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SHEAR BOND STRENGTH OF VISCOUS VERSUS RESIN MODIFIED GLASS IONOMERS TO DENTIN CONDITIONED WITH DIFFERENT PROTOCOLS

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ABSTRACT

Objectives: This study was conducted to examine the effect of conditioning protocols on shear bond strength of viscous glass-ionomer cement (GIC) Versus resin-modified glass-ionomer cement (RMGIC) to dentin.

Materials and methods: Forty caries free permanent molars were used. They were sectioned mesiodistally into two halves to obtain 80 specimens that were divided into eight groups (n=10) according to the conditioning protocol. In Group 1 and 2: Dentin was preconditioned with 10% polyacrylic acid either for 10 or 20 seconds and bonded to viscous glass ionomer (Fuji IX GP Extra) using a specially constructed mold (2 mm diameter X 3mm height). In Group 3 and 4: Preconditioning was followed as in group 1 and 2 but RMGI (Fuji II LC) was used. However, in group 5 and 6, dentin was preconditioned with 37% phosphoric acid either for 10 or 20 seconds followed by packing of viscous GI. Group 7 and 8: Preconditioning was done as previous followed by application of RMGI. The specimens were placed in a universal testing machine (Model 3345, Instron Corp., Canton, Mass., USA) with a cross head speed 0.5 mm/min and subsequently tested for shear bond strength SBS (MPa). Statistical analysis was done by using ANOVA and independent t test.

Results: SBS values revealed higher bond strength values for RMGI in comparison to viscous GI. Polyacrylic acid groups exhibited higher values than those of phosphoric acid. There was no significant difference in bond strength values of specimens conditioned by the two conditioners for either 10 or 20 seconds($P \leq 0.05$).

Conclusions: RMGI experienced high SBS values to dentin. The effect of acid used for dentin conditioning prior to viscous and RMGI can not be overemphasized.

KEY WORDS: viscous glass-ionomer cement, resin-modified glass-ionomer cement, conditioners, phosphoric acid, polyacrylic acid, shear bond strength test.

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INTRODUCTION

Glass-ionomer cements (GICs) were developed with unique properties which are the ability to chemically adhere to tooth structure, and release fluoride.[1] These characteristics enable them to have anticariogenic potential and good biocompatibility.[2] However, they have poor mechanical properties, such as low fracture strength, toughness and wear resistance as well as bad aesthetics and long setting time.[3] Thus, initial formulation of GICs underwent several modifications with the intent to improve handling, mechanical and physical properties.

Enhancement of GICs occurred with the introduction of high powder/liquid ratio products, alternatively termed 'packable' or 'high viscosity' GICs. These products set only by a conventional acid base reaction and have properties that exceed those of the resin modified systems. Setting is rapid, early moisture sensitivity is considerably reduced as well as solubility in oral fluids is minimized. According to manufacturers, the relatively higher viscosity is the result of the addition of polyacrylic acid to the powder and finer grain size distribution. Resin-modified glass-ionomer cement (RMGIC) is characterized by the addition of photo-activated methacrylate, and a small amount of resin, such as 2-HEMA or Bis-GMA, to the glass ionomer cement (GIC).[4,5] This modification provided controlled working time, less sensitivity to moisture, higher fracture and fatigue resistance, lower solubility and better aesthetics than viscous GICs.[6]

Bonding mechanism of RMGICs to dentin differs from that of viscous GICs due to the presence of resin components. It has two mechanisms which are achieved firstly by chemical adhesion with a hydroxyappatite-coated collagen and secondly through shallow hybridization of resin components into the created microporosities. Achieving intimate contact between the unset cement and the cavity walls is very crucial in obtaining high bond strength values. This intimacy can be provided by partial removal of smear layer using cavity conditioner. Polyacrylic acid is the most commonly used conditioner for viscous GICs because it is capable of cleansing the dentin surface without completely unplugging the dentinal tubules. It partially demineralizes the surface and creates microporosities which increases the surface area and promotes a chemical interaction of the polyalkenoic acid with residual hydroxyapatite.[7]

Phosphoric acid, also, could be used as a pre-treatment. It demineralizes the superficial dentin in variable thicknesses (depending on the time of application). This acid removes the hydroxyapatite, and consequently, prevents the formation of ion exchange layer. However, it is indicated to be used prior to RMGI application due to its resin component. The use of phosphoric acid with GICs/RMGICs has not been adequately explored.[8]

Shear bond strength assumes much importance for restorative materials clinically, because of the fact that the major dislodging forces at the tooth restoration interface have a shearing effect, hence high shear bond strength of a restorative material implies better bonding of that material to the tooth.[9] The purpose of this in vitro study was to evaluate the effect of different pretreatment protocols; Polyacrylic acid and phosphoric acid with different time of application on the shear bond strength of highly viscous GICs versus RMGIC to dentin. The null hypothesis tested was that the different pretreatment protocols did not affect the shear bond strength of GIC or RMGIC to dentin.

MATERIALS AND METHODS

A total of forty caries free human permanent molars were collected, thoroughly cleaned of soft tissue debris, calculus and stored in distilled water. Their radicular portion was removed one mm. below the CEJ, then, the coronal portion was sectioned mesiodistally into two halves using carborundum disc (Pico, Germany) under sufficient amount of water coolant. Each half was embedded in self-cure acrylic resin with the help of aluminum mold(3 cm in diameter). The surfaces were ground flat with a trimming machine (Handler, Model 32E, Westfield, USA) until superficial dentinal surface was exposed. Specimens were divided into eight groups (n=10) according to the predetermined dentin conditioning. (Materials, compositions and manufacturers are summarized in **Table 1**).

Group 1 and 2: Dentin was preconditioned with 10% polyacrylic acid either for 10 or 20 seconds, thoroughly rinsed for 10 seconds and gently air dried using oil free compressed air. Viscous glass ionomer (Fuji IX GP Extra) was activated and injected after mixing for 10 seconds into a specially constructed cylindrical teflon mold (2 mm diameter X 3mm height), fast set in 10seconds.

Group 3 and 4: the conditioning protocol for group 1 and 2 was followed, then, RMGI (Fuji II LC) was activated and injected after mixing for 10 seconds into the mold and light cured immediately for 20seconds using Bluephase C5 (Ivoclar Vivadent AG, Schaan, Liechtenstein).

Group 5 and 6: Dentin was preconditioned with 37% phosphoric acid either for 10second or 20 seconds. Then, rinsed for 20 seconds and gently air dried. Viscous glass ionomer (Fuji IX GP Extra) was packed.

Group 7 and 8: Preconditioned as in group 5 and 6. RMGI (Fuji II LC) was packed to dentin**.** All specimens were stored in distilled water for 24 hours before testing.

Shear bond strength testing

Specimens were mounted and secured with the tightening screws to the lower fixed compartment in the Instron universal testing machine (Model 3345; England) with a load cell of 5000 N. A chisel end was positioned as close as possible on the glass ionomer/dentin interface. The test was run at a crosshead speed of 0.5 mm/min until failure. Data were recorded using computer software Blue Hill 3 Instron version 3.3. The maximum load necessary to debond was recorded in Newton (N) and calculated in MPa as a ratio of Newton to surface area of the cylinder.

Statistical analysis

Data were presented as mean and standard deviation (SD) values. They were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests. Shear bond strength values (MPa) showed normal distribution. Three way analysis of variance ANOVA followed by Independent t-test were used to compare between the different tested restorative

TABLE (1) Materials used in this study, their composition and manufacturers:

Materials	**Material Composition**	**Manufacturers**
Viscous GI (Fuji IX GP Extra)	Fluoro-alumino silicate glass. Polyacrylic acid, polybasic carboxylic acid and distilled water	GC corp, Tokyo, Japan.
RMGI (Fuji II LC)	Powder: Fluoro-alumino silicate glass. Liquid: Polyacrylic acid(20%-25%); 2-hydroxyl ethyl methacylate. 30-35%; proprietary ingredient (5-15%) 2,2,4trimethyl hexa Methylene dicarbonate. (1-5%) powder/liquid:0/33g,0/085ml	GC corp, Tokyo, Japan.
Cavity Conditioner	20% polyacrylic acid, 3% Aluminum chloride $ALCl_3$ and distilled water.	GC corp, Tokyo Japan.
Scotchbond universal etchant	50-56 wt %water, 30-40 wt% phosphoric acid, synthetic amorohous silica, 1-5 wt%polyethylene glycol, 1-2 wt% Aluminum oxide	3MESPE, dental company, USA.

materials, pretreatment materials and time. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA) Statistics Version 22 for Windows.

RESULTS

Data reveal that the viscous GI (Fuji IX GP Extra) showed a lower significant value (3.21±0.41 MPa), (3.93±0.95 MPa) compared to RMGI (Fuji II LC) (5.94±0.66 MPa), (6.69±1.2 MPa) at p≤0.001 and p=0.004 when Polyacrylic acid was applied for 10 and 20 seconds, respectively. There was no significant difference between Fuji IX GP Extra (2.22±0.99 MPa) and Fuji II LC (2.44±0.93 MPa) at p=0.717 when phosphoric acid was applied for 10 seconds. Twenty seconds application of phosphoric acid prior to Fuji IX GP Extra showed a lower significant values (1.62±0.47 MPa) compared to Fuji II LC (3.03±0.39 MPa) at p=0.001, **table 2 and figure 1**.

TABLE (2) Mean, Standard deviation (SD) and level of significance for Shear bond strength values (MPa) for both restorative materials.

		Restorative material				P-value
		Fuji IX		Fuji II LC		
		Mean	SD	Mean	SD	
Polyacrylic acid)	10 Sec.	3.21	0.41	5.94	0.66	≤0.001*
	20 Sec.	3.93	0.95	6.69	1.20	0.004*
Phosphoric acid	10 Sec.	2.22	0.99	2.44	0.93	0.717 NS
	20 Sec.	1.62	0.47	3.03	0.39	0.001*

= Significant, NS=Non-Significant

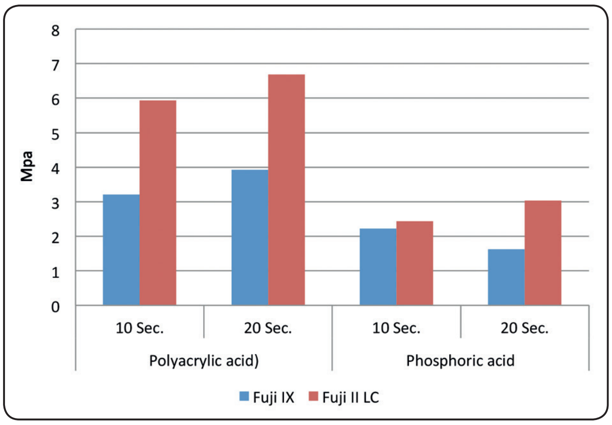

Fig. (1) Histogram showing the mean Shear bond strength (MPa) for Restorative material.

Conditioning agents data reveal that there was no significant difference between Polyacrylic acid (3.21±0.41 MPa) and Phosphoric acid (2.22±0.99 MPa) at p=0.071 with Fuji IX GP Extra for 10 seconds. While, the significant difference existed with 20 seconds application time and the SBS values were (3.39±0.95 MPa) and (1.62±0.47 MPa) respectively at p=0.001. A significant difference was evident between the conditioning agents with the RMGI. Polyacrylic acid reveals higher significant values (5.94±0.41 MPa) and (6.69±1.2 MPa) compared with phosphoric acid (2.44±0.93 MPa) and (3.03±0.39 MPa) for 10 and 20 seconds, respectively at p≤0.001, **table 3 and figure 2**.

TABLE (3) Mean, Standard deviation (SD) and level of significance for Shear bond strength values (MPa) for both conditioning agents.

		Conditioning agents				p-value
		Polyacrylic acid		phosphoric acid		
		Mean	SD	Mean	SD	
Fuji IX	10 Sec.	3.21	0.41	2.22	0.99	0.071 NS
	20 Sec.	3.93	0.95	1.62	0.47	0.001*
Fuji II LC	10 Sec.	5.94	0.66	2.44	0.93	≤0.001*
	20 Sec.	6.69	1.20	3.03	0.39	≤0.001*

= Significant, NS=Non-Significant

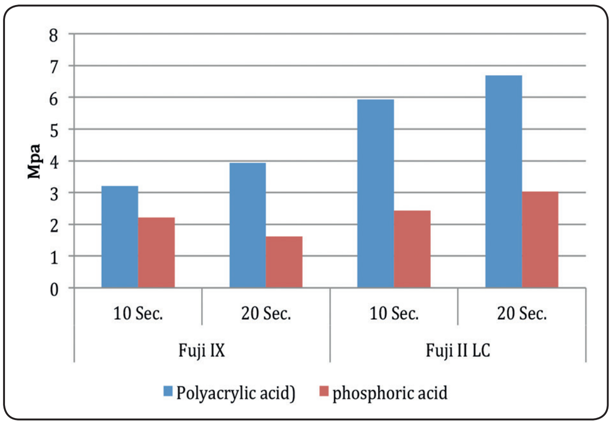

Fig. (2) Histogram showing the mean Shear bond strength (MPa) for both conditioning agents.

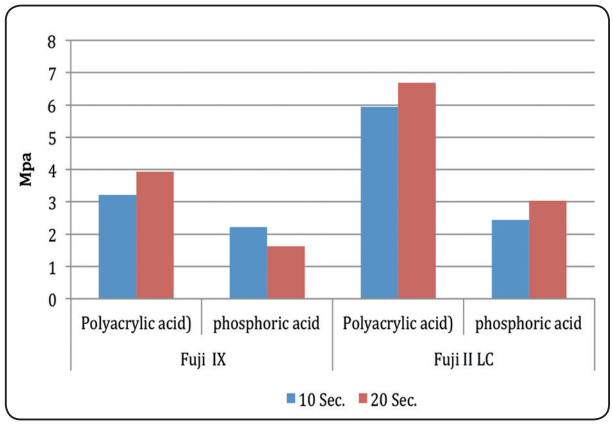

Fig. (3) Histogram showing the mean Shear bond strength (MPa) for both time of application.

SBS values reveal non-significant differences between 10 and 20 seconds time of application for Polyacrylic acid and phosphoric acid prior to either Fuji IX GP Extra or Fuji II LC at p=0.230, 0.261, 0.257 and 0.161, respectively,as shown in **Table 4 and figure 3**.

TABLE (4) Mean and Standard deviation (SD) and level of significance for shear bond strength values (MPa) for both time of application.

		Time				p-value
		10 Sec.		20 Sec.		
		Mean	SD	Mean	SD	
Fuji IX	Polyacrylic acid	3.21	0.41	3.93	0.95	0.230 NS
	phosphoric acid	2.22	0.99	1.62	0.47	0.261 NS
Fuji II LC	Polyacrylic acid	5.94	0.66	6.69	1.20	0.257 NS
	phosphoric acid	2.44	0.93	3.03	0.39	0.161 NS

****= Significant, NS=Non-Significant***

DISCUSSION

Glass ionomer is a promising material because of its unique biomimetic nature including chemical bond to the tooth structure and remineralizing ability. The bonding mechanism of the GICs to the dental hard tissues is very complex, and it differs for viscous GICs compared to RMGICs, [10] hence, two glass ionomer cements were selected in the study to resemble both types.

Pretreatment of the tooth substrate with different dentin conditioners plays an important role in improving glass ionomer bond strength and longevity.[11] Two conditioners were chosen, the Polyacrylic acid which is the most popular dentin conditioner and phosphoric acid. Poly acrylic acid has gained its popularity from its high biocompatibility and being one component of the GI, hence remnants from it will not affect GI setting reaction. It enhances dentin wettability, and controls hydration of dentin as it superficially demineralizes the smear layer. Moreover, it is capable of cleansing the dentin surface without completely unplugging the dentinal tubules. [12] The phosphoric acid was, also, used as it is one of the conditioners that produce dentin demineralization that varies according to its time of application,[13] which justify the selection of two conditioning times in the study.

The shear bond strength is a simple and widely used test to assess the bonding performance of restorative materials, particularly regarding the GICs, which present low bond strength, and other tests may offer great difficulty to be applicable.[14]

The results of the current study approved higher bond strength values of RMGI in comparison to viscous GIC, except when phosphoric acid was used for 10 seconds, there was no significant difference between the two types of glass ionomer. These results could be explained as mentioned formerly, in the introduction. The viscous glass ionomers bond to tooth substrate by ion-exchange while RMGIs bond to tooth substrate through both ion-exchange and micromechanical interlock (dual mechanism of adhesion), as presented before by several authors.[15-17] Moreover, the presence of light-activated resin component hydroxyethyl methacrylate (HEMA) with its superior wetting ability might also affect the bond strength. On the other hand, the slowness of acid-base reaction of the viscous GIC might have resulted in immaturity of the bond, [18] hence, the resultant bond strength was lower than that of RMGIC.

The none significant effect of 10 seconds application of phosphoric acid might be due to the ability of the viscous GIC to bond chemically with the hydroxyapatite that raised its bond strength to be close to that of the RMGIC. This bond strength was decreased after 20 seconds etching and was inferior than that of the RMGIC which might be due to the loss of considerable amount of hydroxyapatite.[19] These results are in agreement with Shebl et al, 2015,[14] and Suryakumari et al, 2012 [20], who found that mean shear bond strengths of light-cured RMGIC materials are significantly higher than that of conventional or viscous glass ionomer materials.

Regarding the effect of conditioning materials, phosphoric acid exhibited lower SBS values to dentin in contrast to polyacrylic acid, except when it was applied for 10 seconds with the viscous GIC, there was no significant difference between both conditioners. Phosphoric acid is considered an aggressive conditioner for dentin and it might result in microporosities deep to the extent that they could not be fully impregnated by the resin component of the RMGI. Moreover, it removed calcium ions beyond the level required for chemical bond to occur between the viscous GI and dentin substrate.[21] The results are in agreement with Parti et al 1992, who found that the use of polyacrylic acid on dentin increases shear strength value of GIC more than the use of another system for pretreatment, and phosphoric acid. [22]

In the contrary, Khoroushi, *et al* and Valente, *et al*. showed that phosphoric acid increases the SBS of RMGI in comparison to polyacrylic acid with RMGI. [23,24] The controversy could be attributed to the variability of substrates to be treated for each study. Moreover, Di Nicolo et al in 2007, used primer after phosphoric acid conditioning and found high SBS to dentin. Primer penetrated the created microporosities and light cured forming a stable well-formed hybrid layer prior to application of RMGI.[25]

Concerning the conditioning time, there was no significant difference on the shear bond strength between dentin conditioning for either 10 or 20 seconds by either polyacrylic acid or phosphoric acid. The insignificant effect of the increased time might be due to the limitation of the demineralizing effect of the conditioner by the buffer properties of hydroxyapatite.[26,27] These results come in agreement with Gordan VV, Kormaz et al. and El-Askary et al. who reported that increasing etching time of dentin had no significant effect on the bond strength of nano-filled RMGIC to dentin. [28-30] On the other hand, Yap et al.[16] and Tay et al.[19] reported that etching dentin with 37% phosphoric acid for 15 seconds causes a significant loss in the bond of GIC to dentin. This controversy might be attributed to the different materials used.

Further studies investigating the GI/ dentin interface after using different conditioning protocols are recommended. The null hypothesis was partially rejected as the type of acid affected the SBS and its time of application did not.

CONCLUSIONS

Under the conditions of the present study the following conclusions are evident:

1- RMGI experienced high bond strength to dentin.

2- Selection of the appropriate dentin conditioning prior to either viscous or RMGI is very important factor for obtaining high SBS.

3- Conditioning does not depend on the application time of the acid.

REFERENCES

1. Davidson CL. Advances in glass-ionomer cements. J Applied Oral Science 2006;14:3-9.
2. Nicholson JW, Czarnecka B. Role of aluminum in glass-ionomer dental cements and its biological effects. J Biomaterial Application 2009;24:293-308.
3. Mount GJ. Glass ionomer cements: past, present and future. Operative Dentistry 1994;19:82-90.
4. Mathis R, Ferracane JL. Properties of a glass-ionomer/resincomposite hybrid material. Dental Material. 1989;5(5):355-358.
5. Di Nicolo R, Shintome LK, Myaki SI, Nagayassu MP. Bond strength of resin modified glass-ionomer cement to primary dentin after cutting with different bur types and dentin conditioning. J Applied Oral Science. 2007; 15(5):459-464.
6. Shashirekha G, Jena A, Hegde J. Bond Strength of Light Activated Glass Ionomer With Different Conditioners on Human Dentin . International J scientificand technology research. 2012 ;1(9):26-29.
7. Poggio C, Beltrami R, Scribante A, Colombo M, Lombardini M. Effects of dentin surface treatments on shear bond strength of glass ionomer cements. Annalidi Stomatologia. 2014;V(1):15-22.
8. Burrow MF, Nopnakeepong U, Phrukkanon S. A comparison of microtensile bond strengths of several dentin bonding systems to primary and permanent dentin. Dental Material. 2002;18(3):239-245.
9. Pereira PNR, Yamada T, Inokoshi S, Burrow MF, Sano H, Tagami J. Adhesion of resin-modified glass-ionomer cements using resin bonding systems. J Dentistry. 1998;26 (5):478-485.
10. Watson T. Bonding of glass-ionomer cements to tooth structure. In: Davidson CL, Mjör IA, eds. Advances in glass-ionomer cements. Chicago: Quintessence International, 1999;121-136.
11. Powis DR, Folleras T, Merson SA, Wilson AD. Improved adhesion of a glass-ionomer cement to dentin and enamel. J Dental Research. 1982; 61:1416-1422.
12. Poggio C, Beltrami R, Scribante A, Colombo M, Lombardini M. Effects of dentin surface treatments on shear bond strength of glass ionomer cements. Annalidi Stomatologia. 2014;V(1):15-22.
13. Nakanuma K, Hayakawa T, Tomita T, Yamazaki M. Effect of the application of dentin bonding agent on the adhesion between the resin-modified glass-ionomer cement and dentin. Dental Material. 1998;14(4):281-286.
14. Shebl EA, Etman WM, Genaid TM, Shalaby ME. Durability of bond strength of glas-ionomers to enamel. Tanta Dent J. 2015;12(1):16–27.
15. Glasspoole EA, Erickson RL, Davidson CL. Effect of surface treatments on the bond strength of glass ionomers to enamel. Dent Mater 2002;18:454-62.
16. Yap S, Yap A, Teo C, Ng J. Polish retention of new aesthetic restorative materials over time. Singapore Dent J 2004;26:39-43.
17. Coutinho E, Van Landuyt K, De Munck J, Poitevin A, Yoshida Y, Inoue S, et al. Development of a self-etch adhesive for resin-modified glass ionomers. J Dent Res 2006;85:349-53.
18. Durability of bond strength of glass-ionomers to enamel
19. Tay FR, Smales RJ, Ngo H, Wei SH, Pashley DH. Effect of different conditioning protocols on adhesion of a GIC to dentin. J Adhes Dent 2001;3:153–167. 17.
20. Suryakumari Nujella BP, Choudary MT, Reddy SP, Kumar MK, Gopal T. Comparison of shear bond strength of aesthetic restorative materials. Contemp Clin Dent 2012; 3:22-6.
21. Yap AU, Tan AC, Goh AT, Goh DC, Chin KC. Effect of surface treatment and cement maturation on the bond strength of resin-modified glass ionomers to dentin. Oper Dent 2003;28: 728–733. 27.
22. Prati C, Montanari G, Biagini G, Fava F, Pashley DH. Effects of dentin surface treatments on the shear bond strength of Vitrabond. Dent Mater. 1992;8(1):21–6.

23. Khoroushi M, Hosseini-Shirazi M, Soleimani H. Effect of acid pre-conditioning and/or delayed light irradiation on enamel bond strength of three resin-modified glass ionomers. Dental Research J 2013; 10 (3): 328-336.

24. Valente RM, De Rijk WG, Drummond JL, Evans CA. Etching conditions for resin-modified glass ionomer cement for orthodontic brackets. American J Orthod Dentofacial Orthop 2002;121:516-520.

25. Di Nicolo R, Shintome LK, Myaki SI, Nagayassu MP. Bond strength of resin modified glass-ionomer cement to primary dentin after cutting with different bur types and dentin conditioning. J Applied Oral Science. 2007;15(5):459-464.

26. Duarte Jr S , Perdigão J, and Lopes MM.: Effect of Dentin Conditioning Time on Nanoleakage. Operative Dentistry, 2006; 30-4, 500-511

27. Gordan VV.: Effect of conditioning times on resin-modified glass-ionomer bonding. Am J Dent.,2000 Feb;13(1):13-6. Abstract

28. Hamlin P, Lynch E, Samarawickrama D. Effect of a new conditioning agent on dentin. American J Dentistry 1990;3:119–124.

29. Tyas MJ, Burrow MF. Adhesive restorative materials: a review. Aust Dent J. 2004;49(3):112–21.

30. Korkmaz Y, Ozel E, Attar N, Ozge Bicer C. Influence of differ- ent conditioning methods on the shear bond strength of novel light-curing nano-ionomer restorative to enamel and dentin. Lasers Med Sci 2010;25:861–866. 4.

31. El-Askary FS, Nassif MS. The effect of the preconditioning step on the shear bo nd strength of nano-filled resin-modified glass-ionomer to dentin. Eur J Dent 2011; 5:150–156.