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Bond Strength of Resin Modified Glass Ionomer Cement and Resin Composite to Four Pulp Capping Biomaterials

*Fouad Salama[1], Fahad Alahaidib[2], Mohammed AlShamrani[3], Latifa Alhowaish[1], Rehab Allam[1]

[1]*Department of Pediatric Dentistry and Orthodontics, College of Dentistry, King Saud University, Riyadh, Kingdom of Saudi Arabia*
[2]*Dental Interns, College of Dentistry, King Saud University, Riyadh, Kingdom of Saudi Arabia*
[3]*General Dentist, Private Clinic, Riyadh, kingdom of Saudi Arabia*
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Correspondence address: Professor Fouad Salama

Abstract
Objective: *The purpose of this in vitro study centred on assessing the shear bond strength (SBS) of four pulp-capping biomaterials, namely two resin-modified glass-ionomer/Photac Fil/Fuji II LC, calcium-hydroxide/Urbical LC, and mineral trioxide aggregate/ProRoot to resin composite/Filtek Z250 XT and Photac Fil, with and without surface treatment.*
Methods: *Forty-eight specimens from each restorative material were prepared for each pulp capping biomaterials. Each group was divided into four individual subgroups of 12, with each one in line with the restorative material (Filtek Z250 XT and Photac Fil) and the surface treatment (with or without phosphoric acid etchant and polyacrylic acid conditioner). The measurement of shear bond-strength was carried out through the application of a universal testing machine at across head speed 0.5 mm/min. The analysis of the data was carried out through the application of a one-way ANOVA and a post hoc Tukey's test ($P<0.05$).*
Results: *For Filtek Z250 XT etched with phosphoric acid, the highest (mean$\pm$SD) SBS was recorded for Photac Fil (23.700$\pm$1.258) whereas the lowest SBS was recorded for ProRoot (4.241$\pm$0.560). For Filtek Z250 XT without phosphoric acid etching, the highest SBS was recorded for Photac Fil (18.642$\pm$0.871) while the lowest SBS was recorded for ProRoot (4.067$\pm$0.551). For Photac Fil etched with polyacrylic acid conditioner the highest and lowest SBS were recorded for Photac Fil (20.498$\pm$0.890) and ProRoot (4.733$\pm$0.501). For Photac Fil without polyacrylic acid conditioner etching the highest and lowest SBS were recorded for Photac Fil (16.345$\pm$0.722) and ProRoot (4.405$\pm$0.757). A significant difference in the shear bond strength was identified between subgroups of Photac Fil, Fuji II LC, and Urbical LC ($P=0.0001$), although this was not significant between ProRoot subgroups ($P=0.291$).*
Conclusions: *The Photac Fil etched with polyacrylic acid conditioner and Filtek Z250 XT etched with phosphoric acidexhibited higher shear bond strength compared to non-surface treatment. For Photac Fil and Filtek Z250 XT with and without surface treatment, ProRoot (mineral trioxide aggregate) demonstrated low shear bond strength.*
Keywords: *Bond-Strength, Pulp Capping Biomaterials, Resin Composite, Resin-Modified Glass-Ionomer*

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I. Introduction

Restorative dentistry has the key objective to restore and maintain dentition health through the most appropriate restorative treatment modalities in an effort to ensure the pulp is protected and its function restored.[1] Should the pulp demonstrate exposure, there is a risk to the overall preservation and success of vitality in the long-term.[2] Accordingly, in the case of deep carious lesions, treatment is complex for the dental clinician.[2] When a pulp is exposed in a sterile environment, it is possible for it to repair itself and accordingly create a dentinal bridge. Nonetheless, when there is bacteria present, pulp disease and ultimately pulp necrosis more likely to occur.[1] In efforts to ensure the pulp is protected from chemical, thermal and other noxious stimuli, pulp capping materials are applied.[3] Accordingly, a suitable bond between the pulp-capping agent and restorative material is critical due to the fact that a lack of a suitable seal can mean bacteria will penetrate the pulp, thus causing failure in the pulp capping procedure.[1] In the past, such treatments demonstrated the use of calcium hydroxide; however, this has not often been the case owing to a lack of certainty in the results, with failure to adhere to dentin and observed dissolving.[1,4] Nonetheless, although the aforementioned issues are inherent in calcium hydroxide compounds, they remain recognised as the gold standard pulp capping materials in human

teeth and are considered in line with the assessment of new materials.[4] Much attention has been directed towards Mineral Trioxide Aggregate (MTA) in terms of its capacity as a pulp capping biomaterial, notably as a result of its ideal biological characteristics and recognised preference in terms of histological/clinical results.[5] MTA is known to be a calcium silicate-based dental material, which was reported in dental scientific research.[6] Throughout the past ten years, much more attention has been centred on MTA, particularly in the fields of pediatric and endodontic dentistry. MTA is known to encompass enhanced features, both physical and regenerative.[5] Studies carried out on MTA have provided findings to recommend the application of the material in different clinical situations, including the capping of pulps with reversible pulpits, furcation repair, internal resorption treatment, pulpotomy procedures, apexification, and obturation.[7-10] Nonetheless, MTA is known to require a very long setting time, which is one of the main disadvantages associated with its use.[11] There have been a number of ongoing efforts centred on eradicating this issue; regardless, however, it is believed that the more favourable aspects of MTA will be reduced should other elements be added or removed in mind of reducing the setting time.[11] One other popular biomaterial in pulp capping is that of resin-modified glass-ionomer cements,[5] and there is much evidence to support such materials in providing the complete inhibition of secondary caries.[12]Furthermore, behaviors resembling dentin under thermal stimuli are recognised.[13] This aspect is acknowledged as fundamental in terms of the material's thermal and mechanical loading.[12] In restorative dentistry, there is a large number of tooth-coloured restorative materials available for the purpose of esthetic restoration, where most may be assigned to two distinct groups, namely glass-ionomer cements and resin composites.[14] After their initial consideration and use, recognition have been afforded to resin composites as a result of their esthetically pleasing appearance and stability across the oral environment.[15] Following pulp therapy, it is fundamental that there be immediate restoration so as to ensure an effective coronal seal is both crated and maintained, with treatment outcomes recognised as affected by the adhesion of pulp biomaterials and restorative materials.[2] Through the initial acceptance of new pulp biomaterials, the placing of restorative materials over them is critical, with the strength of the bond between the pulp capping and restorative material acknowledged as critical in terms of filling quality and restoration success.[2] Furthermore, suitable bonding of the restorative materials to pulp capping biomaterials is known to create an adhesive joint, which has the ability to evenly distribute stress across the whole area of the bond.[16] Owing to the recognition afforded to the bond between the final restorative material and the pulp capping material, this bond has been highlighted as crucial.[1] Number of investigations have been completed examining the strength of the bond between various pulp capping biomaterials and restorative materials through the use of various bonding approaches.[17,18] Only a limited number of studies have considered surface treatment effects in line with the strength of the bond apparent between restoration and capping material.[16] Consequently, the objective of this *in vitro* investigation is centred on assessing the shear bond strength of four pulp-capping biomaterials, namely two resin-modified glass-ionomer/Photac Fil/Fuji II LC, calcium-hydroxide/Urbical LC, and mineral trioxide aggregate/ProRoot to resin composite/Filtek Z250 XT and Photac Fil, with and without surface treatment (with or without phosphoric acid etchant and polyacrylic acid conditioner). The null hypothesis tested in this investigation was there is no difference in the shear bond strength of the four pulp-capping biomaterials tested in this study to resin composite/Filtek Z250 XT and Photac Fil, with and without surface treatment.

II. Materials And Methods

In this study, four pulp capping biomaterials, along with a resin composite and resin-modified glass-ionomer restorative materials have been used. Table 1 shows a summary of the chemical composition and application procedures of the materials used in this study. Forty-eight specimens from each restorative material were prepared for each pulp capping biomaterials, each of which had a diameter measuring 5mm whilst depth was 2mm using cylindrical metal molds. The molds were placed onto a glass microscopic slide and the materials were placed in the mold, and then Mylar® strip (Mylar Uni-Strip, Caulk/DENTSPLY, Milford, DE, USA) and a glass microscopic slide were place on the top of the restorative material surface. The glass slide was pressed until it has a tight contact with the metal mold to flatten the surface. The metal mold has a notch in the bottom surface of each specimen to facilitate identification of the top surface where surface was used for surface treatment and bonding. Every specimen was light cured (Elipar Highlight, 3M ESPE, St. Paul, MN, USA) on each side according to the instructions of the manufacturer. The glass slide and Mylar® strip were removed. All specimens were prepared at room temperature (approximately 25ºC). Following preparations, all specimens were stored in containers containing 30 ml of distilled water (pH 6.8) in an incubator/humidifier (GI2 So-Low Cincinnati, OH, USA) at 37°C for 24 hours. Each specimens was embedded in cylindrical mold filled with acrylic resin (Ortho-Jet, Lang Dental MFG. Co., Inc., IL, USA) in preparation for bonding. The specimens of each restorative material were divided into 4 groups of 12 specimens according to the restorative material and surface treatment (with or without phosphoric acid etchant and polyacrylic acid conditioner). For all groups (1-4) of both restorative materials, subgroup "a" was etched with phosphoric acid, subgroup "b" was etched with polyacrylic acid conditioner, and subgroups "c" and 'd" were not etched and left as control. Groups 1a, 1b, 1c,

1d, 2a, 2b, 2c, and 2d were bonded to the resin-composite. While groups 3a, 3b, 3c, 3d, 4a, 4b, 4c, and 4d were bonded to the resin-modified glass-ionomer. For the pulp capping biomaterials: Two resin-modified glass-ionomer/Photac Fil/Fuji II LC, calcium-hydroxide/Urbical LC, and mineral trioxide aggregate/ProRoot were prepared according to the instructions provided by the manufacturers. The assigned pulp capping material were inserted into a standard PVC tube with internal diameter of 2mm and a height of 2mm which was placed perpendicularly to surface of each specimen. Subsequently, the specimens were stored for a period of 72 hours at a temperature of 37ºC with 100% humidity prior to shear bond strengths testing. The shear bond strengths was measured with a crosshead speed of 0.5 mm/min using a universal testing machine (Instron, model no. 8500, Illinois Tool Works Inc., Norwood, MA, USA). The analysis of the data was carried out through the application of a one-way ANOVA and a post hoc Tukey's test. All statistical analyses were set with a significance level of $p<0.05$. The statistical analysis was carried out with SPSS V16.0 (Statistical Package for the Social Sciences, SPSS, Chicago, Illinois, USA).

III. Results

The mean and standard deviation of shear bond strength values in MPa of all groups are presented in Tables 2-5.

Group1: Filtek Z250 XT etched with phosphoric acid:

For Filtek Z250 XT etched with phosphoric acid, the highest (mean ± SD) shear bond strength was recorded for Photac Fil, followed by Urbical LC and Fuji II LC (23.700 ± 1.258, 22.359 ± 0.952, and 15.242 ± 0.661 respectively) whereas the lowest shear bond strength was recorded for ProRoot (4.241 ± 0.560) (Table 2).

Group 2: Filtek Z250 XT without phosphoric acid etching:

For Filtek Z250 XT without phosphoric acid etching, the highest shear bond strength was recorded for Photac Fil, followed by Urbical LC and Fuji II LC (18.642 ± 0.871, 17.173 ± 0.728, and 11.176 ± 0.812 respectively) while the lowest shear bond strength was recorded for ProRoot (4.067 ± 0.551) (Table 3).

Group 3: Photac Fil etched with polyacrylic acid conditioner:

For Photac Fil etched with polyacrylic acid conditioner, the highest shear bond strength was recorded for Photac Fil, followed by Urbical LC and Fuji II LC (20.498 ± 0.890, 17.388 ± 0.766, and 11.489 ± 0.655 respectively) while the lowest shear bond strength was recorded for ProRoot (4.733 ± 0.501) (Table 4).

Group 4: Photac Fil etched without polyacrylic acid conditioner:

For Photac Fil without polyacrylic acid conditioner etching, the highest shear bond strength was recorded for Photac Fil, followed by Urbical LC and Fuji II LC (16.345 ± 0.722, 12.315 ± 0.848, and 8.637 ± 0.713 respectively) while the lowest shear bond strength was recorded for ProRoot (4.405 ± 0.757) (Table 5).

Figure 1 shows comparison of mean SBS of Filtek Z250 XT and Photac Fil with and without surface etching and bonded to the four pulp capping biomaterials. A significant difference in the shear bond strength was identified between subgroups of Photac Fil, Fuji II LC, and Urbical LC (P=0.0001), although this was not significant between ProRoot subgroups (P=0.291). Table 6 shows comparison of shear bond strength of Filtek Z250 XT and Photac Fil and the four-pulp capping biomaterial with the statistical significance.

IV. Discussion

The null hypothesis was rejected in this study, as there were differences in the shear bond strength of the four pulp-capping biomaterials tested in this study to resin composite/Filtek Z250 XT and Photac Fil, with and without surface treatment. When pulp is involved in restorative treatments but there is unclear results of the clinical and radiographic examinations concerning the type and severity of pulpal damage, proper diagnosis may be difficult.[19]Nonetheless; all efforts need to be made in order to ensure pulp vitality. Methods of treatment, including pulp capping, aim to maintain pulp through bacteria eradication and also with the application of biocompatible materials in order to achieve a strong barrier centred on protecting against bacterial microleaking.[8]Ensuring pulpal health is both maintained and sealed throughout the process is critical.[8] Following pulp capping, suitable restoration is required, with the primary option usually resin composite, particularly when restorative treatment is required in the esthetic region. In contrast, however in situations when there is a lack of enamel available around preparation, a good restorative material is resin-modified glass-ionomer. For various restorations, it has been found that the bond strength between the restorative material and the pulp biomaterials plays a key role in the sealing provided by the restoration as well as in the overall success of the treatment.[5,20] In the present study, the Photac Fil and Filtek Z250 XT with surface treatment (phosphoric acid etchant or polyacrylic acid conditioner) was found to achieve the highest shear bond strength. A number of studies have provided insight to support optimal SBS with total etch adhesive systems when applied with MTA for various periods of time.[21-23] In this regard, phosphoric acid has been recognised in creating a more in-depth and more retentive micro porosity when compared with even the strongest self-etching adhesives.[23-25] Moreover, restorative processes with MTA should be delayed between 72 and 96 hours following MTA mixing so as to enable the material to achieve its optimum physical properties[23-25] which was the case in this study. This study

was not concerned with evaluating the waiting time of SBS of restorative material when combined with pulp biomaterials owing to the fact that other studies have previously considered this. For example, in another study evaluated the SBS of MTA to resin composite and glass-ionomer cement with a total etch adhesive system, and reported mean SBS of 5.8 and 8.9 MPa with resin composite and glass-ionomer cement respectively.[19]Furthermore, the SBS of resin composites were compared in another investigation through the application of various adhesive systems to MTA found that one step self-etch adhesive provided an SBS value equating to 5 MPa.[22]The results of the aforementioned study are seen to be well aligned with the bond strengths reported in MTA groups in this study. Due to the potential negative effects in terms of establishing the risk and time associated with MTA dissolving following acid etching, it was suggested that the placement of resin composite was not recommended on fresh MTA,[26] that was considered in this study. A scanning electron microscopic assessment centred on the effects of acid-etching on MTA surface characteristics provided the insight that, throughout this process, the disordered structure and spindle-shaped crystals are removed; accordingly, around the crystals, the selective removal of the matrix would result in a sponge-like surface recognised as appropriate when bonding to resin restorations without impacting the overall MTA structure.[23,27]

In this study, SBS of MTA to etched resin composite and resin-modified glass-ionomers were 4.241 and 4.733 MPa, whilst SBS of MTA to resin-modified glass-ionomers and resin composite without etching were4.067 and 4.405 MPa. Such a recorded range may be compared particularly in the case of the lowest mean to that which has been detailed in the literature across those studies comparable with the presentinvestigation.[28,29] Across MTA subgroups, the difference in SBS was not found to be statistically significant. However, SBS of MTA when the material is used in pulp capping to the restorative materials adopted in this study, is recognised as not adequate when considering its capacity to resist forces whilst also ensuring the restoration is leakage-free. The SBS required were recognised as falling between 17 MPa and 20 MPa, whereas the bond strengths in case of MTA ranged between 4.067 and 4.733 MPa are seen to be notably lower than this particular control range.[21,30,31]When examining the results gathered from the tests carried out in this study, and in consideration to the material subgroups, it can be seen that the greatest mean SBS recorded was that of the resin-modified glass-ionomers (Photac Fil) when a pulp capping material applied with a resin composite (Filtek Z250 XT) was used as a restorative material with etching the surface with phosphoric acid (23.7 MPa. Importantly, such a strength is recognised as clinically acceptable and is viewed as being able to resist contraction forces and any margin defects to follow.[21,30,31]The findings of this study provide support to show that resin-modified glass-ionomers is able to provide the greatest shear bond strength both with and without surface treatment. For Photac Fil, the lowest recorded SBS was seen to be 16.345 MPa, while the greatest was 23.700. Such an observation is seen to be aligned with the results obtained in anotherstudy.[1]The greater shear bond strength demonstrated by resin-modified glass-ionomers could be due to the chemical bond identified between resin composite and resin-modified glass-ionomers which has been validated in other studies.[32,33] Importantly, resin-modified glass-ionomer is known to encompass a liquid resin component, which is made up of polyacrylic acid (30%); HEMA (30-35%), UDMA (10%) and comphorquinone (1%); notably, the liquid's photoinitiated reaction may be achieved following the mixing of the liquid with fluoroaluminosilicate glass powder; follow by acid base reaction, which is known to complete the reaction between the liquid and powder.[34] As a result of the resin component being present in resin-modified glass-ionomers, it is also possible that there may be copolymerization of unreacted resin double bonds throughout the setting reaction with the adhesive systems. This is recognised as having the propensity to increase the material's overall bond strength when contrasted with other tested pulp capping materials (i.e. MTA, calcium hydroxide) that do not include any resin components in their chemical composition.[1,32]

In the current study, the other type of resin-modified glass-ionomer (Fuji II LC) as a pulp capping material under both resin composites and resin-modified glass-ionomer cements demonstrate a SBS falling within a less-than-acceptable range, both with and without surface treatment (11.176-15.242 MPa). In a prior investigation, dentin-glass ionomer cement bond testing provided results to demonstrate conventional glass-ionomer cements as providing greater bond strengths to dentin when contrasted alongside resin-modified glass-ionomers and calcium hydroxide liners.[35] When considering the shear bond strength of glass-ionomer cement to dentin in the work discussed above, it was found to be 5MPa, with the authors recognising this bond strength as being most critical as opposed to the material's tensile strength.[35] Nonetheless, it is fundamental to recognise that the researchers did not consider the SBS between the various pulp biomaterials and the restorative material, as has been ensured in the current study. Due to the fact that glass-ionomer cement is commonly recognised as biomimetic material, with mechanical properties recognised as comparable to those offered by dentin, it is well positioned to replace the lost dentin.[36] The most critical consideration in the case of conventional glass-ionomer cements is their low strength when made to experience load. As such, resin-modified glass-ionomer cements have been devised in mind of dealing with this problem, with their mechanical properties improved.[35]]Calcium hydroxide provides pulpal compatibility and ability in terms of stimulating reparative dentin formation.[35] Nonetheless, the conventional formulations of calcium hydroxide are known to offer various unfavourable

characteristics: for example, with time they are known to disappear, may demonstrate inadequate mechanical properties, and do not provide a strong enough barrier against microleakage.[35,37] Accordingly, there has been the introduction of light-activated calcium-hydroxide products, which have achieved various improvements in terms of physical properties.[35] Upon applying light cure calcium hydroxide as a pulp capping material across both resin composite and resin-modified glass-ionomer in two different circumstances (notably both with and without surface treatment), SBS recorded was seen to fall within the range of 12.315 and 22.359 MPa. In this regard, it may be seen that there are three subgroups of Urbical LC, which are able to fulfil the range of acceptable shear bond strengths (17-20 MPa). A low shear bond strength was only recognised in the Photac Fil restorations without surface etching group. It is regrettable that a comparable study examining the SBS of Urbical to resin composite and resin-modified glass-ionomers could not be found. Nonetheless, in a work carried out recently, which analysed the shear bond strength of calcium hydroxide to dentin through the application of resin composite restorations, only very low SBS could be achieved (2.19 MPa). However, when it comes to interpreting such data, caution is necessary owing to the fact that the objective was focused on the testing of the dentin-liner SBS, which falls beyond the scope of the current study.[35]

In consideration to pulp capping biomaterials to restorative materials and their bond strength, it is recognised that this may depend on the substances' physical and chemical properties.[27] One study carried out showed that a conventional glass-ionomer cement, along with its superior sealing ability, could be the most preferential intra-orifice barrier material.[38] Importantly, there is a pressing need to determine the most ideal bond strengths between materials, in addition to restorative materials and tooth structure. Taking the best material properties and combining them would always be the objective when aiming to identify the most promising restoration in mind of maintaining pulpal health. One of the limitations of this study was the use of one resin composite and two resin-modified glass-ionomer restorative materials only. It would be beneficial if more and different restorative materials and etch-and-rinse as well as self-etch adhesive systems is tested. Furthermore, application of more pulp capping materials such as glass-ionomer cement and Biodentine. Another limitation is measuring bond strength within a short period. It would be beneficial if bond strengths occur after aging the specimens and thermocycling. The results of this investigation should consider the *in vitro* setting of the study, which may not simulate cumulative long-term effect *in vivo*. In addition, the clinical condition in the mouth is not easy to mimic in the laboratory.[39] However, in this *in vitro* study, standardization of experimental conditions was advantage and the research does describe a number of positive links between *in vitro* efficacy and clinical efficacy. In addition, the results demonstrated a clear correlation between shear bond strength of the four tested pulp-capping biomaterials to resin composite and resin-modified glass-ionomerwith and without surface treatment.

V. Conclusions

Within the limitations associated with the present *in vitro* study, the following conclusions may be drawn:

1. The resin-modified glass-ionomers (Photac Fil) etched with polyacrylic acid conditioner and resin composite (Filtek Z250 XT) etched with phosphoric acid exhibited higher shear bond strength compared to non-surface treatment.
2. A higher shear bond strength is attained when the surface of the tested pulp capping materials bonded to the restorative materials after application of phosphoric acid etchant or polyacrylic acid conditioner.
3. For Photac Fil and Filtek Z250 XT with and without surface treatment, ProRoot (mineral trioxide aggregate) demonstrated low shear bond strength.
4. Photac Fil and Filtek Z250 XT with surface treatment and Filtek Z250 XT without surface treatment demonstrated clinically acceptable and highest shear bond strength when bonded to Urbical LC (calcium hydroxide) and Photac Fil (resin-modified glass-ionomer).

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Table 1: Chemical composition and application procedures of the materials used in this study

Material	Composition	Mode/Steps of Application
ProRoot® MTA (Mineral Trioxide Aggregate) DENTSPLY, Tulsa, OK, USA	Bismuth oxide, tricalcium silicate, dicalcium silicate, calcium dialuminate, and calcium sulfate dehydrated	Mixed powder/liquid ratio: 1/3
Urbical LC® (Calcium-hydroxide) Promedica, Neumuenster, Germany	Dimethacrylates, calcium hydroxide, pigments, initiators, silicate fillers	Apply Urbical LC directly above the needed area, and remove any excess, light cure the material for 40 seconds
Filtek™ Z250 XT, 3M ESPE, MN, USA	BIS-GMA (Bisphenol A diglycidyl ether dimethacrylate), UDMA (urethane dimethacrylate), and Bis-EMA (Bisphenol A polyethylene glycol diether dimethacrylate), light-cured resin is filled with 60% (volume) silica/zirconia. The filler particle size distribution is 0.01 µm to 3.5 µm with an average particle size of 0.6 µm	Apply the bonding agent and light cure for 10 sec, apply Filtek™ Z250 XT and light cure for 20 sec
Photac™ Fil QuickAplicap™ (Resin-modified glass-ionomer), 3M ESPE, MN,USA	Glass powder, surface modified with 2-propenoic acid, 2 methyl-3-(trimethoxysilyl)propyl ester,bulk material	Activate the capsule and then mix it with an amalgamator 10 sec (working time > 2 minute), light cure for 20 sec
GC Fuji II LC® CAPSULE (Resin-modified glass-ionomer), GC America, IL,USA	Powder: Aluminofluorosilicate glass. Liquid: Polyacrylic acid, tartaric acid, distilled water, camphorquinone, dibutyl hydroxy toluene, and three resin complex (mainly HEMA)	Activate the capsule and then mix it with an amalgamator 10 sec (working time > 2.5minute), light cure for 20 sec

Table 2. Mean ± SD of the SBS of Filtek Z250 XT etched with phosphoric acid and bonded to the four pulp capping biomaterials

Filtek Z250 XT etched with phosphoric acid	Pulp Capping Biomaterial	Mean ± SD
	Photac Fil	23.700 ± 1.258
	Urbical LC	22.359 ± 0.952
	Fuji II LC	15.242 ± 0.661
	ProRoot	4.241 ± 0.560

Table 3. Mean ± SD of the SBS of Filtek Z250 XT without phosphoric acid etching and bonded to the four pulp capping biomaterials

Filtek Z250 XT without phosphoric acid etching	Pulp Capping Biomaterial	Mean ± SD
	Photac Fil	18.643± 0.871
	Urbical LC	17.173± 0.728
	Fuji II LC	11.176± 0.812
	ProRoot	4.067± 0.551

Table 4. Mean ± SD of the SBS of Photac Fil etched with polyacrylic acid conditioner and bonded to the four pulp capping biomaterials

Photac Fil etched with polyacrylic acid conditioner	Pulp Capping Biomaterial	Mean ± SD
	Photac Fil	20.498± 0.890
	Urbical LC	17.388± 0.766
	Fuji II LC	11.489± 0.655
	ProRoot	4.733± 0.501

Table 5. Mean ± SD of the SBS of Photac Fil without polyacrylic acid conditioner etching bonded to the four pulp capping biomaterials

Photac Fil without polyacrylic acid conditioner etching	Pulp Capping Biomaterial	Mean ± SD
	Photac Fil	16.345 ± 0.722
	Urbical LC	12.315 ± 0.848
	Fuji II LC	8.637 ± 0.713
	ProRoot	4.405 ± 0.757

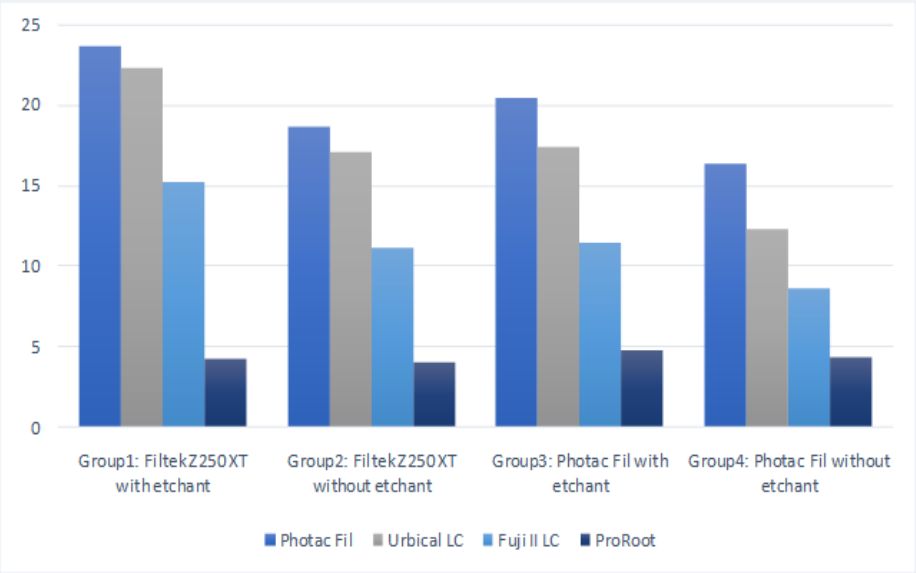

Figure 1. Comparison of mean SBS of Filtek Z250 XT and Photac Fil with and without surface etching and bonded to the four pulp capping biomaterials

Table 6. Comparison of shear bond strength of Filtek Z250 XT and Photac Fil and the four pulp capping biomaterialwith the statistical significance

Pulp Capping Biomaterial	Filtek Z250 XT [Resin Composite] & Photac Fil [Resin-Modified Glass-Ionomer]	*P* value
MTA [ProRoot]	RMGIC Conditioner	0.0241*
	Resin Composite Etch	
	RMGIC No Conditioner	0.3973
	Resin Composite No Etch	
Calcium Hydroxide [Urbical LC]	RMGIC Conditioner	0.0001*
	Resin Composite Etch	
	RMGIC No Conditioner	0.0001*
	Resin Composite No Etch	
RMGIC[Photac Fil]	RMGIC Conditioner	0.0005*
	Resin Composite Etch	
	RMGIC No Conditioner	0.0006*
	Resin Composite No Etch	
RMGIC [Fuji II LC]	RMGIC Conditioner	0.0001*
	Resin Composite Etch	
	RMGIC No Conditioner	0.0002*
	Resin Composite No Etch	

* Significant $p<0.05$
RMGIC = Resin-Modified Glass-Ionomer

*Fouad Salama. "Bond Strength of Resin Modified Glass Ionomer Cement and Resin Composite to Four Pulp Capping Biomaterials." IOSR Journal of Dental and Medical Sciences (IOSR-JDMS) 16.12 (2017): 68-75