RESEARCH PAPER

Comparison of Surface Roughness Between Conventional (Type-2) and Hydroxyapatite Modified Glass Ionomer Cement After Immersion in Fruit Juices - An In Vitro Study

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ABSTRACT

Background: Glass-ionomer cements (GICs) are extensively used in many areas of dentistry. This material has the ability to exchange ions with its surroundings. It also possesses many special qualities like biocompatibility, low toxicity, anti-cariogenicity, and thermal compatibility. Hydroxyapatite (Hap) is a major component of minerals in bone and teeth. It is known for its biocompatibility and bioactivity with its crystal morphology and crystallinity similar to that of tooth enamel apatite crystals. Surface character such as roughness influences the quality and clinical behaviour of a restorative material. Therefore, the aim of the study was to evaluate and compare the effect of fruit juices on the surface roughness of conventional type-2 GIC and Hydroxyapatite (Hap) modified GIC.

Materials and methods: 2 groups of samples were taken - conventional GIC and Hap GIC. 8 disc shaped samples were prepared in total, 4 from each group having 2mm thickness. Fruit juices (orange and grape juice) of required amounts were taken in plastic cups. After immersion of the prepared discs in fruit juices for one week, the surface roughness was measured using the Stylus profilometer in terms of Ra, Rq and Rz. The results were developed using one way ANOVA.

Results: In the current study it was proved that there is an increase in the surface roughness of both conventional and Hap GIC (increase Ra, Rz and Rq values) after immersion in fruit juices. Moreover, Hap GIC demonstrated more increase in surface roughness when compared to conventional after immersion in fruit juices with statistically significant differences ($p<0.05$).

Conclusion: The current study evaluated the influence of fruit juices on 2 types of GIC i.e conventional type-2 and Hydroxyapatite (Hap) GIC with respect to surface roughness and on comparing the 2 groups it was concluded that Hydroxyapatite modified GIC (Hap) was prone to surface erosion after immersion in fruit juices.

Keywords: Glass ionomer cement (GIC), Type-2 GIC, Hydroxyapatite (Hap) GIC, Surface roughness, Fruit juices

How to cite this article: Karunakaran S, Balaji Ganesh S. Comparison of Surface Roughness Between Conventional (Type-2) and Hydroxyapatite Modified Glass Ionomer Cement After Immersion in Fruit Juices - An In Vitro Study. Int J Drug Deliv Technol. 2026;16(21s): 435-439. DOI: 10.25258/ijddt.16.21s.45

Source of support: Nil.

Conflict of interest: None

INTRODUCTION:

The adhesion of restorative materials to tooth substance is an important goal in dentistry. It is believed that a restorative should be identical to the tooth in every way. It should have the same properties as the surrounding enamel and dentin and adhere to it tenaciously. One of the products developed in this direction is glass ionomer cements. Glass-ionomer cements (GICs) are extensively used in many areas of dentistry(1). It is an acid-base biomaterial made up of acid soluble fluoro-aluminosilicate glass powder and polyacrylic acid dissolved in water and tartaric acid (2). This material has the ability to exchange ions with its surroundings. The hydrophilic properties of PAA(polyacrylic acid), which are used in materials that need to be permeable to ions and water, can boost the bioactivity of these cements. GIC produces a highly bioactive water-based restorative material with therapeutic ion supply potential by combining the water solubility of PAA and ion-leachable glasses (3).

Due to these characteristics, GIC is used on patients who are at a high risk of developing dental caries and has a specific application on early intervention of cavitated caries. Furthermore, unlike other restorative materials, they can be easily placed in cavities without the use of bonding agents(4) . GIC additionally has special qualities like biocompatibility, low toxicity, anti-cariogenicity, and thermal compatibility (5). However, the use of GIC is restricted in stress-bearing areas due to its poor mechanical properties and moisture sensitivity (6).

Hydroxyapatite (Hap) is an inorganic compound with a structure similar to natural bone mineral. With a hexagonal crystal structure, Hap is a major component of minerals in bone and teeth (7). It is known for its biocompatibility and bioactivity with its crystal morphology and crystallinity similar to that of tooth enamel apatite crystals. The biocompatibility of nano-Hap can be improved by increasing its surface area and atomicity proportion to reduce particle size (8). The addition of hydroxyapatite nanoparticles to GIC was done to create materials that are similar to human hard tissues and to be used in dental restoration.

A surface character, such as roughness, can influence the quality and clinical behaviour of a restorative material (9). As a result, studies on the roughness of filling materials, particularly glass ionomer cements, have gained prominence. Smooth surfaces can affect material wear, aesthetics , the appearance of spots, and the risk of secondary caries (10,11). Rough surfaces, on the other hand, can aid in the retention, proliferation and survival of many caries-inducing microorganisms (*Lactobacillus spp.* and *Streptococcus mutans*) in the oral cavity and also promote periodontal diseases (*Actinobacillosis actinomicetemcomitans* and *Porphyromonas gingivalis*) (12) thereby causing gingival irritation. Additionally, smoother reconstructions are more durable and simpler to maintain. Therefore, the aim of this study was to evaluate and compare the influence of fruit juices on the surface roughness of conventional type -2 GIC and Hydroxyapatite modified GIC.

MATERIALS AND METHODS:

1. Nanoparticle synthesis:

Calcium oxide (CaO) (purchased from SD Fine Chem Limited, Mumbai, India), orthophosphoric acid (H3PO4) (purchased from Fisher Scientific, Mumbai, India), and ammonium hydroxide (NH4OH) (purchased from Fisher Scientific, Mumbai, India) were used as starting materials in this study. To begin, CaO powder was accurately weighed using an analytical weighing scale. A suspension of Ca(OH)2 was created after 1.42 mol (79.55 g) of CaO powder was added to 500 ml of deionized water in a 1000 ml beaker and vigorously stirred at 1000 r/min for 24 hours at 20°C. To avoid contamination from contact with atmospheric conditions, the beaker was covered. A thermostat-controlled water bath maintains the reaction temperature (20 °C). To accurately weigh the required amount of orthophosphoric acid, an analytical weighing scale was used. At a rate of 1.5 ml/min, 97.32 g of 85% H3PO4 was added to the Ca(OH)2 solution. The pH of the solution was monitored using a handheld pH metre with an accuracy of 0.2 during the acid addition. To aid in the maturation stage, the reactants were continuously stirred for an additional 24 hours at a rate of 1000 revolutions per minute while maintained at the appropriate reaction temperature of 20°C. After a 24-hour ripening period, 0.28mol (9.94 g) NH4OH was added to the Hap slurry to raise the pH of the supersaturation solution above 9. The solution was kept above 9 to maintain a Ca/P ratio of 1.67 . A pH of 10 has been proposed as the appropriate stoichiometric condition for the formation of pure single phase Hap.

2. Sample preparation:

GIC restorative material is available in a pack of powder and liquid components. Powder contains acid soluble alumino silicate fluoride glass and fluoride flux . Liquid contains polyacrylic acid , tartaric acid and water . Four disc shaped samples of conventional GIC restorative material with 2 mm of thickness were prepared using a customised mould(Group A). Likewise, another four disc shaped samples of Hap GIC was prepared with the same thickness of 2mm(Group B).

3. Evaluation of Surface roughness and statistical analysis:

Fruit juices (orange and grape juice) of required amounts were taken in plastic cups. After immersing the prepared discs in fruit juices for one week, the surface roughness was measured using the Stylus profilometer in terms of Roughness average (Ra), Arithmetic average (Ra) and Ten -point mean roughness (Rz). The mean, std.deviation and p value was obtained by one -way ANOVA test.

Image 1: Measurement of surface roughness using Stylus profilometer

RESULTS:

Groups	Mean	[illegible]	[illegible]
Conventional GIC	1.7538	[illegible]	[illegible]
GIC reinforced with HAP	3.8631	[illegible]	

Table 1: Table representing the mean, std deviation and significance of Ra parameter pre and post immersion in fruit juices.

Groups	Mean	Std.deviation	Significance
Conventional GIC	2.5055	0.628	0.0054
GIC reinforced with HAP	5.1269	1.076	

Table 2: Table representing the mean, std deviation and significance of Rq parameter pre and post immersion in fruit juices.

Groups	Mean	Std.deviation	Significance
Conventional GIC	13.3915	1.674	0.0002
GIC reinforced with HAP	26.2155	2.954	

Table 3 : Table representing the mean, std deviation and significance of Rz parameter pre and post immersion in fruit juices.

DISCUSSION:

Numerous parameters, such as acidic food, low pH, ionic composition, ionic strength of the saliva, and enzymatic attack, can impact the quality and quantity of substances released from a restorative material, as well as its physical and mechanical properties(13–22) In this study, the impact of fruit juices on the surface roughness of conventional GIC and Hydroxyapatite modified GIC was compared. For this study, grape and orange juices were chosen. The pH of grapes and oranges is 2.22-2.81 and 2.48-3.06, respectively (13)(23). A stylus profilometer was used in this study as it gives the quantitative measurement of surface roughness (Ra, Rz, and Rq values). This study concentrated on surface roughness because we want a restoration with smoother surface for better aesthetics, to prevent plaque buildup, to lengthen the restoration's lifespan in the oral cavity, and to prevent marginal deterioration that, if present, could lead to secondary caries (24).

In the current study it was proved that there is an increase in the surface roughness of both conventional and Hap GIC after immersion in fruit juices but, Hap modified GIC demonstrated more increase in surface roughness when compared to conventional GIC ($p<0.05$). In table 1, the mean Ra values of Hap GIC was more when compared to conventional GIC though the differences are statistically significant (p=0.0055 which is less than 0.05) .Whereas in table 2 , Hap GIC demonstrated higher mean Rq values when compared to conventional GIC with statistically significant difference(p=0.0054 which is less than 0.05). Hap GIC also demonstrated higher mean Rz values when compared to conventional GIC with statistically significant differences(p=0.0002 which is less than 0.05) in table 3. The acidogenic capacity of fruit juices is not only directly related to its pH because other factors such as different organic acids (for instance, grapes contain tartaric and maleic acid, while orange contain citric acid), phosphate content, titratable acidity and other weak acids with strong buffering capacities in fruit juices also contribute to its erosive action (25).Tamarind juices had a greater effect on the surface roughness of GIC, according to a similar study conducted by M.Siti et al (26). While it was established in the study by B. Sari et al. that the presence of citric acid and phosphoric acid causes the surface roughness of GIC immersed in Coca-Cola® to increase (27,28). Hemalatha et al demonstrated the influence of Gatorade (energy drink) on the surface roughness of light cure RMGIC and nano filled composite (29,30).

Whereas, P. Magnur et al. demonstrated the erosive effects of aerated and fruit drinks on flowable composite and RMGIC in their study (31,32). Due to time constraints, this study was only done in acidic fruit juices and in a short period of time (one week), so the results may be inaccurate. More research with different pH drinks to compare the effect of acidic, neutral and alkaline pH drinks is recommended. It is recommended that samples be immersed for a longer period of time, as the time taken in this study may not represent patients' normal consumption pattern of acidic fruit drinks. Other surface characteristics, such as surface hardness, temperature, staining effects, and other surface characteristics, can be studied in the future.

CONCLUSION:

The current study evaluated the influence of fruit juices on 2 types of GIC(conventional type 2 and Hydroxyapatite(Hap) modified GIC) with respect to surface roughness and on comparing the 2 groups it was concluded that Hydroxyapatite modified GIC (Hap) was prone to surface erosion after immersion in fruit juices.

ACKNOWLEDGEMENTS:

We express our sincere gratitude to the White lab, Saveetha Dental College and Hospitals and Saveetha Institute of Technical and Medical Sciences for their constant support and encouragement.

SOURCE OF FUNDING:

The present study was supported by the following agencies:

- Saveetha Dental College
- Saveetha Institute of Medical and Technical Science, Saveetha University
- S and S Impex

CONFLICT OF INTEREST:

The authors hereby declare that there is no conflict of interest in this study.

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