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Effect of Gel and Solution Forms of Phosphoric Acid on Shear Bond Strength of Composite Resin To Dentin- An in Vitro Study

[1]Dr. S. Devaganesh, CRRI, Department of Conservative Dentistry and Endodontics, Tagore Dental College and Hospital, Rathinamangalam, Chennai, Tamil Nadu, Dr. M.G. R Medical University, India

[2]Dr. C. S. Shobana, Reader, Department of Conservative Dentistry and Endodontics, Tagore Dental College and Hospital, Rathinamangalam, Chennai, Tamil Nadu, Dr.M.G.R Medical University, India

[3]Dr. Sokkalingam Mothilal Venkatesan, HOD, Department of Conservative Dentistry and Endodontics, Tagore Dental College and Hospital, Rathinamangalam, Chennai, Tamil Nadu, Dr.M.G.R Medical University, India

[4]Dr. Vishnu Prasanna S G, Senior Lecturer, Department of Conservative Dentistry and Endodontics, Tagore Dental College and Hospital, Rathinamangalam, Chennai, Tamil Nadu, Dr.M.G.R Medical University, India

[5]Dr. Sangita.I, Senior Lecturer, Department of Conservative Dentistry and Endodontics, Tagore Dental College and Hospital, Rathinamangalam, Chennai, Tamil Nadu, Dr.M.G.R Medical University, India

[6]Dr. Nikesh Sakthi, Senior Lecturer, Department of Conservative Dentistry and Endodontics, Tagore Dental College and Hospital, Rathinamangalam, Chennai, Tamil Nadu, Dr.M.G.R Medical University, India

Corresponding Author: Dr. C. S. Shobana, Reader, Department of Conservative Dentistry and Endodontics, Tagore Dental College and Hospital, Rathinamangalam, Chennai, Tamil Nadu, Dr.M.G.R Medical University, India

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Abstract

Introduction: Acid etching plays an important role in improving the retention of composite resin to the tooth by increasing the surface roughness and better penetration of the dentin bonding agent into the tooth substrate. Solution form of acid etchant has better surface wetting property than gel form whereas gel form has the advantage of ease of application.

Aim: To evaluate the shear bond strength of composite resin to dentin subjected to two different viscosities of Phosphoric acid etchant.

Methodology: Forty non-carious, intact human maxillary premolars that were recently extracted were selected for the study. The prepared specimens were mounted on self-curing polymethyl methacrylate resin to embed the root portion. The occlusal surfaces of the teeth were ground

using a water-cooled trimming wheel to create flat surfaces at a depth of 1.5 mm from the cuspal tip. The teeth were then randomly divided into four groups of ten specimens each, based on the type of etchant used. Group I received Etching Gel (Prevest Denpro Actino), Group II used Etching Liquid (Prevest Denpro Actino), Group III used Etching Gel (Prime Dental), and Group IV used Etching Liquid (Prime Dental). For bonding, Prevest Denpro Fusion Bond 5 was applied to the specimens in Groups I and II, where as Prime Dental Restorite Bond 5 G was applied to the specimens in Groups III and IV, following the manufacturers' instructions. Filtek Z350 composite (3M) was placed in increments on all 40 specimens and cured for 20 seconds. The specimens were stored in a distilled water bath at a controlled temperature of 37°C for 24 hours. Finally, each specimen underwent shear bond strength analysis using a Instron Testing Machine at a crosshead speed of 1.0 mm/minute.

Statistical Analysis: The difference in shear bond strength was calculated using One-way ANOVA and Paired Sample T test. P-value >0.05

Results: On intragroup and intergroup comparison, Group 4 had the highest mean maximum force (33.1380 N), followed by Group 2 (29.4510 N), Group 3 (20.8050 N), and Group 1 (16.9990 N). There was a statistically significant difference in maximum force among the groups. Group 4 also exhibits the highest mean compressive stress (10.6540 MPa), while Group 1 has the lowest (5.6820 MPa). The p-values indicate that these differences are statistically significant ($p < 0.001$).

Conclusion: Within the limitation of this study, it can be concluded that Prime liquid solution provides maximum shear bond strength of composite to dentin.

Keywords: Carborundum Disc, Etching Gel, Phosphoric Acid, Viscosity

Introduction

A crucial component of restorative dentistry is the bonding of composite resin to dentin, which has a direct impact on the durability and clinical success of dental restorations. In 1955, Buonocore demonstrated markedly improved retention of methyl methacrylate resins to enamel after a 30-second application of 85 per cent orthophosphoric acid. As it improves the bonding area and produces micro-retentive surfaces, phosphoric acid etching is a commonly used technique for preparing the tooth surface for bonding. [1] The effectiveness of the bonding process, however, may be impacted by the viscosity of the phosphoric acid etchant (gel and solution forms). [2]

Viscosity affects the flowability and penetration of the etchant into the dentin, potentially influencing the quality of the etched surface and the subsequent bond strength. Previous studies have investigated the effect of phosphoric acid concentration on bond strength, but limited research has focused on the impact of viscosity. [3]

The increasing availability of phosphoric acid etchants with varying viscosities has sparked interest in understanding the optimal viscosity for achieving reliable bond strength.

Solution form of etchant may provide a more effective bonding surface due to its ability to create a more uniform etching pattern when evaluated under a scanning electron microscope (SEM). [2]

Gel form of acid etchant has the advantages of easy application and controlled use. It avoids the irritation of gums during application of etchant. [4]

This study aims to investigate the effect of different viscosities of phosphoric acid etchant on the shear bond strength of composite resin to dentin.

Null Hypothesis

There is no difference in the shear bond strength of composite to dentin when using gel or solution forms of the etchant.

Materials and Methods

Sample Preparation

Forty recently extracted non-carious, intact, human maxillary premolars, teeth free of abnormalities, were acquired and stored in distilled water. The specimens were prepared by grounding the occlusal surfaces into a flat surface using the carborundum disc (Composite Manual Dental Resist Metal Trimming/Cutting Disc) under continuous flow of water standardised to 1.5mm from the cusp tip. Each sample was then placed vertically, exposing the flat occlusal surface, and were embedded in a self-curing polymethyl methacrylate resin (Self cure pyrax Uttarakhand, India) before being tested.

Sample Grouping

Forty teeth were randomly assigned to 4 groups. The specimens were then numbered for identification. The four etching agents used were

Group 1: Etching Gel (Prevest Denpro Actino)

Group 2: Etching Liquid (Prevest Denpro Actino)

Group 3: Etching Gel (Prime Dental)

Group 4: Etching Liquid (Prime Dental)

Groups	
Group 1	Etching Gel (Prevest Denpro Actino, Export Promotion Industrial Park (EPIP), Bari Brahmana, Jammu-181133, India.)
Group 2	Etching Liquid (Prevest Denpro Actino Export Promotion Industrial Park (EPIP), Bari Brahmana, Jammu-181133, India.)
Group 3	Etching Gel (Prime Dental) Plot No. A-148, Road No. 24, MIDC, Wagle Industrial Estate, Thane (West) - 400604, Maharashtra, India.
Group 4	Etching Liquid (Prime Dental) Plot No. A-148, Road No. 24, MIDC, Wagle Industrial Estate, Thane (West) - 400604, Maharashtra, India.

Sample Testing

After the teeth were completely dried with compressed air, the etching agent was applied with a applicator tip for 15 seconds. Each specimen was then rinsed with water for 30 seconds and then blot dried for 20 seconds. Bonding agent was applied according to the manufacturer's instruction – for group I & II Fusion Bond 5 (Prevest Denpro Actino, Export Promotion Industrial Park (EPIP), Bari Brahmana, Jammu-181133, India.) was used and for group III & IV Restorite Bond 5G (Prime Dental Plot No. A-148, Road No. 24, MIDC, Wagle Industrial Estate, Thane (West) - 400604, Maharashtra, India.) was used. All the specimens were cured for 20 secs with LED curing light. (Waldent, New Delhi, India)

Filtek Z350 composite (3M, 3 M ESPE – Bangalore, India) was placed in increments over the samples with the use of 2mm x 2mm teflon mould and cured with LED curing light. To simulate the oral environment, the specimens were placed in distilled water bath for 24hours at the controlled temperature of 37°C.

All specimens were then transferred to the Instron Testing Machine individually and were subjected to shear bond strength analysis at a crosshead speed of 1.0 mm/minute.

Statistical Analysis

The shear bond strength data were analysed by One way ANOVA and paired sample T test and P value set at $P<0.05$ level of significance.

Result

Table 1 shows an intragroup comparison where Group 4 has the highest mean maximum force (33.1380 N),

followed by Group 2 (29.4510 N), Group 3 (20.8050 N), and Group 1 (16.9990 N). The statistical significance ($p < 0.001$) indicates that the differences in maximum force among the groups are statistically significant.

In Table 1, Group 4 also exhibits the highest mean compressive stress (10.6540 MPa), while Group 1 has the lowest (5.6820 MPa). The p-values indicate that these differences are statistically significant ($p < 0.001$).

Table 1: Intragroup comparison of the four groups based on maximum Force [N] & compressive stress at Maximum Force [Mpa]

	Maximum Force [N]			Compressive Stress At Maximum Force [MPA]		
	Mean	Std deviation	P - value	Mean	Std deviation	P - value
Group 1	16.9990	8.37947	<0.001*	5.6820	2.66674	<0.001*
Group 2	29.4510	8.21613		9.7150	2.53198	
Group 3	20.8050	9.50360	0.020*	6.4900	3.00776	0.016*
Group 4	33.1380	6.07953		10.6540	2.08735	

*Statistically significant at p<0.05, Paired samples t-test

Table 2 presents an intergroup comparison, reinforcing the findings from Table 1. Group 4 again shows the highest mean maximum force, and the differences between groups are statistically significant, as indicated by the p-values.

Table 2 confirms these findings with similar trends in compressive stress, where Group 4 maintains the highest mean, and the differences across groups are statistically significant.

Table 2: Intergroup comparison of the four groups based on maximum Force [N] & compressive stress at Maximum Force [Mpa]

	Maximum Force [N]			Compressive Stress At Maximum Force [MPA]		
	Mean	Std deviation	P - value	Mean	Std deviation	P - value
Group 1	16.9990	8.37947	<0.001*	5.6820	2.66674	<0.001*
Group 2	29.4510	8.21613		9.7150	2.53198	
Group 3	20.8050	9.50360		6.4900	3.00776	
Group 4	33.1380	6.07953		10.6540	2.08735	

*Statistically significant at p<0.05, One-way ANOVA

The data suggests that Group 4 demonstrates superior performance in both maximum force and compressive stress compared to the other groups.

From these results, there is a statistically significant difference in shear bond strength when solution form of etchant is used. Thus, the null hypothesis is rejected.

Discussion

For micromechanical adhesion of composite resin to tooth surface, acid etching plays a major role; Acid etchant removes the smear layer and opens the dentinal tubules which makes irregularities in the tooth surface.[2] The unfilled resin or bonding agent can easily penetrate the dentinal tubules and creates a micro mechanical bonding of resin to tooth [5]

When enamel is treated, the acid dissolves the ends of the enamel rods in the remaining enamel while removing roughly 10µm of enamel from the surface. This produces 25µm to 75µm deep porosities that increase the surface area by more than 2000 times and function as a network

of channels into which an unfilled resin or resin bonding agent can flow. The micro mechanical connection between the dentin and resin is significantly strengthened by these modifications. [2]

In 1955, Buonocore discovered that acid etching of teeth enhances bond strength; however, the ideal acid, concentration, duration, and viscosity of the etchant are subjects of differing opinions in various research studies.

Among the etchants, phosphoric acid 37% is the optimal etching acid among other acids. [6]

In viscosity of acid etchants 37% phosphoric acid is mostly available as solution and gel forms. In an earlier study by Brannstrom in 1978 had tested different viscosities of phosphoric acid through SEM evaluation had concluded that there was no difference in the appearance of enamel surfaces when acid liquid or acid gel was used for one minute. [4]

On testing gel and solution forms of phosphoric acid in young permanent teeth, Brannstrom et al, had concluded that there is no difference in the degree of surface irregularities when etchant gel and solution was compared. [7]

Walker compared 33% phosphoric acid gel and solution on primary incisors using three parameters – SEM examination for analysis of quality of etched enamel surface – acid solution was more effective than the acid gel; Resin tag formation and penetration – acid solution had created greater number of evenly distributed tags; Shear bond strength – no significant difference was seen when tooth surface is etched with either acid gel or acid solution. [8]

A clinical study conducted by Hardison examined the retention of pit and fissure sealants on the occlusal surfaces of permanent molars using either a 33% phosphoric acid gel or a 35% phosphoric acid solution as the etchant. The results revealed no significant difference in retention after six months. But the retention rate is slightly higher for gel. [9]

Guba et.al. in 1994 compared three different viscosities of acid etchant on bovine teeth and concluded that there is no significant difference in the tensile bond strength between these three groups. [10]

Shilpa et.al. in 2018 compared gel and solution of 37% phosphoric acid etchant using SEM evaluation of etching pattern and concluded that solution form of etchant gives uniform etching pattern. [2]

Moin and Dogan in 1977 on his study of indirect bonding of orthodontic attachments had concluded that uniform etching pattern was obtained when 37% phosphoric acid etching solution was applied for 60 seconds. [10]

In the current study gel and solution forms of two commercially available acid etchant were compared by analysing the shear bond strength of bonded composite to dentin.

On Compressive stress at maximum force [MPa], shear bond strength was measured in the order of group 4 > group 2 > group 3 > group 1.

Group 4 (Prime dental etching liquid) had the highest bond strength due to better penetrating ability of acid solution and high acidic pH (pH – 0.38) when compared to the other etchant solution.

The limitations of the study include the fact that invitro studies may not comprehensively represent the clinical potential of the substance under investigation.

A more comprehensive evaluation of etchant in liquid and gel form could be achieved by increasing the sample size and conducting an in-vivo analysis.

Conclusion

Within the limitation of this study, it can be concluded that Prime etchant solution provides maximum shear bond strength of composite to the dentin.

The development of evidence-based guidelines for selecting the most effective phosphoric acid etchant viscosity is of the utmost importance, as it enhances the predictability and durability of dental restorations.

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