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Bond strength of resin-modified glass ionomer cement after residual film contamination

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Abstract:

Residual film from fit indicator materials may reduce the bond strength of RMGIC to dentin and the effectiveness of different surface treatments in removing this film is unclear. Fifty extracted molars were divided into five groups of 10 each, first group had no fit-checker or surface treatment, while the other groups received different surface treatments after fit-checker application. Shear bond strength was tested using an Instron machine and analyzed with Tukey's test. The results showed that the 17% EDTA group showed high shear bond strength (2.008 MPa), while the group without surface treatment showed low (0.885 MPa), indicating that EDTA was effective in removing silicone residue and improving bond strength.

Keywords: Shear bond strength, surface treatment, silicone residue, resin-modified glass-ionomer cement

Background:

In clinical practice, one of the most common challenges is improper seating of the crown on a prepared tooth and fit indicators are used to identify internal interferences [1]. Silicone fit indicators, are applied to the internal surface of castings, may leave a thin residual film that can potentially reduce the retention of the cemented restoration [2]. Resin-modified glass-ionomer cement (RMGIC) achieves adhesion to tooth structure through chemical bond and a micromechanical bond similar to that of dentin bonding agents [3]. This class of dental cement overcomes two important flaws of conventional GIC; sensitivity to early moisture contamination and high solubility [4]. The disclosing procedure may compromise the outcome of a dental restoration by affecting the bonding of the luting cement to both the tooth surface and the crown [5]. For this purpose, the combined use of sodium hypochlorite (NaOCl) and a chelating agent such as ethylenediaminetetraacetic acid (EDTA) is recommended [6]. Therefore, it is of interest to evaluate whether residual silicone affects the shear bond strength (SBS) of RMGIC to dentin and, in this case, dentin surface treatments with 17% EDTA, 10% citric acid and 5% NaOCl influence this bond strength.

Materials and Methods:**Study sample and design:**

A total of 50 (n = 50) extracted human molar teeth were collected and stored in 3% hydrogen peroxide solution for 1 week. The occlusal surface of all the specimens were grounded flat to expose the dentin using a model trimmer (801 S, Silfradent S.R.L,

Italy). Later, the radicular portion of all the specimens were embedded in an auto-polymerizing acrylic resin block leaving the coronal portion exposed. The specimens were divided into five groups consisting of 10 specimens (n = 10) in each group. Group-1 (Gr-1) acts as a control group where fit checker (FC) was not applied and no surface treatment (ST) was done. For the remaining groups, silicon fit-checking material (Fit Checker™ Advanced, GC America Inc. IL, USA) was applied on the exposed dentin surface and was peeled-off after 2 minutes after the material sets as per the manufacturer's instructions (Figure 1). Surface treatment was done using an applicator brush for about 1 minute and later rinsed with water and moisture was controlled using tissue paper (Figure 2). In group-2 (Gr-2), FC was applied on the dentin surface without ST. For group-3 (Gr-3) specimens, FC was applied and ST by 17% EDTA solution (Prevest DenPro, DE, USA) was done. In group-4 (Gr-4), FC was applied and ST was done using 10% citric acid solution (Ultradent Products Inc. UT, USA). For specimens in group-5 (Gr-5), FC was applied and ST with 5% NaOCl (Parkas, Septodont, France) was done. A polyvinyl prefabricated mold of 3X3 mm (height X diameter) was positioned on the flattened tooth surface and RMGIC was mixed, placed in the mold and held under hand pressure following manufacturer's instructions. The mold was removed 10 minutes once the cement was set. All the specimens were prepared in the similar manner, later were subjected to SBS test using a universal testing machine. The specimens were adjusted in the universal testing machine (Instron 3400, Norwood, MA, USA) and force was applied onto the cement parallel to the occlusal surface of the tooth at a

crosshead speed of 0.5mm/minute (**Figure 3**). The load at which the fracture occurred was noted by the monitor automatically connected to the testing machine. SBS was calculated using the formula; SBS (MPa)=Failure load(N)/Surface area (mm²). The maximum force needed to debond the specimen was recorded in Newton's (N).

Statistical analysis:

The statistical data was analysed using Statistical Package for the Social Sciences (SPSS) version 22.0 (IBM® SPSS® Armonk, NY, USA). The percentages, means and standard deviations were computed separately. One-way Analysis of Variance (ANOVA) and Tukey's pair-wise comparison was used in the present study.



Figure 1: Peeling of fit checker



Figure 2: Surface treatment was done with 17% EDTA solution by applicator brush

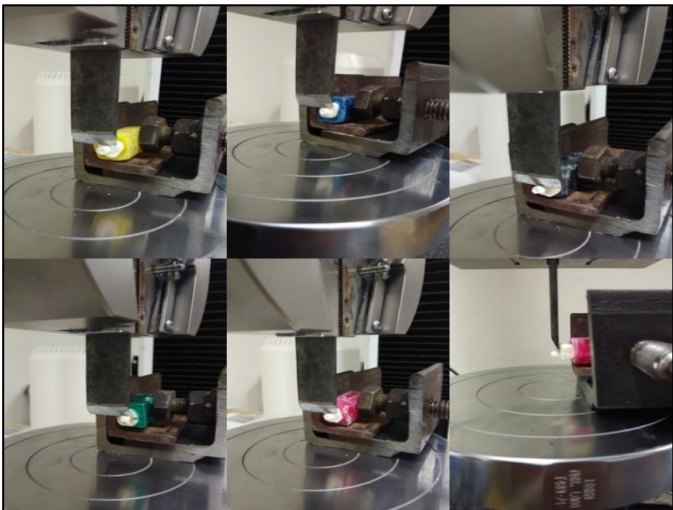


Figure 3: Testing the shear bond strength using universal testing machine

Results:

Table 1 presents descriptive Univariate statistics. Significance of mean shear bond strengths of specimens for all the groups was shown in **Table 2**. Since, ANOVA test reflected significant dissimilarity in the mean performance levels of five groups, Tukey's multiple comparison tests was used for pair-wise comparison of differences amongst means of each group (**Table 3**). The statistical significance level was established at p<0.05. The intergroup comparison of mean shear bond strength (MSBS) of five groups with independent Student's t-test showed; when group-1 was compared to group-2 (p=0.000), group-4 (p=0.000) and group 5 (p=0.007) and group-2 compared to group-3, there was a statistically significant difference (**Table 3**).

Table 1: Mean, standard deviation and standard error of shear bond strength across five specimen groups

Groups	Specimens	Mean	SD	SE
Group 1	10	2.576	0.974454	0.30817
Group 2	10	0.885	0.37527	0.11867
Group 3	10	2.008	0.62455	0.19750
Group 4	10	1.267	0.649941	0.20553
Group 5	10	1.528	0.454968	0.14387

Discussion:

A silicone disclosing medium has been made explicitly used for evaluating the casting adaptation. When using silicone fit indicator, it leaves a residual film in metal retainers that significantly reduces the core retention formed as a by-product of silanol (Si-O-H) group from the silicone paste. So, this should be removed from the intaglio surface of the casting either by using an organic solvent or by air abrading with aluminum oxide or with gentle prophylaxis before cementation. By doing so, this will not only remove the residual silicone film, but also the inorganic debris, tubule exudate and other debris from the dentinal surface thus allowing more intimate contact of the luting cement to the tooth surface [2, 7].

Table 2: Comparison of mean shear bond strength among groups suing one-way ANOVA

Source of variations	Sum of squares	Degree of freedom	Mean sum of squares	F-Value	P-Value
Between the groups	17.324	4	4.331	10.263664	0.000005
In the groups	18.9888	45	0.422		
Total	36.3128	49			

Table 3: Intergroup comparison of mean shear bond strength values using Tukey's post-hoc test

Intergroup Comparison	Mean Difference (I-J)	Std. Error	Significance	95% Confidence Interval	
				Lower Bound	Upper Bound
Group 1					
Group 2	1.69100*	0.29051	0.000	0.8655	2.5165
Group 3	0.56800	0.29051	0.304	-0.2575	1.3935
Group 4	1.30900*	0.29051	0.000	0.4835	2.1345
Group 5	1.04800*	0.29051	0.007	0.2225	1.8735
Group 2					
Group 1	1.69100*	0.29051	0.000	-2.5165	-0.8655
Group 3	1.12300*	0.29051	0.003	-1.9485	-0.2975
Group 4	0.38200	0.29051	0.683	-1.2075	0.4435
Group 5	0.64300	0.29051	0.193	-1.4685	0.1825
Group 3					
Group 1	.56800	0.29051	0.304	-1.3935	0.2575
Group 2	1.12300*	0.29051	0.003	0.2975	1.9485
Group 4	0.74100	0.29051	0.097	-.0845	1.5665
Group 5	0.48000	0.29051	0.473	-.3455	1.3055
Group 4					
Group 1	1.30900*	0.29051	0.000	-2.1345	-0.4835
Group 2	0.38200	0.29051	0.683	-.4435	1.2075
Group 3	0.74100	0.29051	0.097	-1.5665	0.0845
Group 5	0.26100	0.29051	0.896	-1.0865	0.5645
Group 5					
Group 1	1.04800*	0.29051	0.007	-1.8735	-.2225
Group 2	0.64300	0.29051	0.193	0.193	1.4685
Group 3	0.48000	0.29051	0.473	0.473	0.3455
Group 4	0.26100	0.29051	0.896	0.896	1.0865

So, the current study was intended to determine the effect of the presence of silicone residue on the shear bond strength of RMGIC to dentin and the removal of silicone residue by various surface treatments like 17% EDTA, 10% citric acid and 5% NaOCl on dentine surface would show any impact on shear bond strength between RMGIC and dentine surface or not. When tooth surfaces are cut or abraded, a layer of the resulting debris will be deposited on the surface called ‘the smear layer’. This layer reduces the surface energy leading to less adhesion thus, preventing the interaction between underlying dentin and high viscosity resin cement. Hence, it is recommended for removing the smear layer to improve the bond strength. There are many agents prescribed and put forward to remove this smear layer [8, 9]. In order to maximize the adhesion of the restorations to the tooth surface, an increasing demand for newer materials made RMGIC into existence. When compared with conventional GICs, they have greater adhesive properties. It was proven in many studies that, RMGIC has better adhesion properties, it can bond in moist environments; eliminating the need to isolate the teeth during bonding and fluoride releasing properties and a study revealed that smear layer is considered as a major barrier for bonding of RMGICs, particularly to dentin. So, in order to optimize the bonding between the tooth and the restoration, surface treatments should be performed to clear the smear layer [10]. In the current study, we used RMGIC as the cement of choice which is similar to other studies [11]. In a study, three different types of GIC’s; Fuji IX, Ketac Molar Easymix and Maxxion was used [8]. Panahandeh *et al.* assessed

the shear bond strength of four acetone-based one-bottle adhesive systems to enamel and dentin [12]. *Clearfil SE Bond*; a light-cured bonding system was used in another study [13]. In our study, NaOCl and EDTA were used separately as part of surface treatment, whereas, a combination of 17% EDTA with 5.25% NaOCl was suggested as effective root canal irrigation in a study [14]. Gr-2 specimens showed lower MSBS values (0.885MPa) when compared with that of Gr-1 indicating the possible presence of silicone residue film on dentine surface after silicone disclosing procedure which correlates with a study [12]. As the SBS was decreased from Gr-1 to Gr-2, this necessitates the surface treatment for the removal of silicone residue which is similar to the study done by Hammad and Al Amri in their study; they evaluated the efficiency of two fit indicating materials and various cleaning methods on the retention of crowns [7]. In the current study, the most commonly used agents to remove the smear layer such as 17% EDTA, 10% citric acid, 5% NaOCl solution was used. The MSBS values obtained for Gr-3 was more compared with Gr-2, Gr-4 and Gr-5 suggesting that the surface treatment by 17% EDTA showed higher shear bond strength than with 10% citric acid & 5% NaOCl. EDTA is effective in removing the silicone residue and cleansing the dentin surface and increases the SBS between the dentin surface and RMGIC. The results were in accordance with previous studies [2]. The MSBS value of Gr-4 was 1.267 MPa; when compared to Gr-2 SBS of Gr-4 was increased. The higher SBS observed with citric acid treatment compared with the untreated fit-checker group suggests that citric acid conditioning may have

modified the dentin surface; however, the improvement was not statistically significant. When comparing the SBS of Gr-4 with Gr-3 and Gr-5 showed lesser bond strength indicating decreased efficiency of 10% citric acid in removing silicone residue on dentine compared to that of 17% EDTA and 5% NaOCl solution, when compared with other studies [15, 16].

Conclusion:

Residual silicone film significantly reduced shear bond strength between resin-modified glass-ionomer cement and dentin surface suggesting of removal of residual silicon film. Chemical surface treatment using 17% EDTA showed high mean shear bond strength, followed by 5% sodium hypochlorite and 10% citric acid solution indicative of its efficiency in removing the smear layer for better bonding between the indirect restorations and the prepared tooth surface.

Study limitations:

Limitations of the current study being, using the scanning electron microscope to analyze dentin surface can further explore the effect of surface treatments on the removal of silicone residue from the dentinal surface by providing the visibility of action of chelating agents on dentin surface, smear layer, dentinal tubules and presence of any remnants of RMGIC. Use of stereomicroscope can analyze the type of failure of bond or mode of bond failures between the dentinal surface and RMGIC.

Clinical significance:

When using silicone disclosing procedure to check the fit of indirect restorations, not only the inner surface of the restoration must be surface treated, but also cleaning the dentin surface prior to cementation will aid in improving the prosthesis' retention.

Advancement to knowledge:

The study identifies the adverse effect of silicone residue on bonding and demonstrates that 17% EDTA is the most effective surface treatment for enhancing RMGIC adhesion to dentin.

Ethical clearance:

This study was conducted in accordance with the local committee guidelines and policies of Institutional Ethics Committee. The protocol of present study was approved by the

Research Ethics Committee of G. PullaReddy Dental College & Hospital (Ethical number: GPRDCH/PROSTHO/04/2025).

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Conflict of interest:

The manuscript has not been published or submitted as a preprint in any platform.

Data availability:

The data used to support the finding of this study can be made available upon request to the corresponding author.

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