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Research Article

Effects of Various Surface Treatments on Shear Bond Strengths of a Resin Modified Glass Ionomer Luting Agent to Dentin

William G Carney[1]*, Luke F Matranga[2], William T Naughton[2], Wayne W Barkmeier[3] and Stuart J McNally[4]

[1]*Assistant Professor, Department of General Dentistry, Creighton University School of Dentistry, Omaha, Nebraska, USA*

[2]*Associate Professor, Department of General Dentistry, Creighton University School of Dentistry, Omaha, Nebraska, USA*

[3]*Special Professor and Dean Emeritus, Department of General Dentistry, Creighton University School of Dentistry, Omaha, Nebraska, USA*

[4]*Private Practice, Omaha, Nebraska, USA*

***Corresponding Author:** William G Carney, Assistant Professor, Department of General Dentistry, Creighton University School of Dentistry, Omaha, Nebraska, USA.

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Abstract

Introduction: Surface treatments have been shown to effect bond strengths of luting cements to dentin.

Objective: The purpose of this study was to determine if the use of various materials commonly employed in conjunction with the cementation of indirect dental restorations would enhance bond strengths without resorting to proprietary dentin conditioners.

Methods: Flat ground dentin surfaces (600 grit) on de-identified extracted human teeth mounted in acrylic were subjected to eight different surface treatment regimens with a ninth group (N = 15) of untreated dentin serving as a control. These treatments included: 2% Ferric Chloride, 20% Ferric Sulfate, a combination of 2% Ferric Chloride and 20% Ferric Sulfate, 20% Polyacrylic Acid, 25% Aluminum Chloride, 20 - 30% Polyacrylic Acid, water and flour of pumice and water and flour of pumice followed by 2% Ferric Chloride. The surface treatments varied in pH from strong to weak acids. Rexillium rods were cemented onto the dentin surfaces using GC Fuji PLUS cement and then stored in distilled water for 24 hours at 37°C. Shear bond strengths were determined with a universal testing machine at a cross head speed of 1 mm/minute. A one-way ANOVA and Tukey's post hoc test were used for data analysis.

Results: Shear bond strengths ranged from 17.7 (5.6) to 3.2 (2.2) MPa for the nine groups. Significant differences ($P < 0.05$) were observed among the groups.

Conclusion: Dentin surface treatments in the 1.5 - 2.0 pH range offered significantly improved shear bond strengths over the other surface treatments.

Keywords: *Resin Modified Glass Ionomer Cements (RMGIC); Shear Bond Strengths; Dentin*

Introduction

Resin Modified Glass Ionomer Cements (RMGIC) were developed to overcome the limitations of conventional glass ionomer cements, such as sensitivity related to early changes in their water content. RMGICs are a two-part system including an acid-base reaction and diffusion-based adhesion between the tooth surface and the cement [1]. Bond strengths to mineralized tooth structures are enhanced by removing the smear layer of a prepared surface by use of an acid. Weak acids penetrate dentin with greater ease because of the buffering effect that dentin has on strong acids [2]. Optimum adhesion to dentin and enamel can only be obtained if the surface is clean. The presence of contaminants such as saliva and blood will also prevent any ion exchange [3]. Manufacturers of RMGIC's have recommended

the conditioning of dentin with various conditioners specific to the material to enhance bond strengths to dentin. In addition, there is a variety of recommendations for cleaning the prepared tooth prior to cementation, including water spray only [4], wet flour of pumice [5] and conditioning the tooth with 20% polyacrylic acid [6].

Purpose of the Study

The purpose of this research study was to determine the effect that various materials and techniques commonly used in the cementation of indirect dental restorations have on the bond strengths of a RMGIC material to dentin.

Materials and Methods

A total of 135 de-identified, extracted human molar teeth were used in this laboratory study. The experimental protocol for using de-identified human molar teeth was reviewed and approved by the Biomedical Institutional Review Board at Creighton University, Omaha, Nebraska, USA (#760765-1).

The de-identified extracted human molar teeth were mounted in phenolic rings with a chemical-cure methylmethacrylate material (Bosworth Fastray). The coronal surfaces of the mounted teeth were then ground in a model trimmer until dentin was exposed. Each specimen was then polished with a series of carbide paper to 600 grit. Immediately prior to testing, the dentin surfaces were contaminated with human saliva for ten seconds to simulate an acquired pellicle. Specimens were then rinsed with water for 10 seconds and blotted dry. The dentin surfaces were treated, as per manufacturers' instructions, or for 10 seconds in the case of specimens treated with 20% Ferric Sulfate (Ultradent Viscostat), 2% Aluminum Chloride (Ultradent Viscostat Clear), or the combination of 20% Ferric Sulfate (Ultradent Viscostat) and 2%Ferric Chloride (GC Fuji Plus Conditioner). The pH of these treatment agents as reported by the manufacturer is shown below.

After treatment all specimens were rinsed with water for 10 seconds and blotted dry. A Rexillium rod was cemented with GC Fuji Plus cement on each specimen and each group was stored in water for 24 hours at 37°C.

Fifteen (15) specimens were used for each of the following test categories, and treated as stated prior to the cementation of the Rexillium rods:

1. Untreated dentin (control)
2. Dentin treated with 2% Ferric Chloride (GC FUJI Plus Conditioner) pH 2.0
3. Dentin treated with 20% Ferric Sulfate (Ultradent Viscostat) pH 1.0
4. Dentin treated with both 2% Ferric Chloride and 20% Ferric Sulfate
5. Dentin treated with 20% Polyacrylic Acid (GC Cavity Conditioner) pH 1.9
6. Dentin treated with 25% Aluminum Chloride (Ultradent Viscostat Clear) pH 5.0
7. Dentin treated with 20-30% Polyacrylic Acid (3M Oral Care) pH 1.5 - 2
8. Dentin treated with water and flour of pumice only

9. Dentin treated with water and flour of pumice followed by2% Ferric Chloride (GC Fuji PLUS Conditioner) pH 2.0 as per manufacturer's recommendation.

Cylindrical-shaped Rexillium rods, 2.45 mm in diameter and 4.0 mm in length, were fabricated by AAA Dental Laboratory in Omaha, NE USA. The ends of the rods were wet - ground to 600 grit using a sequence of silicon carbide papers. The Rexillium rods were cemented to the flat-ground dentin surfaces in a custom fixture using a 50-gram weight following the product instructions for the cement. The bonded specimens were stored in distilled water at 37°C for 24 hours. The specimens were then mounted in a custom fixture and shear bond strengths were determined using a chisel-shaped rod that was placed immediately adjacent to the dentin surface. The specimens were loaded at 1.0 mm per minute with an MTS Insight machine and Test Works software. Shear bond strength was calculated based on the surface of the bonded area and recorded in MPa.

Data were analyzed with a one-way analysis of variance (ANOVA) and Tukey's post hoc test for pairwise comparisons.

Results

The ANOVA showed a significant difference ($P < 0.001$) among the experimental groups. The shear bond strength (SBS) of Rexillium bonded to dentin with the glass ionomer cement ranged from 3.2 (2.2) to 14.7 (5.6) MPa. The SBS of the control, with no dentin pre-treatment (Group 1), was 6.7 (3.6) MPa compared to highest SBS of 14.7 (5.6) for the Group 7 with dentin pre-treatment of 20-30% Polyacrylic Acid. Treatment groups 7 and 2 yielded the highest SBS in this study.

Treatment Method	MPa (SD)
1.7	14.7 (5.6)a
1.2	10.8 (5.9)ab
1.3	6.8 (3.4)bc
1.1	6.7 (3.6)bc
1.4	6.7 (3.8)bc
1.9	5.3 (1.6)c
1.5	4.8 (1.9)c
1.6	4.5 (2.0)c
1.8	3.2 (2.2)c

Table 1: *Shear bond strength (MPa) of glass ionomer luting agents to dentin.*
Same small case letter in vertical column indicates no difference at 5% significance level.

Discussion

Results from a Clinicians Report Survey indicate that RMGICs were the most popular and the cement of choice for 62% of the respondents [7]. The use of the RMGICs for luting purposes is increasing because of: 1) improved adhesion to tooth structure, 2) improved biocompatibility, 3) ability to form a very thin film layer, 4) fluoride release, and 5) ease of use [8].

The RMGIs are thought to adhere to tooth structure by the formation of ionic bonds at the tooth cement interface because of chelation between the carboxyl groups of the polyacrylic acid with the calcium and/or phosphate ions in the apatite of the tooth's enamel and dentin [9]. This ionic exchange with dentin and enamel results in a union practically free of microleakage [3].

Studies have indicated that the RMGICs have higher bond strength to dentin than their conventional counterparts and that this bond strength may be further increased by cleansing the dentin with polyacrylic acid prior to cementation and removal of the dentinal smear

layer [6]. Removal of the dentinal smear layer, prior to the placement of the RMGI, has been shown to improve both the shear bond strength of RMGCs to dentin and the clinical retention rate of glass ionomer restorations [10]. It has also been shown that there is a more thorough removal of the smear layer with an active scrubbing of the dentinal surface [10]. In addition to the presence of a smear layer, the presence of saliva and the formation a dental pellicle can also interfere with the bonding procedure of RMGICs [3].

The existence of an acquired pellicle covering the tooth surface has been well established and is composed in part of calcium [11]. The dental pellicle is an acellular layer of adsorbed salivary and other macromolecules on the tooth surface. The adsorption of the first molecular layer on a clean tooth surface is immediate upon contact with saliva [12].

All the specimens used in this study were contaminated with saliva prior to each cementation process in an effort to produce an acquired pellicle. Without the removal of the acquired pellicle prior to cementation, the bond established by the RMGICs may be with the calcium of the acquired pellicle.

Since Buonocore first described chemically treating enamel to change its surface characteristics in 1955 [12], many surface treatment regimens have been developed to improve the adhesion of restorative materials to enamel and dentin. The results of this study indicate that the bond strength of RMGICs benefit from some pre-treatment approaches to improve adhesion.

Conclusion

Pre-treatment of dentin surfaces prior to bonding Rexillium with a RMGIC showed significant differences among the treatment regimens. Dentin pre-treatment with polyacrylic acid (3M Oral Care) and a dentin conditioner (GC Fuji Plus Conditioner) resulted in the higher shear bond strengths to dentin using a RMGIC than other treatment regimens tested. Dentin cleansing with acids of moderate pH appear to enhance the bond strengths of RMGIC to dentin in the absence of using flower of pumice prior to cementation.

Conflicts of Interest

The authors certify that they have no proprietary, financial, or other interest of any nature or kind in any product, service, and/or company that is presented in this article.

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