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Effect of Pediatric Dentifrices on Surface Roughness of Glass Ionomer Cement Restoration - An In Vitro Study

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KEYWORDS

Caries, GIC, Toothpaste,

Surface roughness.

ABSTRACT:

Background and Aim: The surface roughness of dental restorations tends to increase following tooth brushing with commonly used abrasive-containing toothpaste, which promotes greater plaque accumulation and consequently elevates the risk of dental caries. The purpose of this study was to assess and compare the impact of three toothpastes (colgate kidz, pediflor kidz, mamaearth kids toothpaste) on the surface roughness of glass ionomer cement restorations.

Methods: The purpose of this study was to assess and compare the impact of three toothpastes (colgate kidz, pediflor kidz, mamaearth kids toothpaste) on the surface roughness of glass ionomer cement restorations.

Results: As per the findings, there was a statistically significant difference ($p < 0.05$) between the three groups' surface roughness (Ra) values at baseline and post brushing. The maximum Ra seen in Mamaearth kids toothpaste (group III), followed by pediflor kids toothpaste (group II), and least increase was colgate kids toothpaste (group I).

Conclusions: As a result of our study showed that Colgate Kids toothpaste are superior because of reduced surface roughness when compared with other groups

1. Introduction

Dental caries is a common chronic oral condition that affects 60% to 90% of school-going children worldwide[1]. The primary preventive measure is to maintain good dental hygiene, which has significant implications for biological, psychological, and social effects[2]. Effective plaque control is essential for preserving oral well-being since dental plaque is the main factor of etiology in the beginning and development of both periodontal and caries diseases. Although the removal of plaque with a toothbrush is a crucial aspect of disease control, using a toothbrush in conjunction with dentifrice improves the mechanical control of plaque [3]. Abrasives are present in toothpaste along with humectants, gelling and binding agents, flavors, perfumes, and preservatives. The most prevalent abrasives content used these days are silica derivatives. Along with the quantity of abrasive, additional factors that affect a toothpaste's abrasiveness include the size, surface structure, and chemical interactions of the product's other ingredients [4].

Glass ionomer cement (GIC) is utilized in proximal or occlusal cavities with modest occlusal loads in cases of cervical or root caries, primarily in patients with a high risk of developing caries [5,6]. Their beneficial qualities, including

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biocompatibility, adherence to tooth structure, and fluoride release, have led to their widespread usage in pediatric dentistry [7]. While brushing teeth, abrasion is known to increase the production of dental plaque and alter the surface roughness of the restorative materials [8]. However, the surface quality of the restorations is a critical factor that influences their clinical efficacy. A smooth surface can improve the longevity and aesthetics of repair by reducing plaque build up and surface discolouration [9].

Research has shown that 0.2 µm is the threshold surface roughness (Ra) for bacterial colonization [10]. When the surface roughness is greater than 0.2 µm, the risk of decayed tooth increases because of the large rise in bacterial accumulation, plaque maturation, and PH. Furthermore, surface roughness might have a direct impact on the restoration's wear behavior and marginal integrity [11].

Some of the commonly used pediatric toothpaste are Colgate kids, Pediflor kidz, Mamaearth kids. The GIC's surface roughness after using these three toothpastes has not been evaluated. Henceforth in vitro study aims to evaluate and compare the impact of various commercially available pediatric dentifrices on the surface roughness of GIC restorations.

2. Methods

Sample size calculation

Based on the study proposed by Poonacha et al., the sample size was calculated using G*Power statistical software. The effect size, d = 0.336, α error = 0.2, β error is 0.8. The estimated sample size is 27 but the total sample was approximated into 30 with 10 in each group (n=10). The study conducted after obtaining the NLH ethical clearance from our institution [No:VDCW/IEC/462/2024]

Specimens preparation

In total, 30 samples were made using traditional restoration GIC (Ketac molar GIC). Following the manufacturer's recommendations, the GIC was mixed. Cylindrical plastic molds with measurements of 2 mm in height and 15 mm in diameter were filled with the material[12]. The samples were gently taken out of the molds (Figure 1) and placed in a circular acrylic holders after an initial setting time of five minutes. Prior to additional testing, all samples were kept in distilled water at 37°C for 24 hours in order to mimic the natural aging process.

The 30 prepared samples were randomly allocated into three category (n = 10 each). Each sample was assigned a number from 1 to 30, and the division was performed using a random allocation method. Every group's samples were subsequently treated with their respective pediatric dentifrices. They are Group 1: Colgate Kids Toothpaste, Group 2: Pediflor Kidz Toothpaste and Group 3: Mamaearth Kids Toothpaste.

The test surface was positioned 1 mm above the edge of the acrylic plate orifice to provide uniform exposure, and each specimen was firmly placed in the middle of the orifice. Using a soft-bristled toothbrush, 10,000 reciprocal strokes were delivered at a rate of 60 strokes per minute, with a linear speed of 30 mm/s. In order to replicate clinical toothbrushing dynamics, the toothbrushes moved in a circular manner while the sample holder rotated during the brushing simulation. The GIC samples were brushed using a 200g force using soft toothbrushes and three distinct pediatric dentifrice solutions, which contained 25 g of toothpaste and 40 mL of distilled water.



Figure 1. Prepared GIC samples and different

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pediatric toothpaste

Surface roughness assessment

The mean surface roughness (Ra) of the specimens was measured using a nanomechanical testing system (Hysitron TI 700 Ubi 1, Hysitron Inc., Florida, USA). Surface roughness measurements were recorded at baseline and upon completion of the brushing protocol. For each specimen, multiple randomly selected sites were scanned to obtain the arithmetic mean surface roughness (Ra), expressed in nanometers (nm). (figure 2)

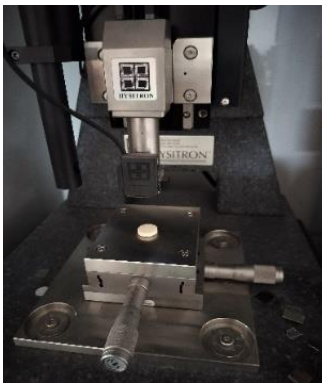


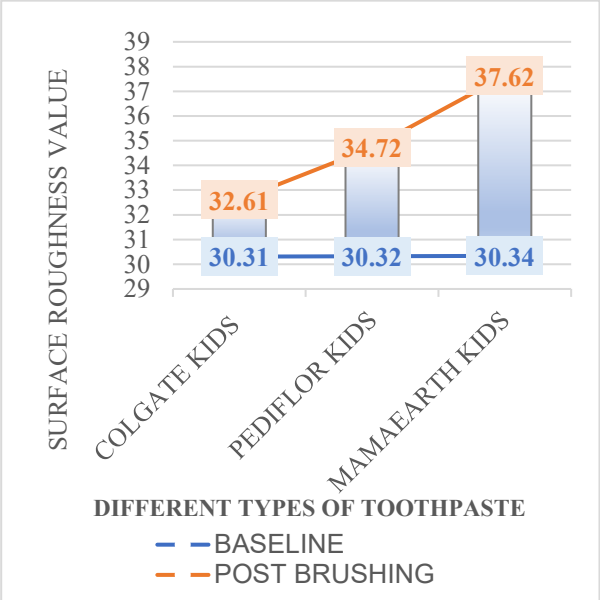
Figure 2. Nanomechanical testing machine

Statistical analysis

Statistical analysis was performed using IBM SPSS software, version 26.0 (IBM Corp., Armonk, NY, USA). The Shapiro–Wilk test confirmed that the data were normally distributed ($P > 0.05$). Descriptive statistics, including mean, standard deviation (SD), standard error, minimum, and maximum values, were computed. For inferential analysis, a paired t-test was employed to assess differences in surface roughness before and after brushing simulation the intervention within each group. Intragroup comparisons were performed using post hoc Bonferroni test. A significance level of $\alpha = 0.05$ was set, and results with $P < 0.05$ were considered statistically significant.

3. Results

On intragroup comparison, difference between the Ra values at pre and post brushing was observed between three categories, which was statistically significant ($p < 0.05$). The maximum increase in Ra seen in Mamaearth kids toothpaste (group III), followed by pediflor kids toothpaste (group II), and colgate kids toothpaste (group I) (table 1). The mean value of baseline and post-brushing for colgate kids toothpaste is 30.31±1.36 and 32.61±1.53 with mean difference of -3.262 which is least when compared to other groups. On intergroup comparison of post-brushing, colgate kids and pediflor kids toothpaste groups and pediflor kids and mamearth kids toothpaste groups shows statistically significant ($p < 0.05$). Colgate kids and mamaearth kids toothpaste groups shows highly significant ($p < 0.001$) (table 2)



Graph 1 Difference in surface roughness among groups

Using paired t test

**indicates p<0.05 – statistically significant*

***indicates p<0.001 – highly significant*

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Groups	Internals	Mean± sd	T value	P value
Colgate Kids	Baseline	30.31±1.3	-3.262	0.01*
	Post brushing	32.61±1.5		
Pediflor kids	Baseline	30.32±1.0	-7.358	0.001*
	Post brushing	34.72±1.3		
Mamaearth kids	Baseline	30.34±1.0	-11.949	0.001*
	Post brushing	37.62±2.3		

Table 1. Intra-group comparison between baseline and post-brushing

Using Bonferroni post hoc tests

**indicates p<0.05 – statistically significant*

***indicates p<0.001 – highly significant*

Groups	Mean± sd	T value	P value
Colgate kids	32.61±1.53	-2.11	0.041*
Pediflor kids	34.72±1.34		
Colgate kids	32.61±1.53	-5.01	0.001**
Mamaearth kids	34.72±2.34		
Pediflor kids	34.72±1.34	-2.90	0.004*
Mamaearth kids	37.62±2.34		

TABLE 2: Inter-group comparison of post-brushing

4. Discussion

GIC's are widely used in pediatric dentistry which have distinctive features such as biocompatibility, adhesion to tooth structure and fluoride release. In our study, Ketac molar GICs were used which has mechanical properties, its packable consistency and greater radiopacity. A prepared GIC specimens were kept in distilled water because chemical dissolving process increases the Ra in restorative material. An elevated Ra of GIC-based restorative materials after toothbrushing has been reported in studies by Dudás et al[8], and Demirel et al[13]. The commonly used abrasive content in toothpaste was alumina, calcium carbonate, silica, hydrated silica, and sodium bicarbonate. The toothpastes employed in this study contained silica (colgate kids, pediflor kids toothpaste) and hydrated silica (mamaearth kids toothpaste) as the abrasives.

According to Yilmaz.,[14] The relatively smaller particle size of silica commonly used in toothpastes (4–12 μm) compared to the larger particle size of hydrated silica (14–20 μm) may contribute to differences in abrasive potential. This variation in particle size is likely a determining factor in the extent of surface alterations observed, as smaller particles are generally associated with less aggressive abrasion. In the context of intraoral hard surfaces, a threshold surface roughness of 0.2 μm has been identified in several in vivo studies[11]. Surface roughness exceeding this value has been associated with a significantly increased risk of plaque accumulation, which in turn contributes to a heightened susceptibility to tooth decay and periodontal inflammation.

In this study, the abrasive effects of various children's toothpastes on enamel were evaluated using a nano-indentation testing machine following a simulated toothbrushing protocol of 10,000 cycles. A TriboScanner in a nanoindentation testing machine can often perform topographical scanning using a Berkovich probe, similar to how AFM works. It allows for 3D mapping of surface features. In applications like bacterial colonization, where even minor surface features can affect adhesion, the assessment of SR at the nanometer scale is especially crucial. The interaction force between the Berkovich probing tip and the specimen surface is negligible, so it has no adverse effect on the surface or measurement[15].

The Colgate Kids and Pediflor Kids, both containing silica as the abrasive agent, and Mamaearth Kids toothpaste, which uses hydrated silica. Distilled water was used as the storage medium. The results showed that the type of

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abrasive significantly influences the enamel surface roughness. Among the three toothpastes, Mamaearth Kids toothpaste, containing hydrated silica, exhibited the highest abrasivity, leading to the greatest increase in enamel surface roughness. Pediflor Kids toothpaste showed moderate abrasivity, while Colgate Kids toothpaste was the least abrasive, resulting in the lowest surface roughness after brushing. These findings suggest that Colgate Kids toothpaste may be more suitable for reducing enamel wear during brushing, whereas formulations with hydrated silica, such as Mamaearth, may contribute to greater enamel surface alteration.

Poonacha et al. (2023) reported that Chicco dentifrico, containing hydrated silica, caused greater surface roughness on GC Gold GIC discs than Colgate anticavity kids toothpaste with silica, following a 15-day brushing simulation. The higher abrasivity of hydrated silica may be attributed to its larger particle size, aligning with the findings of the present study[16]. Binhasan et al. (2022) demonstrated that Colgate Optic Charcoal, containing hydrated silica, produced greater surface roughness on Z350 composite discs than Colgate Optic White with silica after 25,000 brushing cycles. This supports the higher abrasivity potential of hydrated silica, consistent with current findings.In contrast, a study using Ketac Molar GIC discs showed that R.O.C.S Kids toothpaste with silica caused greater surface roughness than SPLAT kids toothpaste with hydrated silica after 7 days of brushing. This contradicts typical trends and suggests that factors beyond abrasive type, such as formulation or brushing dynamics, may influence abrasivity.[12]

Yilmaz et al. (2020) evaluated the surface roughness of Ketac Molar glass ionomer cement (GIC) discs after a seven-day toothbrushing simulation using R.O.C.S. Kids Fruit Cone, containing silica, and SPLAT Kids, containing hydrated silica. Their results showed that R.O.C.S. Kids toothpaste produced greater surface roughness compared to SPLAT Kids toothpaste. This finding contrasts with the results of the present study, where SPLAT Kids toothpaste exhibited a higher abrasive effect on GIC surfaces[17]. The discrepancy may be due to differences in experimental parameters, such as brushing protocols, abrasive particle characteristics, concentration of abrasives, or toothpaste formulation, highlighting the need for further comparative research to clarify these variations.

5.Conclusion

Within the limitation of this study, Our study showed that colgate kids toothpaste are superior because of reduced surface roughness when compared with other groups. This smoother surface minimizes plaque accumulation, thereby contributing to a lower risk of dental caries and supporting better long-term oral health in pediatric populations. Nevertheless, the study's limited replication of in vivo conditions highlights the necessity for more comprehensive and representative investigations in future research.

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