to the procedure in group 3 and then mixed, introduced into the molds, and light activated two minutes after application similar to group 2.

Fuji II LC RMGI was polymerized using a halogen light-curing unit (Coltolux 2.5, Coltene AG, Feldwiesenstrasse Altstätten/Switzerland) with a light output power of 480 mW/cm^2. For all specimens, the distance of the light curing tip from the RMGI was 1 mm. After 24 hours of storage at 37°C, the specimens were exposed to 500 rounds of thermocycling

Table 2: *Bond Strength of the Specimens in the Enamel Groups in MPa (*p=*0.037)*

Groups	Group definition	Mean	SD	CI 95% LB	CI 95% UB	Min	Max
1	Control	9.34	3.56	7.07	11.60	5.09	15.92
2	2-min delay	11.92	5.07	8.40	14.84	5.73	22.29
3	Prewarming	8.94	4.77	5.90	11.97	4.77	22.29
4	Prewarming plus 2-min delay	9.18	4.45	6.34	12.00	3.18	19.10

Abbreviations: CI, confidence interval; LB, lower bound; UB: upper bound.

between 5°C and 55°C (Mp Based, KARA1000 Inc, Tehran, Iran) with a dwell time of 30 seconds and a transfer time of 12 seconds. Subsequent to fixation, the samples were tested for shear bond strength (SBS) at a crosshead speed of 0.5 mm/min by means of a universal testing machine (Dartec, HC10, Dartec Ltd, Stourbridge, UK). SBS values were calculated by dividing the force at fracture by the initial bonded area.

Two-way analysis of variance (ANOVA) was used to analyze the effect of curing protocol and prewarming on SBS using SPSS 11.5 software. Furthermore, one-way ANOVA and Tukey HSD *post hoc* tests were used to determine differences in SBS between the groups within the materials. Statistical significance was defined at $p<0.05$. The fracture modes of RMGI cylinders on enamel and dentin surfaces were evaluated under a light microscope at 16× and classified as follows:

1. Cohesive fracture: fracture in the RMGI or dental tissue
2. Adhesive fracture: fracture in the adhesive interface
3. Mixed fracture: adhesive/cohesive fracture (Tables 3 and 4)

Interface Evaluation by Scanning Electron Microscopy

In each experimental group, two additional specimens were prepared for evaluation by scanning electron microscopy (SEM). Subsequent to preparing each tooth according to the method described previously, the specimens were prepared by sectioning each specimen. The samples were dehydrated in ascending concentrations of ethanol (50%, 70%, 95%, and 100%) for 1 hour and embedded in acrylic resin and polished down using decreasing grit abrasive papers (400, 600, 800, 1200, and 1500; Buehler Ltd, Lake Bluff, IL, USA) and 0.5 μm diamond paste (Buehler Ltd) with a polishing cloth. Between each polishing step, specimens were put in an ultrasonic device for 10 minutes. The exposed interfaces were treated with 6 N hydrochloric acid for 30 seconds followed by a 10-minute immersion in 2.5% sodium hypochlorite. Subsequent to 10-minute ultrasonication, the specimens were dehydrated for 24 hours, affixed to an aluminum mounting stub, and sputter-coated with platinum-gold to a thickness of 10 nm for analysis under SEM. Different magnifications were used to provide SEM images at a distance of 20 mm. An accelerating voltage of 15.0 kV was used for the analysis.

RESULTS

Shear bond strength (SBS) values in MPa (mean ± SD), minimum/maximum values, and 95% confidence intervals for the groups are summarized in Tables 2 and 3. ANOVA revealed significant differences in SBS values among the enamel and dentin groups ($p<0.05$). Among enamel groups, group 2 specimens showed higher SBS values compared to other groups ($p<0.05$). No significant differences were observed between groups 3 and 4 and the control group ($p>0.05$; Table 2).

Regarding dentin groups, group 1 specimens showed higher SBS values compared to other groups ($p<0.05$). No significant differences were observed

Table 3: *Bond Strength of the Specimens in the Dentinal Groups in MPa (*p=*0.018)*

Groups	Group definition	Mean	SD	CI 95% LB	CI 95% UB	Min	Max
1	Control	13.79	5.18	10.5	17.09	7.96	22.29
2	2-min delay	8.88	2.99	6.98	10.78	4.77	14.33
3	Prewarming	7.96	2.25	6.52	9.38	3.18	11.14
4	Prewarming plus 2-min delay	7.56	2.89	5.72	9.39	4.77	14.33

Abbreviations: CI, confidence interval; LB, lower bound; UB, upper bound.

Table 4: *Different Fracture Modes in the Study Groups in Enamel Specimens,* N*(%)*

Mode of fracture / Groups	Adhesive	Cohesive	Mixed	Total
1 (control)[1]	6 (50%)	4 (33.4%)	2 (16.6%)	12 (100%)
2 (2-min delay)[1]	6 (50%)	5 (41.6%)	1 (8.4%)	12 (100%)
3 (prewarming)[2]	8 (66.6%)	3 (25%)	1 (8.4%)	12 (100%)
4 (prewarming and delay)[2]	9 (75%)	2 (16.6%)	1 (8.4%)	12 (100%)

[a] *Groups with the same superscript are not statistically different (*p*>0.05).*

between groups 2 and 3 and also between groups 3 and 4 ($p>0.05$; Table 3).

Two-way ANOVA revealed that SBS values in the four enamel groups were influenced by "delaying the irradiation procedure" ($F=3.861$, $p=0.037$), "prewarming" ($F=1.195$, $p=0.028$), and "delaying the irradiation/prewarming" ($F=4.618$, $p=0.043$).

Also, two-way ANOVA revealed that SBS values in the four dentin groups were influenced by "prewarming" ($F=12.493$, $p=0.001$) and "delaying the irradiation procedure" ($F=6.866$, $p=0.012$), and "delaying the irradiation/prewarming" ($F=4.954$, $p=0.031$).

One-way ANOVA for the study groups was significant ($p<0.05$). Multiple comparisons by Tukey test for enamel and dentin groups demonstrated significantly higher SBS values in groups 1 and 2 compared to the other groups, respectively ($p<0.05$).

Table 5: *Different Fracture Modes in the Study Groups in Dentin Specimens,* N*(%)*

Mode of fracture / Groups	Adhesive	Cohesive	Mixed	Total
1 (control)[1]	5 (41.6%)	4 (33.4%)	3 (25%)	12 (100%)
2 (2-min delay)[1]	5 (41.6%)	6 (50%)	1 (8.4%)	12 (100%)
3 (prewarming)[2]	8 (66.6%)	3 (25%)	1 (8.4%)	12 (100%)
4 (prewarming & delay)[2]	7 (58.3%)	4 (33.3%)	1 (8.4%)	12 (100%)

[a] *Groups with the same superscript are not statistically different (*p*>0.05).*

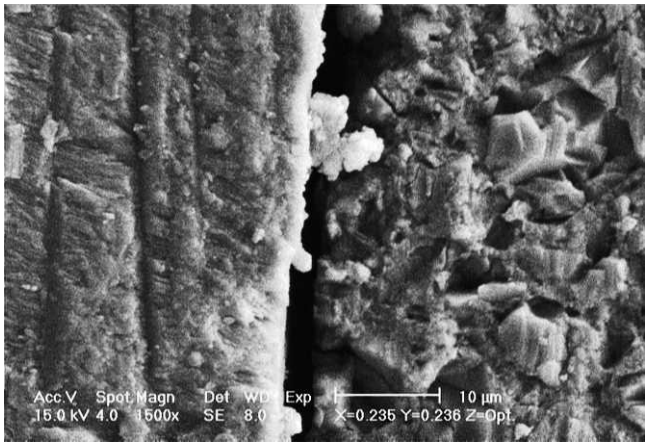

Figure 1. *Enamel/Fuji II LC interface in group 1. (Magnification = 1500×). In all the figures, the SEM photomicrographs of enamel and dentin study groups. As it appears in the photomicrographs, the resin interface area seems to be wider in groups 3 and 4. It seems that there is a better adaptation between the restorative material and tooth structures in groups 1 and 2. The glass particles seem to be larger, which might be attributed to less opportunity of the material to react with other particles and tooth structure subsequent to warming. (Magnification = 1500×).*

The fracture modes are summarized in Tables 4 and 5. According to the results, the majority of adhesive fractures were observed in groups 3 and 4 in both the enamel and the dentin group.

The SEM photomicrographs are shown in Figures 1 through 8 for enamel and dentin study groups. As it appears in the photomicrographs, the resin interface area seems to be wider in groups 3 and 4. There is a better adaptation between the restorative material and tooth structures in groups 1 and 2. The unreacted particles seem to be larger, which might be attributed to less opportunity for the material to react with tooth subsequent to heating.

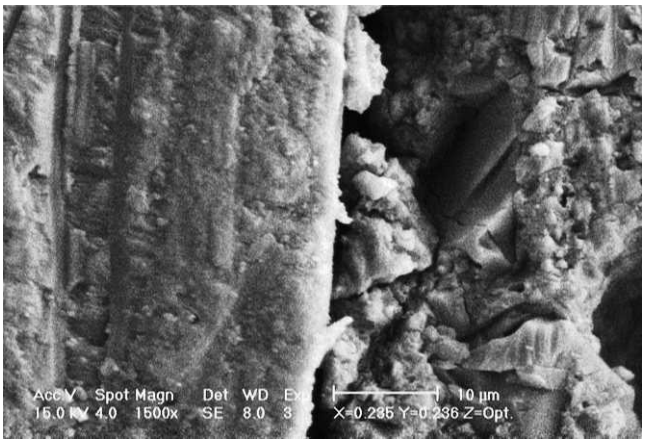

Figure 2. *Enamel/Fuji II LC interface in group 2. (Magnification = 1500×).*

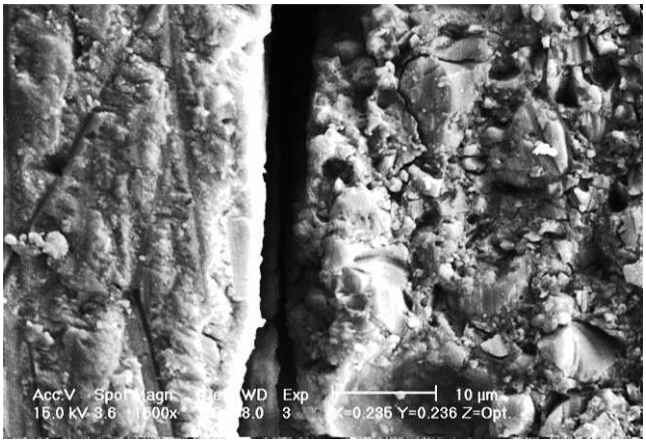

Figure 3. *Enamel/Fuji II LC interface in group 3. (Magnification = 1500×).*

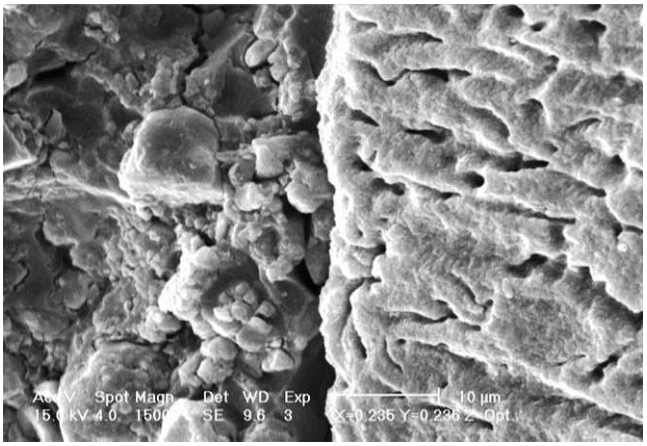

Figure 5. *Dentin/Fuji II LC interface in group 1. (Magnification = 1500×).*

DISCUSSION

Hybrid material types, such as RMGI, were developed in an attempt to improve mechanical properties, decrease setting time, and reduce moisture sensitivity of glass ionomers. However, RMGICs exhibit shrinkage and substantial water sorption because of their hydrophilic water-soluble resin content.[18]

RMGIs are a hybrid of glass ionomers and composite resins, and thus contain acid-base and polymerizable components. The setting reaction in glass ionomers is described as a series of overlapping stages.[6] Polyacrylic acid protons liberate metal ions and fluoride from the glass, forming a silica hydrogel around the glass surface. The high aqueous phase pH causes polysalt precipitates to form from the migrating ions, which act as cross-links to the polyacrylic acid chains. Setting times are approximately several minutes, although further maturation occurs over time.[19] Conversely, the resin reaction rate is much faster, although the complex photoinitiated polymerization process eventually results in a diffusion-controlled, polymer chain propagation as the concentration and mobility of monomer decrease during the formation of cross-linked matrix networks.[20–22] The final degree of conversion is dependent on monomer mobility and diffusion.[21]

In the present study, a cavity conditioner was used to remove the smear layer. The cavity conditioner (Fuji II LC I) consisted of polyacrylic acid (20%) and aluminum chloride (3%), which was applied to enamel and dentin surfaces for 10 seconds and then rinsed according to manufacturer's instructions. Earlier studies have reported that cavity conditioners are effective in improving the bond strength of Fuji II LC I restorative material.[23,24] According to the mentioned protocol, the initial bond strengths of the material under study to enamel and dentin were

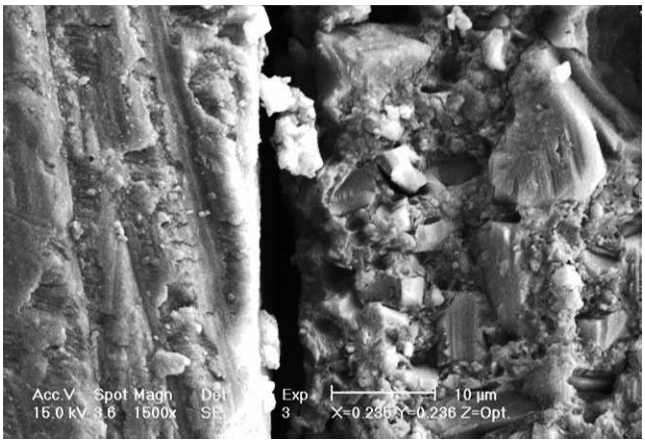

Figure 4. *Enamel/Fuji II LC interface in group 4. (Magnification = 1500×).*

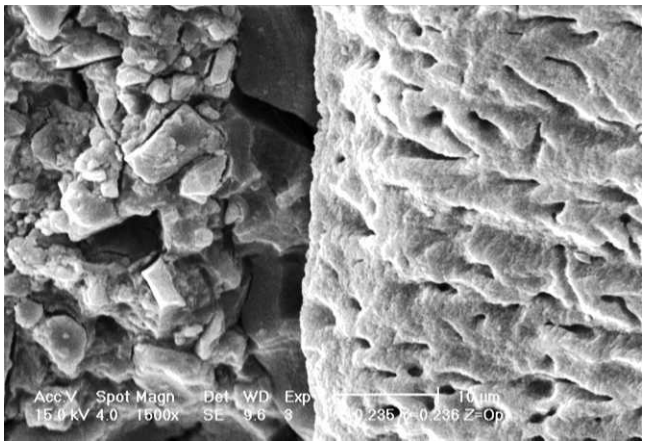

Figure 6. *Dentin/Fuji II LC interface in group 2. (Magnification = 1500×).*

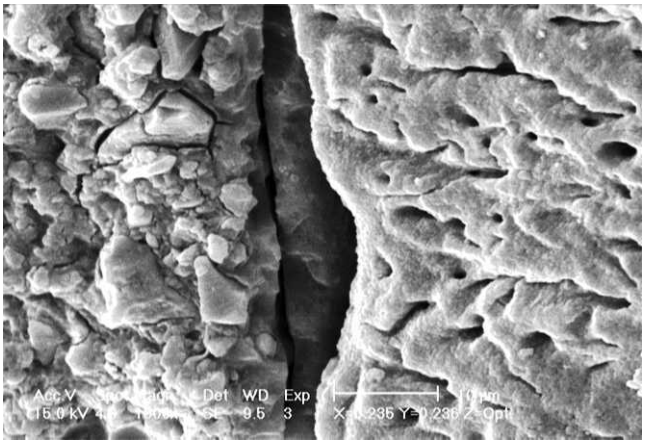

Figure 7. *Dentin/Fuji II LC interface in group 3. (Magnification = 1500×).*

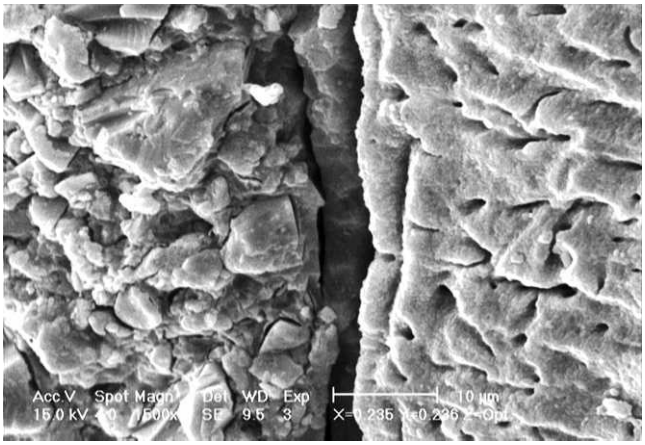

Figure 8. *Dentin/Fuji II LC interface in group 4. (Magnification = 1500×).*

9.34 ± 3.56 and 13.8 ± 5.18 MPa, respectively. The dentin bond strength values in the control group in the present study are consistent with the results of two previous studies.[25,26] In the second study,[26] the enamel and dentin bond strength values for Fuji II LC were reported to be approximately 10 and 13 MPa, respectively. Application of phosphoric acid has previously been reported to be effective in increasing the bond strength of light-cured glass ionomers to enamel.[27,28] It is probable that if a stronger acidic conditioner, such as phosphoric acid, is used for the enamel surfaces, a higher initial bond strength will be achieved when the material is light cured immediately after insertion, based on manufacturer's recommendations. In such a situation, it seems that it is better for the handling of the material to be similar to that with the composite resin, and delaying the light-activation procedure should be avoided so that acid-base reactions will not have an opportunity to proceed immediately; however, further studies are necessary in this regard.

In the present study, enamel bond strength increase and dentin bond strength decrease were observed in group 2 or groups with a two-minute delay, an increase in bond strength, that might be attributed to a greater opportunity of the material for acid-base reaction with the enamel surface, which is highly mineralized and rich in calcium and hydroxyapatite crystals. The shrinkage of glass ionomers has previously been reported to be around 3%.[5,18] Since delaying light activation has been parallel with a delay in material shrinkage and regarding the fact that a cavity conditioner with a weak acid was used in the present study, the results seem quite rational by taking into account the highly mineralized nature of enamel. As RMGIs are set by acid-base and polymerization reactions and each mechanism depends on reactant diffusion prior to gelation, it seems that the delay in RMGI light activation allows for greater acid-base reaction, reduces resin degree of polymerization[6], and results in an improvement in bond strength. However, in the case of dentin, it is probable that delaying the light-activation procedure makes the dentin surface more hydrophilic because the dentinal tubules are patent after acid conditioning with cavity conditioner. The cavity conditioner removes the smear layer, opening the dentinal tubules and making them more permeable.[22,24] Therefore, delaying the light-activation process contributes to the acid-base reaction of the material and probably decreases the concentration of the ions, decreasing the effect of the material on producing a stronger chemical bond.

In the present study, the effect of prewarming RMGI capsules on the bond strength to enamel and dentin was evaluated. Recent research has shown that conventional and light-cured glass ionomers set faster by the application of extrinsic energy sources such as ultrasonic energy or heat.[7,8,22] It is claimed that such energy application is efficacious in improving the surface topographical characteristics of glass ionomers in the early phases of setting reaction. O'Brein and others[18] evaluated the effect of application of two types of heat energy and one type of ultrasonic energy on the surface hardness of glass ionomer and reported that prewarming of glass ionomer capsules prior to mixing increases the hardness of the material compared to application of light or ultrasonic energy.

In the present study, group 3 enamel and dentin bond strengths decreased up to 30% and 45%, respectively, compared to the control groups. The

heating process in the present study was gradual: the process was carried out at 40°C for 90 seconds according to the procedure used in a study carried out by O'Brein and others.[18] This process is usually carried out at 55°C-60°C in the case of composite resin. Based on the results of the present study, the mechanical mixing of the material increased its temperature from 22°C to approximately 22.5°C. Since the material is supplied in powder and liquid forms, the prewarming process influences the temperature of both the powder and the liquid. After mechanical mixing, the temperature increased almost 0.5°C. After heating and mixing, the material temperature increased to 24°C (an increase of 2°C). Therefore, it appears that rising temperature results in a faster setting reaction, preventing the material from reacting properly with the substrate tissues. In addition, it is probable that heating helps compounds such as HEMA evaporate. Furthermore, the formation of poly-HEMA might be accelerated in the material while there is less opportunity for acid-base and free radical reactions.[18] Therefore, under the limitations of the present study, prewarming of hybrid glass ionomers is not recommended based on the results.

In the fourth group in the present study, the effect of two variables of pre-warming and delaying the light activation were evaluated. It was concluded that the effect of these two variables on the bond strength was not significant, which appears to be a logical result when the separate effect of each variable and the means of bond strength values in groups 2 and 3 and their comparison with bond strength values in group 4 are considered. Therefore, it is concluded that the prewarming variable had a negative effect on bond strength and yielded bond strength values similar to those in the control group (group 1) when it was combined with delayed light activation in group 4; this fact shows the insignificant positive effect of delaying the light-activation process compared to group 3.

Regarding dentin groups, it is probable that delaying the light-activation procedure and prewarming of the material can evaporate HEMA, help to rapidly form poly-HEMA, help the osmotic pressure and expel fluids out of the dentinal tubules, produce a more hydrophilic dentin surface with lower surface energy, dilute the ions present on the surface for acid-base reaction, and finally lead to an inappropriate surface for the polymerization of free radicals. Therefore, what happens in the case of RMGI is not recommended and is inconsistent with what happens in the case of composite resin, in which a higher flowability of composite resin is achieved, especially in the case of highly filled composite resins, resulting in a better bond strength and quality.[16,17] Simply stated, although prewarming of composite resins, especially posterior composites, has yielded positive results regarding bond strength and marginal seal,[16,17] the same results have not been achieved with RMGI.

Finally, the results of the present study showed that although the clinical behavior of RMGI regarding light activation according to manufacturer's instructions is similar to that of composite resins, changing the light-activation protocol and prewarming before mixing in particular do not necessarily yield the same results as those with composite resin. Therefore, more attention to the dual nature of the material and the theory of "network competition" is needed, especially in relation to its clinical behavior and its comparison with composite resins; in addition, further studies are necessary regarding the differences in the results with two principal tooth substrates (ie, enamel and dentin).

The results of the present study, in relation to the failure of RMGI in the groups under study, showed the effects of prewarming and prewarming/delaying light activation on increasing the rate of adhesive failures in the two enamel and dentin substrates in groups 3 and 4, which is consistent with the numerical bond strength values.

In the present study, given the limitations of SEM, the photomicrographs were not appropriate for comparison to extend the results to bond strength results. Certainly, meticulous TEM evaluations will be useful in this regard and are highly recommended.

CONCLUSIONS

Under the limitations of this in vitro study, the following may be concluded:

1. Delaying light activation of RMGI and/or prewarming prior to mixing in relation to dentin substrate cannot be recommended. The standard procedure recommended by the manufacturer yields greater bond strength.
2. Delaying the light-activation procedure and allowing for acid-base reaction in the RMGI material under study might have improved enamel bond strength after preparing enamel surfaces with a cavity conditioner, although further studies are highly recommended. Until then, it remains clinically advisable to use the conventional bonding directions recommended by the manufacturers.

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