Effect of Protective Coating on Microleakage of Conventional Glass Ionomer Cement and Resin-Modified Glass Ionomer Cement in Primary Molars: An In vitro Study

Abstract

Aim: The aim of this in vitro study was to evaluate and compare the effect of protective coating G-Coat Plus on microleakage of conventional glass ionomer cement (CGIC) and resin-modified glass ionomer cement (RMGIC) in primary molars. Materials and Methods: A total of 120 samples were divided into four groups with 30 samples in each group. Group A – teeth restored with CGIC. Group B – teeth restored with CGIC coated with G-Coat Plus. Group C – teeth restored with RMGIC. Group D – teeth restored with RMGIC coated with G-Coat Plus. Microleakage was tested using 2% basic fuchsin dye penetration and measured at ×40 original magnification under the stereomicroscope. Results: The results of this in vitro study showed that coating with G-Coat Plus showed a reduction in microleakage in CGIC and complete absence of microleakage in RMGIC when compared to the noncoated groups, which was statistically significant. CGIC without G-Coat Plus showed highest microleakage followed by RMGIC without G-Coat Plus, followed by a relatively less microleakage in CGIC with G-Coat Plus. Conclusion: Significant reduction in microleakage was seen in conventional GIC and RMGIC with G-Coat Plus when compared to conventional GIC and RMGIC without G-Coat Plus.

Keywords: Conventional glass ionomer cement, G-Coat Plus, microleakage, primary molars, resin-modified glass ionomer cement

Introduction

Dental caries is the most common chronic disease of childhood. Worldwide, the contribution of dental caries to the burden of oral diseases is about ten times higher than that of periodontal disease, the other common oral condition. In dentistry, dental caries is the major reason for tooth loss, representing a major challenge for oral health care.[1] Recently, a National Epidemiologic Data clearly showed that for 5-year-old children, the caries value and prevalence were 3.7% and 69.8%, respectively.[2] The job of a pediatric dentist treating children is two-fold, we must place quality work for our patients and we must be masters at managing our patient’s experience. We must be able to work with speed and accuracy. This can only be possible if we have materials at hand that are easy to handle and give dependable results. One such material is glass ionomer cement (GIC).[3]

Glass ionomer has been used as a dental material since its introduction in 1972. With its introduction as a restorative material, there were some limitations to the material.[4] Since their introduction, glass ionomers have evolved and have been improved immensely. Today’s glass ionomers are easier to handle, have better wear resistance, and have better esthetics than the original GIC.[5] Glass ionomers have many advantages as a restorative material. These include, but are not limited to the ability to bond chemically to dentin and enamel, biocompatibility, favorable thermal expansion, decreased moisture sensitivity, and the ability to release fluoride, and then act as a fluoride reservoir. As a result of these qualities, GIC is ideal for the uncooperative child as well as the “high caries risk” children.[6]

One of the main drawbacks of the restorative materials is the microleakage around a tooth, which can be seen as staining around the margins of the restoration, postoperative sensitivity,

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secondary caries, pulpal pathology or pulpal necrosis and the second being reduced bond strength of the restorative cement leading to partial or total failure of the restoration itself.

According to Nakabayashi and Pashley, microleakage is defined as the passage of fluids and substances through minimal gaps on the interface of the restoration and teeth. In the conventional glass ionomer cements (CGIGs), water plays an important role in the setting. Water is responsible for the transport of calcium and aluminum cations, which will react with the polyacid to form a polyacrylate matrix. Incorporation of water with glass ionomers is associated with increase in the translucency of the GIC. The loosely bound water can be lost from the surface by desiccation. This causes an unsightly chalky appearance as microscopic cracks develop in the drying surface and leads to microleakage. Furthermore, the presence of moisture can lead to absorption of water and hygroscopic setting expansion. To prevent this, it is important to protect the cement by covering it with an appropriate varnish or petroleum jelly. Another advantage of using such surface protectors is that they fill small surface voids and defects and may help to preserve the original color of the restorations by reducing the uptake of stains.

The 21st century is the era of nanotechnology. Nanofillers improve the wear resistance of coating agent, thus providing more protective coating over CGIGs. Recently, G-Coat Plus, a nanofilled, self-adhesive, light-cured protective coating has been introduced for conventional GIC, RMGIC, resin composite, and compomer restorations. Previous studies have confirmed that when applied, the uniformly dispersed film thickness of 35–40 µm of G-Coat Plus provides higher wear resistance, strengthens the restoration, and gives highly gloss appearance.

The effect of surface-coated petroleum jelly and cavity varnish of conventional GIC on microleakage and fluoride release has been reported in previous studies. However, the effect of nanofilled coating agent on microleakage of conventional GIC and RMGIC has not yet been reported in the literature.

Therefore, the present study was undertaken to investigate the effect of G-Coat plus (nanofilled, self-adhesive, light-cured protective coating) on microleakage of conventional GIC and RMGIC in primary molars.

Materials and Methods

Study design

This was an in vitro single-blind study, which was carried out in the Department of Pediatric and Preventive Dentistry. Sample size for testing the microleakage was calculated based on the hypothesis test as well as an α of 5% and a power of 90%. The test for association between the four groups and the presence of microleakage using Mann–Whitney U-test a with a moderate effect size of 3.4 population mean required a total sample of 120 for testing the association at 5% level of significance. As a result, the final sample should consist of 30 restorations per group. One hundred and twenty human primary molars (extracted due to caries/exfoliated) were used for this study. Samples were stored in 0.9% saline solution at room temperature before the investigation. The selected teeth were cleaned to remove soft-tissue debris using an ultrasonic scaler and were placed in 10% formaldehyde for 2 days for disinfection.

Cavity preparation

Class V cavities 4-mm length × 2-mm wide × 1.5-mm deep were prepared on the buccal surface of the teeth with no retentive features incorporated in the cavity design, using burs (No. 1 round bur, No. 57 straight fissure) with high-speed air rotor handpiece with water coolant. All cavosurface margins were kept at 90° without bevel designs and burs were changed after every five preparations. The standardization of the cavities was confirmed using a divider and a graduated probe for further confirmation of the depth of the cavity.

To stabilize the tooth during cavity preparation and restoration, the teeth were mounted in wax blocks and then removed before subjecting it to microleakage test.

A total of 120 samples were divided into four groups with 30 samples in each group as follows:
- **Group A** – Teeth restored with CGIC
- **Group B** – Teeth restored with CGIC coated with G-Coat Plus
- **Group C** – Teeth restored with resin-modified glass ionomer cement (RMGIC)
- **Group D** – Teeth restored with RMGIC coated with G-Coat Plus.

The teeth in Group A were restored with conventional GIC (GC Fuji IX Gold Label 2 LC, GC Corporation Tokyo, Japan) according to the manufacturer’s instructions. GC cavity conditioner was applied for 10 s using a cotton pellet. The cavity was rinsed and air dried using a three-way syringe and restored with the cement using a powder liquid ratio of 1:1, following which a layer of petroleum jelly was applied on the restoration.

The teeth in Group B were restored with conventional GIC same as in Group M1, followed by the application of G-Coat Plus (GC G-COAT PLUS, Tokyo) using a microtip applicator and light cured using a light curing unit (576-nm wavelength with the intensity >500 mW/cm²; LED light) for 20 s.

The teeth in Group C were restored with RMGIC (GC Gold Label 2 LC, GC Corporation, Tokyo, Japan) according to the manufacturer’s instructions. GC cavity conditioner was applied for 10 s using a cotton pellet. The cavity was rinsed and air dried using a three-way syringe and restored with RMGIC using a powder–liquid ratio of 1:1 followed by light curing for 20 s using visible light curing unit.
The teeth in Group D were restored with RMGIC as in Group C, followed by application of G-Coat Plus using a microtip applicator and light cured for 20 s. After restoring all the teeth, the wax block was removed. The teeth were then stored in a container having 50 ml distilled water at room temperature for 24 h and then subjected to 1000 thermocycles at 5°C and 60°C for 20 s alternatively.

All the tooth surfaces were covered with two coats of nail polish except the restoration and 1 mm of tooth surface margin. The coated teeth were then immersed in 2% basic fuschin dye solution (Ranbaxy Fine Chemicals Ltd, India) for 24 h at room temperature. After removal from the dye, the teeth were thoroughly washed under tap water, dried, and mounted horizontally on an acrylic block for ease of handling on the microtome. The teeth were sectioned longitudinally through the center of the restorations with a diamond saw of the hard-tissue microtome such that the restoration is sectioned in the center. The degree of dye penetration was examined at x40 original magnification under the stereomicroscope. The extent of marginal leakage was scored and tabulated according to criteria described by Wilder et al.[11] in Table 1.

Statistical analysis

All the values were tabulated and were subjected to statistical analysis. Nonparametric Mann–Whitney U-test was used to compare the mean microleakage value of conventional GIC and RMGIC with and without G-Coat Plus. \( P \) value was calculated for statistical significance. \( P < 0.05 \) denotes that the results are statistically significant.

Table 2 shows the distribution of samples according to the microleakage scoring criteria. All the samples show some degree of microleakage in Group A and none of the samples showed microleakage in Group D. In Group B and C, few samples showed a microleakage score of 1.

Graph 1 shows that all the samples of conventional GIC without G-Coat Plus showed microleakage score of 1–3 when compared to conventional GIC with G-Coat Plus, in which only 4 samples showed a microleakage score of 1. The microleakage in conventional GIC without G-Coat Plus (Group M1) is more when compared to conventional GIC with G-Coat Plus (Group M2), which was statistically significant \( (P = 0.000) \).

Graph 2 reveals that eight samples of RMGIC without G-Coat Plus showed a microleakage score of 1, whereas there was absolutely no microleakage seen in RMGIC with G-Coat Plus. \( P = 0.003 \) shows that it is statistically significant.

Graph 3 reveals that the microleakage in conventional GIC without G-Coat Plus (M1) was more when compared to RMGIC without G-Coat Plus (M3) which was statistically significant \( (P = 0.000) \).

Graph 4 shows that there was microleakage observed in conventional GIC with G-Coat Plus (M2). There was no microleakage observed in the RMGIC with G-Coat Plus (M4) group. \( P = 0.040 \) shows that it is statistically significant.

Table 3 shows that the microleakage in conventional GIC and RMGIC without G-Coat Plus is more when compared to conventional GIC and RMGIC with G-Coat Plus, which is statistically significant \( (P = 0.000) \).

Discussion

Conventional glass ionomers (GIC) have been advocated as a restorative material because of their ability to chemically bond to tooth structure and release fluoride. They are widely used in dentistry for restoration, as a liner.
or base, and luting cements. Conventional GICs are most moisture sensitive restorative materials in the early stages of placement.[12] Water plays a key role in the maturation of GIC. Dehydration and water contamination during the initial setting stages can compromise the physical properties of the restoration.[10]

According to Gemalmaz et al. (1998), when GIC restorations were contaminated by moisture, their mechanical strength decreased and the surface of the material eroded or wore rapidly. The ability of glass ionomer to minimize the extent of microleakage at the tooth or restoration interface is an important factor in clinical success. In the literature, microleakage can occur due to deterioration of the tooth-restoration interface, differences between thermal expansion coefficients of the restorative material – tooth tissue or polymerization shrinkage, causing staining, recurrent caries, and failure of restoration.[11]

To overcome the drawbacks of GIC from moisture contamination and desiccation during initial setting stage, it has always been recommended that GICs must be covered immediately after placement with a water-proof surface coating.[8]

Studies have recommended surface protection during the initial setting of GIC with various surface coating agents such as cocoa butter, waterproof varnish, and even nail varnish.[10] Earl et al. (1989) have shown that immediate covering of immature GIC with a light-cured bonding resin is the most effective method of limiting water movement across the surface.[10]

In the present study, coating with G-Coat Plus showed a statistically significant reduction in microleakage in conventional GIC and complete absence of microleakage in RMGIC when compared to the noncoated groups. Conventional GIC and RMGIC without G-Coat Plus showed more microleakage when compared to conventional GIC and RMGIC with G-Coat Plus, which was statistically significant. Yoshaskam Agnihotri et al. (2011)[12] who had reported a significant reduction in RMGIC with G-Coat Plus. On the contrary, Ninawe et al. (2004)[10] had reported that conventional GIC with G-Coat Plus exhibited significantly higher microleakage than vaseline. But in the present study, conventional GIC without G-Coat Plus were coated with petroleum jelly according to manufacturer’s instructions and showed significantly higher microleakage when compared to other groups with G-Coat Plus. Furthermore, in the present study, RMGIC showed significantly less or no microleakage when compared to conventional GIC with and without G-Coat Plus.

As there are no other studies available in the literature comparing conventional GIC with and without G-Coat Plus coating, further studies on microleakage with G-Coat Plus with large samples are needed to confirm these contradictory findings.
The possible protective effect of G-Coat Plus is due to the presence of single-phase dispersed nanofillers (30 nm) which would develop a “microlamination effect” with uniform flow and complete wetting of the cement surface. This, in turn, would develop a thick protective coating of about 35–40 µm. This toughened laminate layer with a smooth and glossy surface, strengthens, protects, and enhances the hardness of the restorations. It also protects the cement surface against excessive water contamination during the initial cure, and fills the voids, thereby reducing microleakage.[11]

The reduction in microleakage in RMGIC when compared to conventional GIC can be due to the difference in the setting reaction of both the cements. In conventional GIC during initial setting, if it comes into contact with intraoral fluid, the matrix-forming ions (Ca and Al) are washed out which leads to improper matrix formation with inferior mechanical properties, and hence increased microleakage. On the other hand, RMGIC is set by two processes, primary and prominent setting by acid–base reaction and secondary auxiliary setting by photopolymerization reaction. In this, water is partially replaced by hydroxyl ethyl methacrylate. The structure of RMGIC consists of a matrix of metal polyacrylate salts and of a polymer matrix. Hence, it is generally believed that RMGIC are less affected by moisture and shows reduced microleakage than conventional GIC.[13]

**Conclusion**

The study concluded that significant reduction in microleakage was seen in conventional GIC and RMGIC with G-Coat plus protective compared to protective coating and the color stability of cements is enhanced with the use of a light-cured protective coating.

Furthermore, it gives highly glossy appearance and bonds chemically to the tooth structure.

Thus, the G-Coat Plus which is a self-adhesive, nanofilled resin-coating provides a high hydrophilicity combined with an extremely low viscosity, which accounts for a perfect seal of conventional GIC and RMGIC surface.

**Conflicts of interest**

There are no conflicts of interest.

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