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Evaluation of Microhardness of Self-Adhesive Pediatric Filling

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Abstract

Objective: The purpose of this study was to evaluate how beverages affected the self-adhesive hybrid pediatric cement's microhardness.

Materials and Methods: Specimens measuring 5 mm in diameter and 2 mm in thickness were fabricated from Surefil one self-adhesive hybrid GIC and subjected to exposure by acidic beverages. The study involved three groups (artificial saliva as control, Cola, Sparkling water with lemon). Samples for Vickers hardness were immersed for 15 minutes daily for 28 days. Then, samples were tested using a Vickers microhardness tester. Statistical analysis involved the use of one-way Anova and post hoc Tucky test at the level of significance of 0.05.

Results: When Surefil One samples were submerged in simulated saliva, their Vickers microhardness significantly decreased. Samples submerged in Cola showed the largest decline, indicating a negative impact on material integrity.

Conclusions: Beverages affected the self-adhesive hybrid pediatric cement's microhardness.

Keywords: Fluoride release; Glass Ionomer Cement; Microhardness; Surefil One.

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Introduction

Because of its exceptional qualities, which include fluoride release, biocompatibility, and adhesion to dentin and enamel, glass-ionomer cements have been used in both restorative and preventative dentistry [1,2]. Glass ionomer cements are a crucial and essential component of several restorative, pedodontic, and preventative dental procedures. This is because these materials may closely mimic the structure of teeth and allow for remineralization at the tooth-material contact. GICs stand out as practical and clinically essential among the wide range of dental materials that are accessible, and they are a mainstay of modern dentistry treatment [3].

Recent developments in dental material science have sparked a great deal of interest in learning more about how different environmental conditions affect GIC characteristics. One area of interest is how various drinks and beverages affect some of these restorations' mechanical, chemical, and physical characteristics [4]. For both academics and clinicians, knowing how popular beverages affect glass ionomer materials is crucial because it provides valuable information on how long dental restorations will last in real-world situations [5].

Depending on the beverage's composition and pH levels, different drinks may interact differently with glass-ionomer cements. Acidic drinks, including carbonated drinks and citrus juices, pose a risk to GICs because they cause acidic erosion and filling material deterioration [6,7]. The integrity and qualities of the cement matrix may be compromised by the breakdown of glass particles brought on by the acidic environment. Furthermore, extended exposure to acidic drinks might hasten the GIC's fluoride release, decreasing its effectiveness and encouraging remineralization [8]. In a previous study, conventional and Resin-Modified Glass Ionomer Cements

Dentistry 3000
Vol 13 No 1 (2025) DOI 10.5195/d3000.2025.822

revealed qualitative surface changes after immersion in different drinks (Coca-Cola, Lemonade, and Fuzetea), characterized by the presence of unevenly distributed micro-cavities on the surface [9]. Furthermore, research suggests that such drinks can have erosive effects on GICs, with different erosion patterns observed. The depth of erosion was found to be greater at the margin than at the body of the restoration [10].

Fluoride release from dental restorative materials is an important aspect of their effectiveness in avoiding tooth decay and supporting oral health [11]. Several research have been undertaken over time to explore the fluoride release qualities of different dental repair materials [12,13]. However, these studies have frequently produced significantly variable results, which can be due to variances in methodology, specimen size, storage conditions, and measuring procedures [14]. In a previous study, it was found that glass carbomer exhibited the highest fluoride release into deionized water compared to conventional GIC (Chemfil Rock) and resin-modified GIC (Fuji II LC). However, the fluoride uptake by glass carbomer did not lead to increased fluoride release, unlike the conventional and resin-modified GICs, where fluoride uptake enhanced subsequent fluoride release. This suggests that while glass carbomer may be highly effective in initial fluoride release, its recharging mechanism differs from other GICs [15,16].

Material and Methods

The materials and its composition used in the study are listed in (Table 1).

Table 1. Materials used.

Material	**Composition**
Surefil One Self-Adhesive composite hybrid	Powder: silanated aluminum-phosphorus-strontium-sodium-fluoro-silicate glass, dispersed silicon dioxide, ytterbium fluoride, and pigments Liquid: acrylic acid, polycarboxylic acid, bifunctional acrylate, self-cure initiator, camphorquinone, and stabilizer
Cola	Carbonated Water High Fructose Corn Syrup (or Sucrose) Caramel Color (E150d) Phosphoric Acid Natural Flavors Caffeine Citric Acid Sodium Citrate

Dentistry 3000
Vol 13 No 1 (2025) DOI 10.5195/d3000.2025.822

Sparkling Water with lemon	Sparkling Water Fresh Lemon Juice Lemon Slices

Study Design

The purpose of this prospective in vitro study was to investigate the effects of acidic drinks on Surefil One's Vickers microhardness. Three groups—Group A, Group B, and Group C—were formed according to the immersion solutions that were used: sparkling water, Cola, and artificial saliva, respectively. There were ten samples in each group, for a total of thirty samples per test condition.

Samples Preparation

Samples were fabricated using molds crafted from clear acrylic plates (Perspex Cell Cast Acrylic, Clairvaux-les-Lacs, France). For the microhardness test, disks were standardized to dimensions of 5 mm in height and 2 mm in thickness [11,17,18].

The molds were put on the surface of a thick glass plates, then celluloid transparent strips (Stripmat, POLYDENTIA, CH-6805 Mezzovico, Switzerland) were interposed between them to ensure a even surface and reduce the risk of air bubbles. After filling the molds with Surefil one material, excess material was removed, and another transparent strip was applied followed by a second glass plate. Samples were polymerized for 20 seconds using an LED curing light source (Optilight LD MAX, Gnatus, Ribeirão Preto, SP. Brasil). The tip of the light cure 8mm in diameter and the intensity of the light of 1200 mW as measured with a radiometer (Denshine, China). After curing, the samples were cautiously taken out of the molds and finished by only trimming any excess with sheets of 1200 grit silicon carbide.

Immersion Procedure

Three groupings of samples were created: Group A: As a control, disks were submerged in fake saliva for the length of the trial. Group B: For 28 days, samples were submerged in the acidic beverage (Cola) for 15 minutes every day. Group C: Similarly to Group B, samples were submerged in the freshly made acidic beverage (Sparkling water with lemon) for 15 minutes every day for 28 days, and the pH was measured with a pH meter (Milwaukee, USA). When not submerged in liquids, samples in groups B and C were maintained in artificial saliva.

Vickers Microhardness

Ten disc-shaped samples per group, each measuring 5 mm in height and 2 mm in diameter, were prepared for Vickers microhardness testing. After removal from the molds, the samples were incubated for 24 hours at 37°C. Surface microhardness was evaluated by a digital tester (laryee hvs-5Manufacturing Limited, Beijing, China) as shown in (Figure 1). Three indentations were made within 15 seconds of dwell time with a load of 100 g and a magnification of 20×. The mean surface microhardness value for each sample was recorded in Vickers hardness numbers (VHN).

Figure 1. Vickers microhardness test.

Dentistry 3000
Vol 13 No 1 (2025) DOI 10.5195/d3000.2025.822

Statistical Analysis

The statistical analysis for this study involved descriptive statistics such as mean, standard deviation, minimum, and maximum values. Analysis of variance (ANOVA) was used to compare the mean values of compressive strength and Vickers microhardness among the different groups. Independent t test was used for fluoride release and uptake tests. Finally, post-hoc analysis such as Donnette's test and Tuckey's HSD, was conducted to determine which specific groups differed significantly from each other

Results

Vickers Microhardness

The highest recorded value was observed in group A, followed by group C, and then group B. Tuckey post hoc test revealed highly significant differences between all the groups (Table 2).

Table 2. Descriptive statistics for Vickers microhardness test.

Group	Min	Max	Mean	±SD	F	P-value	Groups	P-value
Group A	76.50	79.50	78.1000	0.87000	102.345	0.000	A B	0.000
Group B	71.50	73.50	72.8000	0.85000			A C	0.000
Group C	73.50	76.50	75.0000	0.89000			B C	0.000

Levene's statistics = 3.045, P-value = 0.085 [NS]

Discussion

The observed decrease Vickers microhardness of SureFil one following immersion in acidic beverages such as cola and sparkling water with lemon underscores the intricate interplay of chemical and physical processes inherent in the composition and behavior of the material. SureFil one, a self-adhesive composite hybrid, comprises a unique blend of components designed to impart superior mechanical properties and ease of application in dental restorations. The material's main component, high molecular weight polyacrylic acid functionalized with polymerizable groups (referred to as MOPOS), forms the backbone of its structural matrix. This polyacrylic acid bears similarities to Vitrebond copolymer, present in Vitremer and Ketac Nano. Moreover, SureFil one contains monomers with two photopolymerizable ends (BADEP), introduced to the polyacrylic acid chains as cross-linkers, enhancing the material's mechanical strength [19,20].

Cola and sparkling water with lemon are both acidic. Cola contains phosphoric acid and carbonic acid, sparkling water with lemon contains organic acids such as malic and citric acids. Upon exposure to such acidic beverages, the chemical constituents of SureFil one are subjected to degradation and alteration. The acidic environment catalyzes hydrolytic degradation of the resin matrix, facilitated by the presence

Dentistry 3000
Vol 13 No 1 (2025) DOI 10.5195/d3000.2025.822

of phosphoric acid in cola and organic acids in the sparkling water juice. Acid-catalyzed hydrolysis and ion exchange processes lead to the leaching of fillers from the resin matrix, resulting in a depletion of reinforcing components and a consequent decline in compressive strength [21,22,23]. In addition, the acids in such beverages can erode the surface layer of Surefil one. The acrylic and polycarboxylic acids of Surefil one may react with these external acids which leads to breakdown of polymer network. Such erosion can expose the underlying filler particles and decrease the surface resistance to wear and indentation [24].

Furthermore, the acidic constituents of the beverages can interact with the chemical constituents of SureFil one, such as the modified polyacid MOPOS and cross-linker BADEP, precipitating complex chemical transformations that compromise the intermolecular bonding within the material [25.] Acid-base reactions between the acidic components of the material and those of the beverages result in the formation of new chemical species, altering the material's microstructure and contributing to a reduction in Vickers microhardness [26,27]. In addition, the presence of water in such beverages enables the entrance of water inside the structure of SureFil one increasing water absorption and causes hydrolysis of the ester bonds in the bifunctional acrylate, which can induce swelling and plasticization of the material, further weakening the mechanical properties and aggravating the decrease in compressive strength and microhardness [28-30].

Conclusion

Almost all glass ionomer cements are affected by beverages, and this study showed that Surefil one is also affected by the exposure to Cola and sparkling water with lemon, that’s why clinicians should pay attention to such factors to maintain the long-term performance of the restoration and ensure the satisfaction of patients.

Conflicts of interest

The authors declare no competing interest.

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Dentistry 3000
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