World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Research Article)

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The differences in surface roughness and hardness of glass ionomers cement coated with vaseline and cocoa butter after immersion in UHT milk

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World Journal of Advanced Research and Reviews, 2024, 24(03), 2374-2379

Publication history: Received on 10 November 2024; revised on 22 December 2024; accepted on 24 December 2024

Article DOI: https://doi.org/10.30574/wjarr.2024.24.3.3898

Abstract

Background: Dental caries affects 513.8 million children globally, and glass ionomer cement (GIC) is a common treatment due to its fluoride release. However, GIC is moisture-sensitive and prone to solubility during maturation. UHT milk, often consumed by children, disrupts ionic bonds on GIC surfaces affecting roughness and hardness. Increased surface roughness leads to plaque accumulation, while decreased surface hardness ensures compressive strength and abrasion resistance. Coating agents like vaseline and cocoa butter help preserve GIC properties by maintaining roughness and hardness.

Purpose: To analyze differences in surface roughness and hardness values of GIC treated with vaseline, cocoa butter, and without coating after being immersed in UHT milk for 7 days.

Methods: The experimental study used a post-test control group design with three groups of six specimens each, immersed in UHT milk for seven days. Groups included GIC without coating, coated with vaseline, and cocoa butter. The test results were then measured using a surface roughness tester and Vickers hardness tester and analyzed using the ANOVA.

Results: GIC coating with vaseline has the lowest value of surface roughness and highest surface hardness, followed by GIC coating with cocoa butter and without coating. However, the three groups did not have significant differences in statistical data analysis.

Conclusion: There is no difference in the surface roughness and hardness values of GIC without coating, coated with vaseline, or cocoa butter after being immersed in UHT milk for 7 days.

Keywords: Surface roughness and hardness; Glass ionomer cement; Vaseline; Cocoa butter; UHT milk

1 Introduction

The World Health Organization (WHO) in 2022, reported that 513.8 million children experience tooth decay, the estimated global average prevalence of caries of deciduous teeth is 43%, and 134 of 194 (69% of countries) [1]. One of the treatments that can be done for tooth decay in children is filling with glass ionomer cement [2]. Glass Ionomer Cement (GIC) is chosen for pediatric treatment due to its ability to release fluoride, which functions as an anticariogenic agent. Fluoride helps prevent secondary caries through mechanisms such as enhancing remineralization, inhibiting demineralization, and suppressing microbial growth [3]. Fuji IX glass ionomer cement was developed for use in

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atraumatic restorative treatment (ART), which refers to tooth restoration using a method of removing caries tissue only using hand instruments [4].

During childhood, milk is essential for growth due to its rich nutritional content, including calcium, protein, and vitamins, which support bone growth, brain function, and heart health [5]. UHT milk is a popular choice among toddlers and children [6]. Food and Agriculture Organization (FAO) in 2022, stated that milk consumption levels are below 30 kg per capita per year in the middle class and over 150 kg per capita per year in the high class. [7]. In the oral cavity, milk contamination is known to affect the physical and mechanical properties of glass ionomer cement restoration [8].

Milk has a slightly acidic to near-neutral pH, which decreases over time [9]. Acidic beverages can affect the surface of restorations because the acidic pH can break ionic bonds on the surface of dental restorative materials [10]. Ions such as strontium, calcium, and aluminum can be released from GIC to neutralize the acid if glass ionomer cement is exposed to acidic beverages [11]. These ions are essential components in the formation of the matrix during the setting reaction of GIC. If these matrix-forming ions are lost, it can lead to decreased translucency, dimensional changes, and reduced physical and mechanical strength [12]. Some important aspects of the physical and mechanical properties of GIC are the surface roughness and hardness of GIC. The surface roughness of glass ionomer cement as a restorative material is related to the accumulation of dental plaque, and surface hardness correlates with compressive strength and abrasion resistance [8, 13].

A coating agent is required to protect GIC from acidic pH contamination caused by milk. Several coating agents can be used, including varnish, vaseline, and cocoa butter. Currently, varnish is being phased out due to its inhibition of fluoride release [14]. A literature mentions that vaseline and cocoa butter can serve as coating agents for GIC. Therefore, the researcher aims to test these coating agents, which are commonly used in clinical practice, namely vaseline and cocoa butter [15]

2 Material and methods

2.1 Experimental Design

The study was conducted experimentally in a laboratory post-test control group design with 3 groups, each consisting of 6 specimens and immersed in UHT milk for 7 days. The three groups were GIC without coating (C), GIC coated with cocoa butter (T1), and GIC coated with vaseline (T2). The surface roughness and hardness of the samples were tested using a surface roughness tester and Vickers hardness tester on the eighth day.

2.2 Research Methodology

Sample preparation was conducted at the Research Center of the Faculty of Dentistry, Universitas Airlangga. GC Gold Label IX Extra Capsule GIC samples were placed in molds with a diameter of 6 mm and a height of 3 mm. Celluloid strips were applied to the base and top surfaces of the GIC. A thin glass slab and a 500 g weight were then placed on top of the GIC. The GIC was removed from the mold after 7 minutes. In Group C, GIC was left uncoated. In Group T1, GIC was coated with cocoa butter (GC, Japan), and in Group T2, GIC was coated with vaseline (Vaseline®, Unilever, USA). Each group was placed in a separate container and immersed in UHT milk stored at 4-6°C. The UHT milk in the containers was replaced with UHT milk opened from a new package every 24 hours for 7 days. The pH of the milk was measured at the beginning of each replacement and after 24 hours of immersion. On the eighth day, the samples were tested for roughness using a surface roughness tester (Mitutoyo SJ-210, Japan) and for hardness using a Vickers hardness tester (Shimadzu HMV Series, Japan). For the roughness test, the instrument settings were ISO 1997 with a stylus traversing distance of 4 mm, a cut-off value for surface roughness of 0.8 mm, and a measuring speed of 0.5 mm/s. For the hardness test, each specimen was subjected to a test load of 9.807 N (~1 Kgf) for 10 seconds with 3 indentations spaced at least 100 µm apart.

2.3 Data Processing and Analysis

The collected data was processed and analyzed using IBM SPSS Statistics version 29.0.2.0. The data was tested for normality (using Shapiro-Wilk test) and homogeneity (using Levene's test). Subsequently, a Welch's ANOVA test was used to determine the significance of surface roughness, while a one-way ANOVA test was employed for the analysis of hardness.

3 Results

The preliminary test on the pH of milk showed that the average pH values over seven days ranged from 6.53 to 6.90 on the figure 1. Based on this, it can be concluded that the pH in this study is acidic but close to neutral.

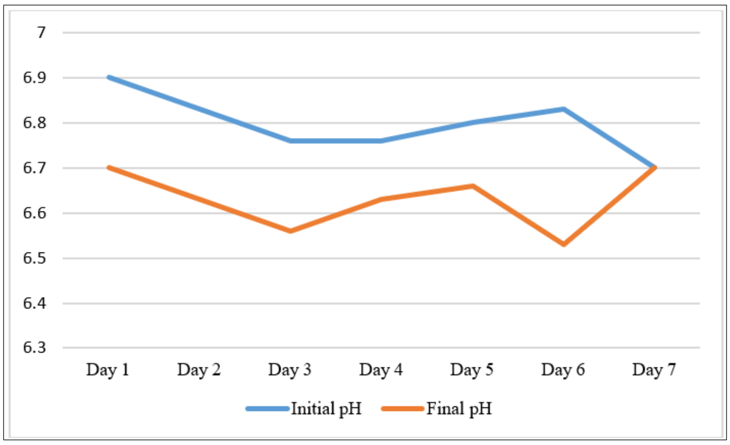

Figure 1 The UHT milk was used to initially immerse the GIC (glass ionomer cement) sample, allowing measurement of the initial pH. After 24 hours, the pH was measured again to determine the final pH after immersion. This process was repeated daily for 7 days**.**

Figure 2 shows that group T2 (vaseline) had a lower average surface roughness value of glass ionomer cement compared to group C (without coating) and group T1 (cocoa butter). In the vaseline group, the average surface roughness value was 0.379 ± 0.071640 (μm), while the without coating group was 0.544 ± 0.210344 (μm) and the cocoa butter group was 0.4297 ± 0.038872 (μm).

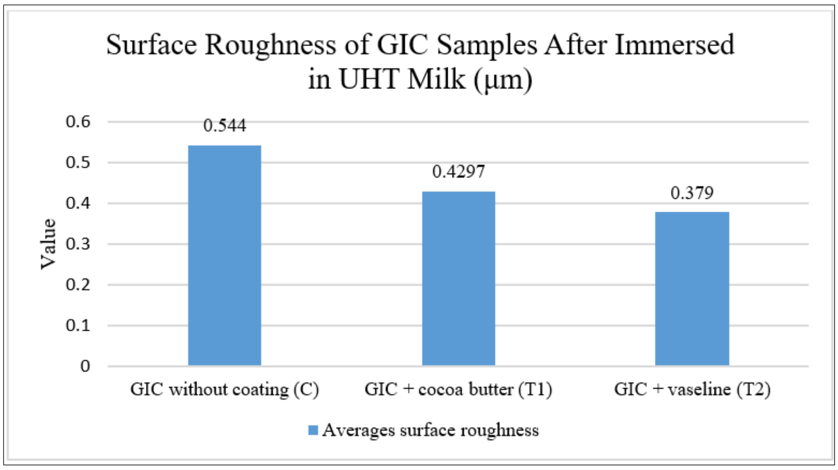

Figure 2 Graph of the average surface roughness value of glass ionomer cement for each group

Figure 3 shows that the highest average surface hardness value of GIC was found in treatment group 2 (T2), which used vaseline coating, with a value of 76.87 ± 1.98 VHN. The lowest average surface hardness was in the control group (C), which had GIC without coating, at 73.45 ± 1.67 VHN. The treatment group 1 (T2), using cocoa butter coating, had an average surface hardness of 73.72 ± 1.55 VHN.

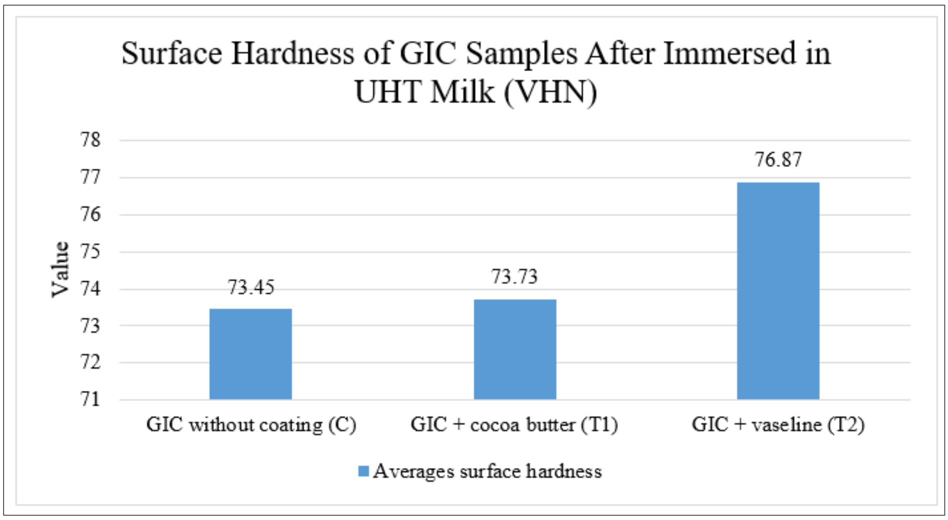

Figure 3 Graph of the averages surface hardness value of glass ionomer cement for each group

Data were analyzed using IBM SPSS Statistics version 29.0.2.0. The surface roughness of the GIC was analyzed using Welch's ANOVA, while the surface hardness was analyzed using one-way ANOVA. The results of both analyses showed no significant difference ($p > 0.05$).

4 Discussion

Based on the research data, there was no significant difference in surface roughness and hardness of GIC immersed in UHT milk for 7 days between group T1 (cocoa butter), group T2 (vaseline), and group C (without coating). This is because the pH of the milk, which is close to neutral, may also be a contributing factor to the non-significant data. Acidic pH exposure from milk contaminating GIC may be one of the causes of decreased surface roughness and hardness. Previous research found that the acidic pH of kefir lactate had a stronger effect than distilled water on surface hardness, as its high acidity caused a decrease in the hardness of glass ionomer cement [16]. In this study, the average pH of the milk was found to be close to neutral, so it did not have a significant effect on the release of ions that form the setting reaction of glass ionomer cement, which is related to the decrease in the physical and mechanical properties of GIC [11]. In addition, the literature also mentions that the use of coats such as cocoa butter and vaseline provides minimal protection, as they can be easily removed when exposed to friction or chewing activities in the oral cavity [17, 18].

Group T1 (cocoa butter) had a lower value of surface roughness than group C (without coating), but a higher value of surface roughness than group T2 (vaseline). This indicates that group T1 has a smoother surface than group C, but a rougher surface than group T2. Meanwhile, the surface hardness value of group T1 (cocoa butter) was higher than group C (without coating), but lower than group T2 (vaseline). This suggests that group T1 has a harder surface than group C, but a softer surface than group T2. These results may be due to the cocoa butter's fat content reacting with the casein in the milk, which can emulsify the difference in polarity between liquids by reducing surface tension, allowing milk to contaminate the GIC surface, thus releasing strontium, aluminum, and calcium ions [19, 20].

Group T2 (vaseline) showed the lowest surface roughness and the highest surface hardness values GIC among the tested groups. This indicates that group T2 had the smoothest and hardest surface compared to the other groups. Unlike cocoa butter, vaseline contains 100% pure petroleum jelly, where emulsification does not occur in petrolatum, thus preventing ion leaching from the GIC matrix [21].

5 Conclusion

The research data showed no difference in surface roughness and hardness of GIC immersed in UHT milk for 7 days between group T1 (cocoa butter), group T2 (vaseline), and control (without coating).

Compliance with ethical standards

Acknowledgments

All research plan and works were self-sponsored by the authors mentioned.

Disclosure of conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this document

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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