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An in Vitro Evaluation of the Fluoride-Releasing Ability of Conventional GIC, Modified GIC, and Composite: A Comparative Analytical Study

Running title: In Vitro Evaluation of the Fluoride-releasing Ability

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KEYWORDS

Caries, Glass ionomer, Fluoride release, Modified GIC, Composite, Colorimetry

ABSTRACT:

Introduction: Purpose of this study is to understand ability of these materials to release fluoride ions, which is important in preventing dental caries. Fluoride release plays a vital part in remineralization, by replacing lost ions in demineralized tooth structures, reducing enamel solubility, and increasing mechanical properties. GIC are known for their fluoride- releasing capability, but Modified GIC and Composite(surefil)are also gaining attention

due to their potential for reducing secondary caries. Understanding fluoride-releasing potential of these materials may influence clinical decision-making in preventive dentistry.

Objectives: This study aims to investigate fluoride ion-releasing properties of three different dental restorative materials: conventional Glass Ionomer Cement (GIC), Modified GIC, and Composite.

Methods: In this study, 45 samples of the three distinct restoration material types were prepared for the investigation and split into three groups. Conventional Glass Ionomer Cement (GIC) is Group 1, Group 2: Modified GIC category 3: Composite; there are 15 samples in each category. Colorimetry was used to quantify fluoride ions and obtain results in the specified parts per million (ppm) units. Descriptive, quantitative data was expressed in mean and standard deviation respectively. Data normality was checked by Shapiro – Wilk test. Overall intergroup comparison between three study groups was done using One way Anova F test followed by Tukey's post hoc test for pairwise comparison.

Results: Every material used in the investigation showed signs of fluoride release. Even though the quantity of fluoride emitted varied between GIC, Modified GIC and Composite. Conventional GIC had

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the largest initial fluoride release, followed by Modified GIC and Composite. Composite showed least amount of fluoride released at all time intervals.

Conclusions: The initial Fluoride release was highest from Conventional GIC followed, Modified GIC and Composite. This is most likely due to the glass filler particles being surrounded by a well-established glass ionomer matrix in GIC.The maximum amount of fluoride released on days 1 and then materials exhibited a decline in the amounts of fluoride released.

1. Introduction

Dental caries is regarded as a chronic illness that affects people worldwide and is quite common. The primary goal of modern dental care is not just to restore the damaged teeth; it also aims to alter the hard tissues of the teeth in order to increase their resistance to the start of the caries process. Even after carious dentin has been removed, microleakage from the buildup of microorganisms beneath the repair might result in unintended consequences such pulp damage and pulp necrosis. The primary objective of treatment is to excavate caries and restore the affected areas using an appropriate restorative material. Over the period of time, restorative dentistry has experienced significant and quick development, driven by the idea of preserving and restoring the dentition's natural occlusion and function. As is well known, a remineralization procedure can successfully treat tooth decay in its early stages. Reintroducing calcium and phosphate ions from the surrounding environment into the spaces in the demineralized tooth structure is part of this complex restoration process.[1]

Consequently, there is a notable increase in overall mineral accumulation and the deposition of hydroxyapatite crystals. When fluoride ions are present, they exchange place with hydroxyl ions in hydroxyapatite to generate fluorapatite,which is caries-resistant. As a result of this change, the tooth's mechanical strength significantly increases and the minerals become less soluble. This well-established mechanism is well recognized to be essential in preventing enamel demineralization and actively encouraging tooth remineralization. Numerous studies attest to fluoride's critical function in preventing tooth cavities.[2]

It is widely acknowledged that fluorides exhibit anti cariogenic attributes, impeding the initiation and progression of caries by forming a resilient complex with the inorganic constituents of tooth material. Thus, dental restorative materials that integrate fluoride into their formulation, facilitating a sustained release of fluoride, may prove beneficial in restraining dental caries in adjacent teeth and preventing secondary caries in pre-restored teeth.[3]

Glass ionomer cement (GIC) has gained global popularity as a versatile material for luting, base, liners, and restorative applications due to its adhesive properties, biocompatibility, and fluoride- releasing capabilities. However, significant disadvantages, including low fracture toughness, wear resistance, and susceptibility to high dissolution in water sorption, pose challenges, leading to restoration failure and the risk of secondary caries or tooth fracture.[4]

Modified GIC, represents a cutting-edge dental material that seamlessly integrates the advantageous features of both glass ionomer cement (GIC) and composite resin. Much like its traditional glass ionomer counterparts, Modified GIC releases fluoride, actively contributing to remineralization and significantly lowering the risk of secondary decay. An additional advantage lies in

Modified GIC's potential for minimized shrinkage upon setting when compared to traditional resin- based composites. This characteristic not only reduces the likelihood of marginal leakage but also serves as a proactive measure against secondary decay. Modified GIC stands as a testament to dental innovation, embodying a harmonious blend of fluoride release, mechanical prowess, and reduced shrinkage for optimal clinical outcomes.[5]

Composite emerges as a premier dental restorative material tailored for cavity fillings, setting a benchmark in the realm of dental composites. Its composition involves a resilient resin matrix seamlessly integrated with select fillers like glass or ceramic particles, ensuring

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a harmonious blend of robustness and lasting durability. Distinguishing itself with a unique fluoride release attribute, Composite (Surefil) actively contributes to the remineralization process, effectively mitigating the risk of secondary decay. This versatile composite is adept at accommodating various restoration needs, whether for the delicate anterior (front teeth) or the sturdy posterior (back teeth) applications.[6]

2. Objectives

a) To evaluate the fluoride ion releasing abilities of Conventional Glass Ionomer Cement (GIC), Modified GIC and Composite using Colorimetry on 1st and 7th day.

3. To compare fluoride ion releasing abilities of Conventional Glass Ionomer Cement (GIC), Modified GIC and Composite on 1st and 7th day.

Methods

The study involved preparing 45 samples from the three materials, with each group consisting of 15 samples. The fluoride ion release was measured using colorimetry at intervals of 7 and 21 days. .

Total 45 samples was prepared in Round stainless steel mould samples measuring 10 mm in diameter and 3 mm in thickness was prepared for the study(as shown in fig 1 and 2). Three different types of materials used for restoration was taken and divided into 3 groups. Group 1 – Conventional Glass Ionomer Cement (GC Gold Label 9) Group 2 – Modified GIC (Shofu Beautifil ii refills A2) Group 3- Composite (Dentsply Surefil composite).

Sample Preparation-

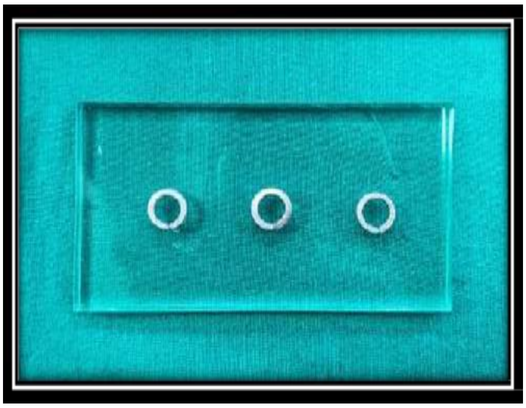

Fig 1- Round stainless steel mould samples measuring 10 mm in diameter and 3 mm in thickness was prepared for the study.

Preparation of the sample for group 1(GIC)- Using a plastic spatula, mix equal parts liquid and powder until a condensable consistency is achieved on an oil-impermeable paper pad.

Preparation of the sample for group 2 (Modified GIC)- This group's specimen was made with cement that was dispensed from a syringe and light-

cured for 20 seconds using an LED probe that was positioned as vertically as possible to the specimen.

Preparation of the sample for group 3(Composite)- The specimen in this group was made using cement that was dispensed from a syringe, as instructed by the manufacturer, then light-cured for 20 seconds using an LED probe that was positioned as vertically as possible to the specimen.

After that each samples was placed into bottom of the standard test tube was filled with 15ml of deionized water at 37^0C (as shown in fig 3). The water from 8 test tubes of each group was subjected for testing at the end of 7 days and water from remaining test tubes of each group was subjected for testing at the end of 21 days. Flouride ions quantification was done by colorimetry to get the values in the designated parts per million (ppm) units.

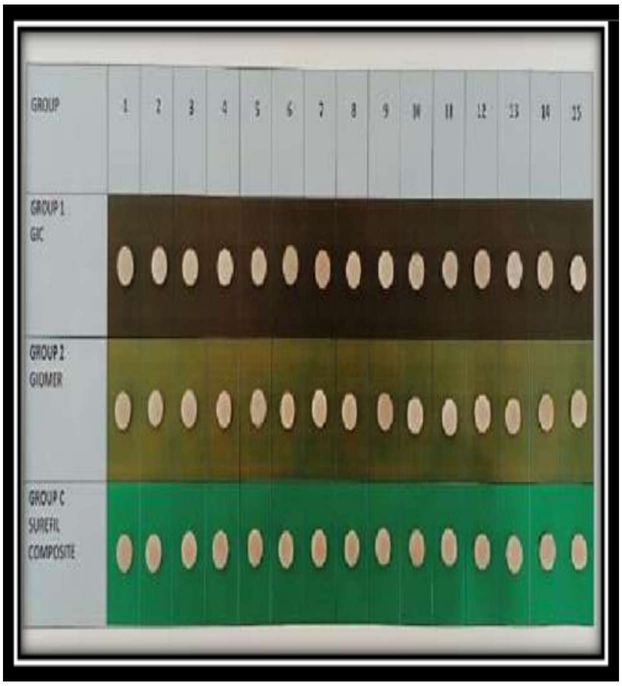

Fig 2- Showing all prepared 45 samples.

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Fig 3-Samples are placed in deionized water

4. Results

Data analysis showed that the test materials' fluoride releases at various time intervals varied significantly. Mean fluoride release (in ppm).

Table 1: Comparison of release of F Ions on 1st day among groups:

Time	1st day	Intergroup comparison F value, p value
GIC	1.44±0.15	F=449.324, p<0.001
Giomer	0.58±0.05	
Surefil Composite	0.39±0.05	
Post-hoc comparison		
GIC vs Giomer	p<0.001**	
GIC vs Surefil Composite	p<0.001**	
Giomer vs Surefil Composite	p<0.001**	

**Statistically highly significant

According to table 1 at the **1st** day mark, the mean value for GIC was 1.44 ± 0.15, while Giomer showed a mean of 0.58 ± 0.05, and Surefil Composite had a mean of 0.39 ± 0.05. The intergroup comparison revealed a significant difference with an F value of 449.324 and a p-value of less than 0.001, indicating highly significant statistical results. Post-hoc analysis showed that the comparison between GIC and Giomer, as well as GIC and Surefil Composite, yielded p-values of less than 0.001. Similarly, the comparison between Giomer and Surefil Composite also showed a p- value of less than 0.001, confirming significant differences among all groups.

Table 2: Comparison of release of F Ions on 7th day among groups:

Time	7th day	Intergroup comparison F value, p value
GIC	0.90±0.07	F=356.025, p<0.001
Giomer	0.35±0.08	
Surefil Composite	0.29±0.04	
Post-hoc comparison		
GIC vs Giomer	p<0.001**	
GIC vs Surefil Composite	p<0.001**	
Giomer vs Surefil Composite	p=0.035*	

*Statistically significant **Statistically highly significant

As per table 2 on the 7th day, GIC had a mean value of 0.90 ± 0.07, Giomer showed a mean of 0.35 ± 0.08, and Surefil Composite recorded a mean of

0.29 ± 0.04. The intergroup comparison resulted in an F value of 356.025 with a p-value of less than 0.001, indicating a highly significant difference among the groups. Post-hoc analysis demonstrated that the comparisons between GIC and Giomer, as well as GIC and Surefil Composite, were highly significant with p-

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values less than 0.001. The comparison between Giomer and Surefil Composite showed a p-value of 0.035*, indicating a statistically significant difference.

Hence it was found that the initial Fluoride release was highest from Conventional GIC followed,

Modified GIC and Composite. The maximum amount of fluoride released on days 1 and then materials exhibited a decline in the amounts of fluoride released.As shown in fig 4.

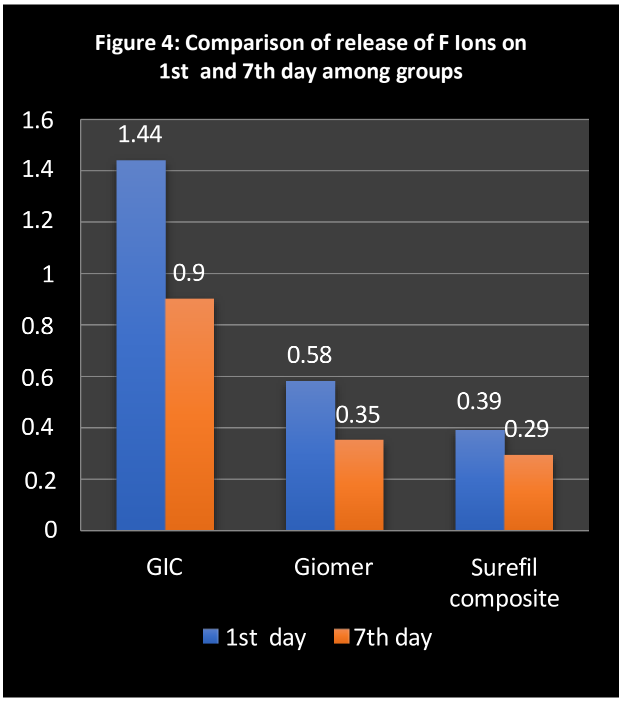

Figure 4: Comparison of release of F Ions on 1st and 7th day among groups

5. Discussion

Dental caries is an infectious bacterial illness that has plagued humans for generations. The goal of treatment is to replace dental caries with an appropriate filler to repair the damaged areas. Without changing the material's physical characteristics or causing the filling to deteriorate excessively, restorative materials should have a high fluoride content and release. In this study, the initial fluoride release from three materials was measured during a seven-day period. GIC is a golden standard for the prevention of secondary caries. Precipitation of calcium complexes is facilitated by the fluoride ions at the restoration- tooth interface to aid remineralization. Since deionized water is readily available and releases more fluoride than artificial saliva, it was chosen as the specimen storage solution.

According to the current study's findings, only GICs exhibited an early fluoride burst effect. A brief burst of fluoride release from the surface precedes a significant decrease in elution and the subsequent release of trace amounts of fluoride into the surrounding media, which characterizes the first step. It has been demonstrated that while Modified GICs and Composite do not initially produce a fluoride burst, the amounts of fluoride released over time stay largely consistent. In the case of conventional GIC, the ion leachable glass is broken down by proton attack at the surface after the liquid and powder have been combined, and fluoride ions are then released from the glass particles.

Conventional GIC has a more extensive acid-base reaction, which produces a better-defined matrix layer. Modified GICs provide a stable GIC phase in the restoration by using pre-reacted glass ionomer technology. When compared to Composite, Modified GICs exhibit a higher amount of release because to the hydrogel layer of glass fillers and a more extensive acid-base reaction. The acid-base interaction is less widespread than with GIC, though. Reactive glass fillers are used in composites. Thus, it is reasonable to anticipate an intrinsic acid-base interaction that releases fluoride. All samples in deionized water exhibit very minimal fluoride release (below the effective threshold) when stationary non-released reactive glass filler is used.

The fluoride leakage from conventional GIC was considerably higher than that from Modified GIC and Composite. This is most likely due to the glass filler particles being surrounded by a well- established glass ionomer matrix in GIC. Conventional GIC had the highest fluoride leakage, followed by Composite and Modified GIC.

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