ORIGINAL RESEARCH

The Impact of Various Pretreatment Agents on Shear Bond Strength between Self-adhesive Resin Cement and Dentin: An *In Vitro* Study

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Abstract

Background: Self-adhesive cement has found widespread use in various applications within prosthetic dentistry. Several conditioning agents, including phosphoric acid, polyacrylic acid, citric acid, and tannic acid, can influence the self-adhesive resin cement's bond strength. These agents have been studied for their effects on improving the self-adhesive resin cement's bond strength in different dental procedures.

Materials and methods: A total of 24 recently extracted maxillary premolar teeth were carefully chosen for the present study. To protect their integrity, these teeth were cleaned and kept in distilled water until the procedure was performed. After that, the samples were split into four groups, each with 24 teeth. Group I was the control group, which received no surface treatment. In group II, 10% polyacrylic acid was scrubbed on the prepared tooth surface for a duration of 20 seconds. Group III involved the application of tannic acid (15%) on the prepared teeth for a period of 10 minutes. Lastly, group IV received a surface treatment with phosphoric acid (37%) applied for 15 seconds. After the surface treatment was completed, Rely X U200 cement was bonded to the prepared tooth surfaces in all four groups. The samples were put through a test utilizing a universal testing machine, which delivers controlled force to gauge the shear bond strength.

Results: A statistically significant difference ($p < 0.05$) was found between the groups when the Kruskal-Wallis test was used to compare the shear bond strength between the groups. The Mann-Whitney *U*-test was used to do further *post hoc* pairwise comparisons. According to the findings, group II's shear bond strength was much greater than that of the other three groups. There were no appreciable variations between group I and group III, group I and group IV, or group III and group IV, though. In conclusion, while no significant differences were discovered among the other pairwise comparisons, group II showed a considerably larger shear bond strength compared to the other three groups.

Conclusion: The self-adhesive resin cement's bond strength to dentin was significantly improved by pretreating the dentin with 10% polyacrylic acid. This finding indicates that using polyacrylic acid as a conditioning agent can effectively improve the adhesive properties of the cement, leading to a stronger bond between the cement and dentin surface.

Keywords: Bond strength, Citric acid, Phosphoric acid, Polyacrylic acid, Resin cement, Self-adhesive, Universal testing machine.

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Introduction

Self-adhesive resin cement consists of an intricate blend of functional monomers, solvents, and water, all of which exhibit a strong affinity for water due to their high hydrophilicity. This characteristic allows the adhesive resin to permeate the smear layer. Self-adhesive cement has found extensive use in various prosthetic dentistry applications. The main advantages of this material include easy application, reduced postoperative sensitivity, and lower susceptibility to moisture. Nevertheless, certain self-adhesive resin cement have exhibited a restricted ability to etch and establish a deep interaction with dentin.[1,2] Although these cement eliminate the need for pretreating the dental surface, several research studies propose that removing the smear layer using an acidic solution can improve the self-adhesive resin cement's bond with the dentin.[3,4] Different conditioning agents, including phosphoric acid, polyacrylic acid, citric acid, and tannic acid, can affect the self-adhesive resin cement's bond strength. To increase the bond between dentin and glass ionomer cements (GICs), polyacrylic acid is frequently utilized as a dentin conditioner. Phosphoric acid creates a wettable surface by removing the smear layer. The utilization of tannic acid aims to alter or eliminate the smear layer and improve the bond between GICs and dentin by promoting enhanced collagen cross-linking.

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This original research aimed was to assess how 15% tannic acid, 10% polyacrylic acid, and 37% phosphoric acid affect the self-adhesive resin cement's shear bond strength.

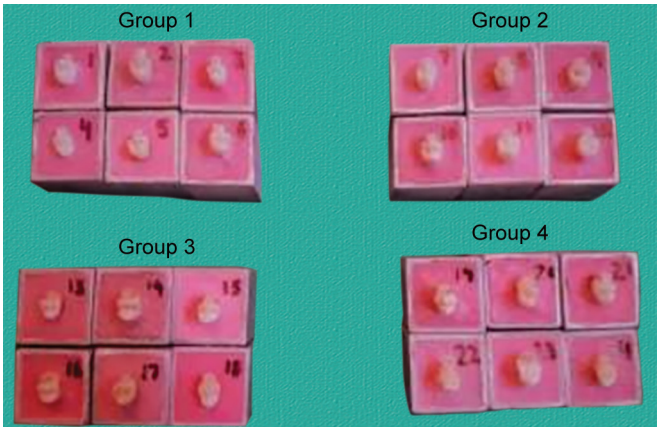

Fig. 1: Distribution of samples

Materials and Methods

Sample Selection

A total of 24 recently extracted maxillary premolar teeth were carefully chosen for the present study. To protect their integrity, these teeth were cleaned and kept in distilled water for storage up until the procedure was performed.

Sample Preparation

Each chosen tooth's roots were encased in a polymethyl methacrylate (PMMA) resin block, leaving only the tooth's crown protruding from the cementoenamel junction (CEJ) of the resin block. This was done to facilitate easy handling of the specimens during the load testing process.

Tooth Preparation

A buccal reduction of 2 mm was performed using a bur. Self-limiting three-tier depth cutting disks of 2 mm were used to determine the depth of the cuts. Standard grit round-end diamond burs were then used to complete the preparation while maintaining a depth of 2 mm. Under running water, the dentin surface was polished using silicon carbide paper with a standard grit. The preparation process consisted of removing the buccal enamel surface from each tooth at a perpendicular angle to the tooth's long axis using a water-cooled cylindrical diamond bur (SS White, USA).

Distribution of Samples

The samples (n = 24) were divided into four different groups (Fig. 1) as follows:

- Group I: The control group did not have the prepared tooth surface treated in any way. They went straight through the bonding process without any more phases.
- Group II: For 20 seconds, 10% polyacrylic acid was administered to the tooth surface after it had been prepared. The surface was then washed for 30 seconds with distilled water. The tooth surface was then dried to prepare it for bonding.
- Group III: The teeth in this group received an application of a 15% tannic acid solution, which was left on for 10 minutes. After rinsing with distilled water, the teeth were dried by the air for 3–5 seconds.
- Group IV: The teeth were treated with phosphoric acid (37%) for 15 seconds before being rinsed with distilled water.

Bonding Self-adhesive Resin Cement to the Tooth Surface

After surface treatment, RelyX U200 cement was bonded to the prepared tooth surface in all groups. The self-adhesive resin cement was applied to the tooth surface using a plastic ring with a 3 mm diameter and a 2 mm height. A curing light was used to cure the resin cement cylinder for 3 seconds after it had been inserted into the ring. After the light curing, the resin cement was allowed to chemically cure for 5 minutes.

Storage of Samples

Before the bond strength testing, the prepared specimens were stored at room temperature in a standard saline solution.

Shear Bond Strength

The samples were put in a universal testing machine to assess the shear bond strength (specifically, the Instron Corp. model located in Canton, Mass.). The test was conducted using a knife-edge loading head. The teeth were positioned in such a way that the knife-edged loading head was perpendicular to the self-adhesive resin cement (SARC) cylinder, positioned 1 mm away from the tooth surface. The experiments were carried out up until a crosshead speed of 1.0 mm/min caused the resin cement cylinder to come away from the tooth. A computer linked to the Instron machine during the testing procedure recorded the outcomes of each test. Using the formula L/A, where L is the load in Newtons (N) and A is the adhesive area, the shear bond strength value, expressed in MPa (megapascals), was obtained. The mean failure load and standard deviation (SD) for each group were computed using the recorded data.

Statistical Analysis

The gathered information was placed into an Excel spreadsheet and thoroughly checked to make sure there were no errors or missing items. The Statistical Package for Social Sciences (SPSS) version 21 was used to analyze the data. The mean and standard deviation were used to summarize the variable, and graphs were produced using Microsoft Excel. The Shapiro-Wilk test was used to determine if the data were normally distributed. Nonparametric tests of significance were used for inferential statistics because the data did not conform to the assumptions of a normal distribution.

Results

Intergroup comparison of Shear bond strength

Shear bond strength					
Group	*Mean*	*N*	*Standard deviation*	*p^a-value*	*p^b-values of Post hoc pairwise comparison*
I	4.58	6.00	2.15	<0.0001, S	1*2 – 0.022, S
II	7.50	6.00	1.12		1*3 – 0.195, NS
III	2.68	6.00	0.82		1*4 – 0.971, NS
IV	4.18	6.00	1.88		2*3 – <0.001, S
					2*4 – 0.008, S
					3*4 – 0.381, NS

[a]Kruskal-Wallis test, [b]Mann-Whitney *U* test

The Kruskal-Wallis test was used to compare the shear bond strength between groups, and it showed that there was a statistically significant difference ($p < 0.05$) between the groups. After that, pairwise comparisons using the Mann-Whitney *U* test

were performed *post hoc*. In comparison to the other three groups, the results showed that group II had a much higher shear bond strength. There were no appreciable variations between group I and group III, group I and group IV, or group III and group IV, though. Compared to the other three groups, group II showed a considerably higher shear bond strength, in conclusion.

Discussion

The utilization of self-etching/self-adhesive luting agents simplifies the cementation technique and helps reduce postoperative sensitivity and technique sensitivity. In this original research study, the efficiency of bonding self-adhesive resin cement to the dentin surface was evaluated using a macro-shear bond strength method. Both the thickness of the smear layer and the depth of the smooth dentin surface was attempted to be standardized in order to assure accurate results while minimizing any confounding variables. Comparing the effects of polyacrylic acid, tannic acid, and phosphoric acid on the shear bond strength of self-adhesive resin cement to dentin was the main goal of this in vitro investigation.[5]

According to the kind of surface treatment used, a total of 24 samples were generated for this investigation and divided into four groups. The initial group acted as the control and had its surface left untouched prior to bonding. The surfaces of the second, third, and fourth groups were treated, respectively, with 10% polyacrylic acid, 15% tannic acid, and 37% phosphoric acid. The specimens were not subjected to thermocycling in order to assess the binding strength between dentin and self-adhesive resin cement under normal circumstances.

According to the results of shear bond strengths in this study, the application of RelyX U200 to dentin without surface treatments yielded a shear bond strength of 4.58 MPa, which was similar to the findings of a previous study. Self-adhesive resin cement bonds to the tooth substrate primarily by a chemical reaction between the calcium in the hydroxyapatite of the tooth structure and the acidic monomers present in the cement. Self-adhesive resin cement, in contrast to other adhesive solutions, is unable to entirely eradicate the smear layer, develop resin tags within the tooth structure, or produce a clearly defined hybrid layer. As a result, the primary source of adhesion for its bonding mechanism is the chemical reaction between the acidic monomers and the tooth substrate.

In the current study, the group that underwent treatment with polyacrylic acid exhibited the highest mean shear bond strength value.[6] Polyacrylic acid is a gentle acid frequently employed as a cavity-cleaning agent during the restoration of tooth cavities using glass ionomer materials. It partially eliminates the smear layer while leaving smear plugs within the dentinal tubules. This process facilitates improved chemical interaction with restoration materials by releasing calcium and phosphate ions onto the dentin surface. Conversely, both the control group (without any surface treatment) and the phosphoric acid-treated group displayed significantly lower mean shear bond strength values compared to the polyacrylic acid-treated group.

Tannic acid, however, had a marginally adverse effect on bond strength when compared to the control group, even though the difference was not statistically significant. The initial bond strength was also somewhat, but not significantly, decreased when various tannic acid concentrations and application periods were examined. Tannic acid exerted an astringent effect on both the smear layer and the peritubular dentin, but only partially removed the smear layer.

The study had some limitations, such as variations in the quality of the human teeth used and the potential loss of dentin fluid protein due to tooth extraction. These factors may have affected the bonding performance of the resin cement. Additionally, errors could have occurred during the application of the cement, despite efforts to standardize the test procedures. It is important to note that shear bond testing assesses the quality of adhesion, while other parameters such as retention form, marginal integrity, and clinical micro-leakage are essential for evaluating the long-term performance of a resin cement system in a clinical setting.

Conclusion

The following inferences can be made based on the methodologies used and the study's limitations:

- Self-adhesive resin cement's shear binding strength to dentin is within the range considered clinically acceptable.
- Compared to dentin without any surface treatment, dentin treated with polyacrylic acid on the surface had a higher shear bond strength.
- The self-adhesive resin cement's average shear bond strength to dentin without surface preparation was 4.58 MPa. The shear bond strength dramatically increased to 7.50 MPa after dentin was treated with 10% polyacrylic acid, outperforming the other three groups.
- Self-adhesive resin cement to dentin mean shear bond strengths were measured at 2.68 MPa and 4.18 MPa, respectively, with surface treatments of 15% tannic acid and 37% phosphoric acid.
- In summary, 10% polyacrylic acid pretreatment of dentin enhances the bond strength of self-adhesive resin cement to dentin.

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