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Effects of pediatric liquid medications on surface properties of dental restorations

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ABSTRACT

Background/purpose: Tooth-color restorations have diverse stability in regard to their surface properties especially after exposure to abrasive conditions, such as acid media or medication. This *in-vitro* study aimed to investigate the effects of exposure to liquid pediatric medications on the color stability and roughness of three tooth-colored restorative materials (a resin-modified glass ionomer cement, nanocomposite, and compomer). *Materials and Methods:* For each material, 55 disk-shaped samples were prepared and stored in a thermocontrolled incubator for 24 h while submersed in one of five exposure media (a multivitamin, bronchodilator, antiepileptic, antibiotic, and distilled water). All specimens were tested before and after exposure to estimate the shift in color and surface properties. *Results:* The medications significantly affected color stability, surface roughness, or both in all dental restorations. A significant and unfavorable change in color stability was observed for all restorative materials after immersion in the bronchodilator and antiepileptic, with the composite sample showing the least color stability after exposure. The resin-modified glass ionomer cement demonstrated the greatest change in surface roughness (P-value = 0.003). The best color stability, below 3.3, and surface roughness, below 0.2µm, were observed for the compomer. *Conclusion:* The medications evaluated in this study had a negative affect on the color and roughness of the materials under investigation. Parents should be instructed in proper oral hygiene to limit the negative impact of prolonged exposure to these medications. More *in-vivo* studies are required to improve the stability of direct restorations.

Keywords: Drugs Effects; Medicine; Prescription Drugs; Surface Properties; Dental Restorations; Pediatric Dentistry.

1. INTRODUCTION

Tooth-color restorations are the most sought-after option for both patients and clinicians, particularly given the increasing concern regarding esthetic appearances which necessitates improved knowledge of biomaterials properties to enhance material selection practices seeking a material with higher resistance to environmental change (Iazzetti et al., 2000; Bagheri et al., 2005). In pediatric dental clinics, composite resins, glass ionomers, and

compomers are typically used to restore damaged teeth. However, their use is dependent on specific indications and situations for each case (Burke et al., 2002; Tran and Messer, 2003; Uhlen et al., 2019).

Restoration discoloration, or staining, represents a major esthetic obstacle. Several studies have demonstrated staining of composites, and several research have shown that staining of composite restorations may be caused by extrinsic and intrinsic causes, the effects of which grow with time (Villalta et al., 2006; Ceci et al., 2017). Some extrinsic factors of interest include beverages and even some dental products, which have been evaluated extensively and were reported to exert a harmful impact on the properties of tooth-colored restorations (Bagheri et al., 2005; Villalta et al., 2006; Bajwa and Pathak, 2014; Khan et al., 2015; Maganur et al., 2015; Tekçe et al., 2015; Mickeviciute et al., 2016). The effects of medications on teeth and restorative surfaces have been studied. Specifically, the cariogenic and non-cariogenic effects of oral drugs on dental tissue have been documented (Xavier et al., 2013; Scatena et al., 2014; Tupalli et al., 2014; Saeed et al., 2015; Tuzuner et al., 2017). Nevertheless, knowledge regarding the effects of medications on the properties of dental restorations remains limited.

The present study aims to assess the color stability and surface quality of common restorations used in pediatric dental clinics after long-term exposure to some medications typically used to treat medical symptoms in medically compromised pediatric patients.

2. MATERIALS AND METHODS

This Research-study was conducted Over 8 month period from 1st of July 2019 to 27 February 2020 at Advanced Technology Dental Research Laboratory at King Abdulaziz University in Jeddah, Saudi Arabia

Specimen preparation

The pediatric medications and restorative materials used are detailed in Table 1 and samples grouping process is illustrated in Figure 1. The studied medications were liquid medications that are typically prescribed for an extended period of time for pediatric patients with chronic illnesses. The selected restorative materials were modified or nano-enhanced restorations. Experiment protocol was appraised and approved by the local research ethics committee.

Fifty-five disk shaped samples were prepared from three different restorative material groups for a total of 165 samples (After preparation, the samples were divided among five exposure sub-groups, with each subgroup containing 11 samples. Each sample was constructed as a standardized disk (8mm diameter and 2mm thickness) by using a custom-made mold to obtain the desired dimensions suitable for testing equipment.

Sample preparation involved filling a mold with the restorative materials and covering it from both sides (above and below the mold) with a clear strip and glass slide to ensure a smooth surface of the restorative material. Each specimen was cured as recommended by the manufacturer.

Immersion

All samples were stored at 37 °C in a thermostatically controlled incubator throughout the storage phase of the study. They were stored in a dark glass container filled with artificial saliva for the first 24 h to ensure complete setting of the restorative materials, followed by another 24 h of immersion in an assigned liquid medication.

Assessment

Color stability followed by surface roughness measurements were performed on each sample. All samples were tested before and after exposure to the assigned media. To detect any alterations, the pre- and post-exposure values were compared. A spectrophotometer (Color Spectrophotometer X rite Color Eye 7000a/Net Profiler Ready/USA) and a non-contact optical surface profilometer (Optical Profilometer Contour GT/BRUKER, Germany) were utilized to determine the color stability and surface quality, respectively.

Two values were obtained from each sample, namely, for the color stability and roughness of the surface. The first was recorded as a delta value (ΔE); it was regarded as clinically significant when $\Delta E > 3.3$ (Seghi et al., 1989; Lindsey and Wee, 2007; Johnston 2009). The second (Ra) was recorded to evaluate the surface change and was regarded as clinically significant when Ra > 200 nm (0.2 μm) (Quirynen and Bollen, 1995; Bollenl et al., 1997).

Statistical analysis

The Statistical Package for Social Sciences version 18.0 was used to conduct the statistical analysis (SPSS Inc., Chicago, IL, USA). The data revealed a non-normal distribution and non-parametric statistical tests were carried out in the present study. The significance level was set as 0.05.

Color stability readings were analyzed via the Mann–Whitney U test to determine the impact of each medication on the color alteration of different restorations in comparison to distilled water. For surface roughness, the Wilcoxon signed-rank test was applied to compare differences in the effects between values before and after exposure to each medication, and the Kruskal–Wallis test was utilized to compare the impact among restorations.

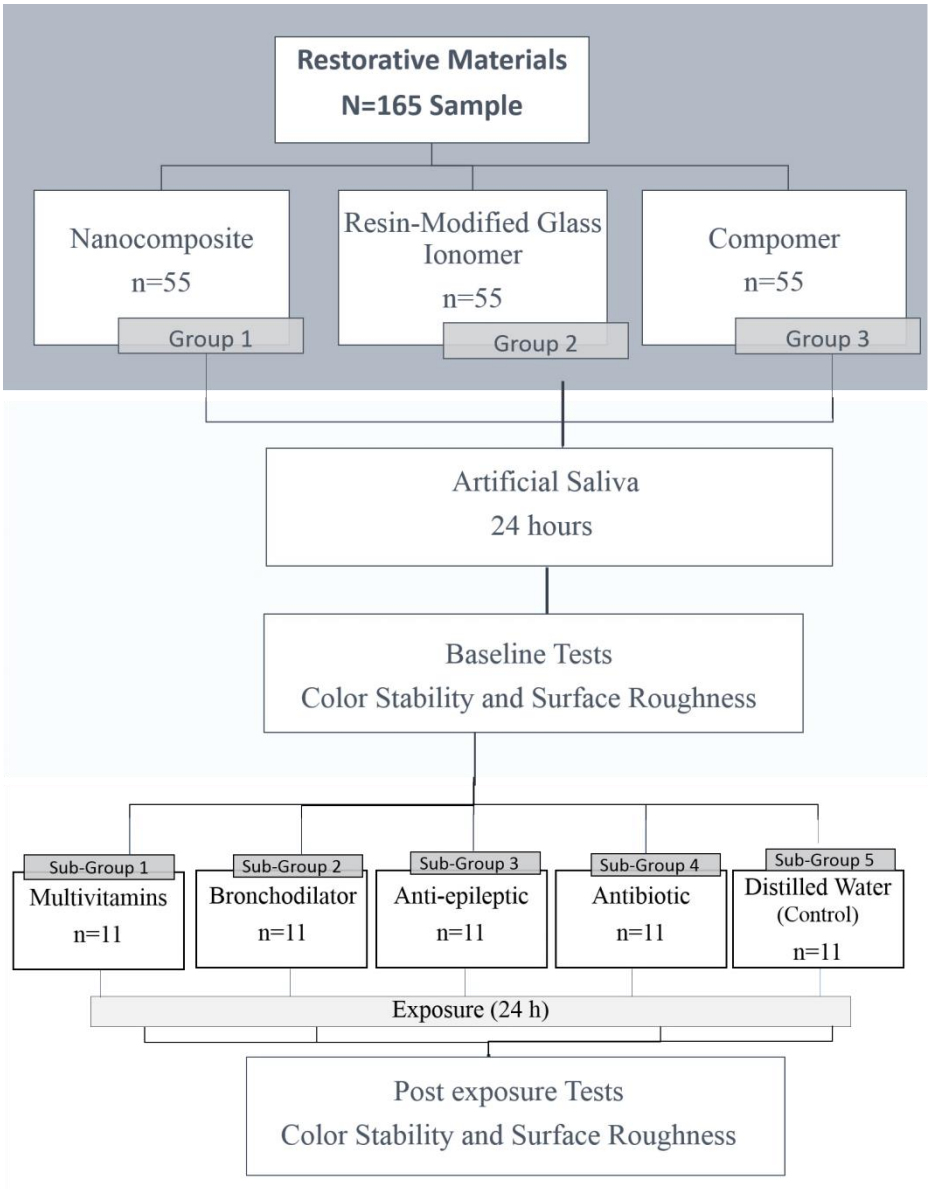

Figure 1 Study flow chart

Table 1 Pediatric medications and restorative materials used in the study

Groups #	Manufacturer	Material type	Mixing / Curing	Composition / Components
G I	3M TM ESPE- Filtek TM Z350 XT – 3M ESPE (USA) LOT # 3653661	Nanocomposite	NA/ 40 s*	Resin contains: bis-GMA, UDMA, TEGDMA, and bis-EMA(6) resins Fillers: silica filler/zirconia filler

G II	Compoglass F VivadentEts (Liechtenstein) LOT#X20608	Polyacid-modified composite resin / Compomer	NA/40 s*	Aluminum fluorosilicate glass Dicarboxylic acid, Monomer: UDMA, PEGDMA and Cycloaliphat. dicarbonic acid dimethacrylate	
G III	Photac TM Fil Quick 3M ESPE (USA) LOT # 3653661	Resin-Modified Glass Ionomer Restorative	10 s with a mixer /20 s*	Na-Ca-Al-La-fluorosilicate glass, copolymer acids (maleic and acrylic acid), HEMA	
Sub-Groups #	Exposure Media	Commercial name	Pharmaceutical company	pH	Color
SG I	Multivitamins	Calvitalis	Gulf Pharmaceutical Industries Ras Al Khaimah UAE	3.82	Dark gold
SG II	Bronchodilator	Butalin Syrup	Pinewood Laboratories Ltd., Ballymacarbry, Ireland	3.86	Transparent
SG III	Antiepileptic	Tegretole	DelpharmHuningue S.A.S France For Novartis Pharma AQ, Basle Switzerland	4.18	Grayish-white(Platinum)
SG IV	Antibiotic	Ospen Syrup	Sandoz Pharmaceuticals Tic. Inc.Küçükbakkalköy ŞakirElkovan Cd.	5.55	Pale gold
SG V (Control)	Distilled Water			7.81	Transparent
	Artificial Saliva	Sodium chloride (0.4 g/L), potassium chloride (0.4 g/L), calcium chloride-H_2O (0.795 g/L), sodium dihydrogen phosphate-H_2O (0.69 g/L), sodium sulfur-$9H_2O$ (0.005 g/L), and 1000 mL distilled water)		7-8	Transparent
*: Seconds - BisGMA:Bisphenol A glycidyl methacrylate - GIC : Glass Ionomer Cement -EGDMA: Ethylene glycol dimethacrylate - HA :Hydroxyapatite -HEMA:Hydroxyl ethyl methacrylate					

3. RESULTS

ΔE varied among the medications, with values ranging from 0.53 to 4.64 for all the drugs/restorative materials tested. Table 2 and figure 2 show the color change after exposure to each medication compared to the control. Data indicated that all restorations were affected by the medications except for Filtek Z350 (Filtek), which was not significantly affected by Ospen, and Compoglass F (Compoglass), which was not affected by Calvitalis. The results also showed that Butalin and Tegretol Syrup induced a statistically significant change in all the restorations considered in this study. Filtek and PhotacFil (Photac) showed higher mean values of color changes with most medications, with ΔEvalues of 0.53–4.64 for Filtek and 0.99–4.31 for Photac. On the other hand, Compoglass displayed lower mean values, with values of 0.80–3.32, compared to those observed with Filtek and Photac.

Table 3 and figure 3 shows the surface roughness change from baseline to post-exposure readings. The mean values for Photac ranged between 237.42 and 371.83 and were the highest compared to those of Filtek (52.70–98.51) and Compoglass (72.67–158.25). Clinically significant surface roughness changes were observed with all exposure media for Photac only. The values of surface change for Filtek were statistically significant with Caltivalis and Butalin Syrup, while there were no statistically significant changes with Compoglass F. Table 4 demonstrates the changes in surface roughness between the restorations. None of the medications caused a significantly different change.

Table 2 Mean difference in color change among restorations after exposure to medications

Exposure Media / Restorations	Distilled water Mean ± SD (95%CI)	Calvitalis Mean ± SD (95%CI)	Butalin Mean ± SD (95%CI)	Tegretole Mean ± SD (95%CI)	Ospen Mean ± SD (95%CI)
Filtek Z350	0.59 ± 0.48 (0.27–0.92)	3.99 ± 1.09 (3.27–4.73)	3.87 ± 0.95 (3.23–4.51)	4.64 ± 1.17 (3.85–5.42)	0.53 ± 0.19 (0.40–0.65)
p-value	-	<0.001	<0.001	<0.001	0.797
PhotacFil Quick	0.99 ± 0.74 (0.49–1.49)	4.31 ± 0.70 (3.84–4.78)	2.81 ± 0.76 (2.30–3.32)	1.36 ± 0.35 (1.13–1.60)	3.48 ± 0.62 (3.07–3.90)
p-value	-	<0.001	<0.001	0.039	<0.001
Compoglass F	1.29 ± 0.31 (1.08–1.49)	1.09 ± 0.54 (0.72–1.45)	3.32 ± 2.40 (1.71–4.93)	0.80 ± 0.27 (0.61–0.98)	1.95 ± 0.44 (1.66–2.25)
p-value	-	0.139	0.020	0.001	0.001

Statistically significant at P≤ 0.05. - P-value of medications vs distilled water using Mann–Whitney U test.
SD: standard deviation CI: confident interval

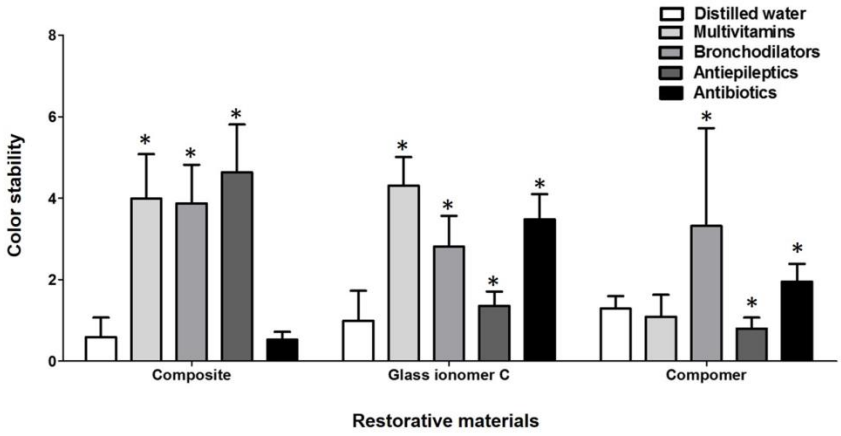

Figure 2 Color change of restorative materials after exposure to medications compared to distilled water.
*: Significance versus distilled water

Table 3 Mean surface roughness values of restorations before and after exposure to different medications

Exposure Media / Restorations	Distilled water Mean ± SD (95%CI)		Calvitalis Mean ± SD (95%CI)		Butalin Mean ± SD (95%CI)		Tegretole Mean ± SD (95%CI)		Ospen Mean ± SD (95%CI)	
	Before	After	Before	After	Before	After	Before	After	Before	After
Filtek Z350	52.70 ± 9.68 (46.19–59.20)	55.27 ± 12.48 (46.88–63.65)	82.44 ± 8.44 (76.78–88.11)	98.51 ± 14.22 (88.96–108.07)	74.13 ± 10.34 (67.18–81.08)	90.32 ± 24.05 (74.17–106.48)	92.07 ± 23.36 (76.38–107.76)	94.60 ± 22.08 (79.76–109.43)	95.23 ± 35.86 (71.14–119.32)	90.69 ± 26.01 (73.21–108.16)
p-value	0.533		0.016		0.006		0.477		0.859	
PhotacFil Quick	292.59 ± 67.02 (247.57–337.61)	371.83 ± 81.82 (316.86–426.79)	237.42 ± 49.27 (204.32–270.52)	302.36 ± 85.94 (244.62–360.09)	271.81 ± 37.73 (246.46–297.16)	328.16 ± 86.00 (270.34–385.89)	307.58 ± 72.62 (258.79–356.37)	274.92 ± 51.43 (240.37–309.48)	280.09 ± 59.36 (240.21–319.96)	291.49 ± 80.24 (237.58–345.39)

p-value	0.003		0.033		0.026		0.328		0.929	
Compoglass F	94.61 ± 42.97 (65.74–123.47)	91.84 ± 33.23 (96.52–114.17)	97.66 ± 18.34 (85.34–109.98)	104.02 ± 12.40 (95.69–112.35)	139.96 ± 73.53 (90.57–189.36)	158.25 ± 87.21 (99.66–216.85)	114.79 ± 15.42 (104.42–125.15)	104.89 ± 14.96 (94.85–114.94)	76.27 ± 33.26 (53.93–98.62)	72.67 ± 32.68 (50.71–94.62)
p-value	0.859		0.248		0.286		0.110		0.534	

* Statistically significant at P≤ 0.05.- P-value using Wilcoxin Sign Rank test - SD: standard deviation - CI: confident interval

Table 4 Comparison of the mean difference in surface roughness among restorations after immersion in different medications

Medication / Restoration	Calvitalis Mean ± SD 95%CI	p-value	Butalin Mean ± SD 95%CI	p-value	Tegretole Mean ± SD 95%CI	p-value	Ospen Mean ± SD 95%CI	p-value
Filtek Z350	16.07 ± 16.66 (4.88–27.26)	.236	16.19 ± 17.02 (4.76–27.62)	.149	2.53 ± 31.65 (-18.74 – 23.79)	.424	-4.55 ± 37.40 (29.85–20.85)	.993
PhotacFil Quick	64.93 ± 78.71 (12.05–117.81)		56.30 ±70.78 (8.75–103.86)		-32.65 ± 86.94 (-91.06 – 25.75)		12.36 ± 72.88 (-44.08 – 66.88)	
Compoglass F	6.36 ± 22.93 (-9.04 – 21.76)		18.29 ± 50.41 (-15.58 – 52.16)		-9.89 ± 18.70 (-22.46 – 2.67)		-3.61 ± 32.60 (-25.51 – 18.30)	

Statistically significant at P≤ 0.05. - P-value using Kruskal–Wallis and post-hoctests -SD: standard deviation - CI: confident interval

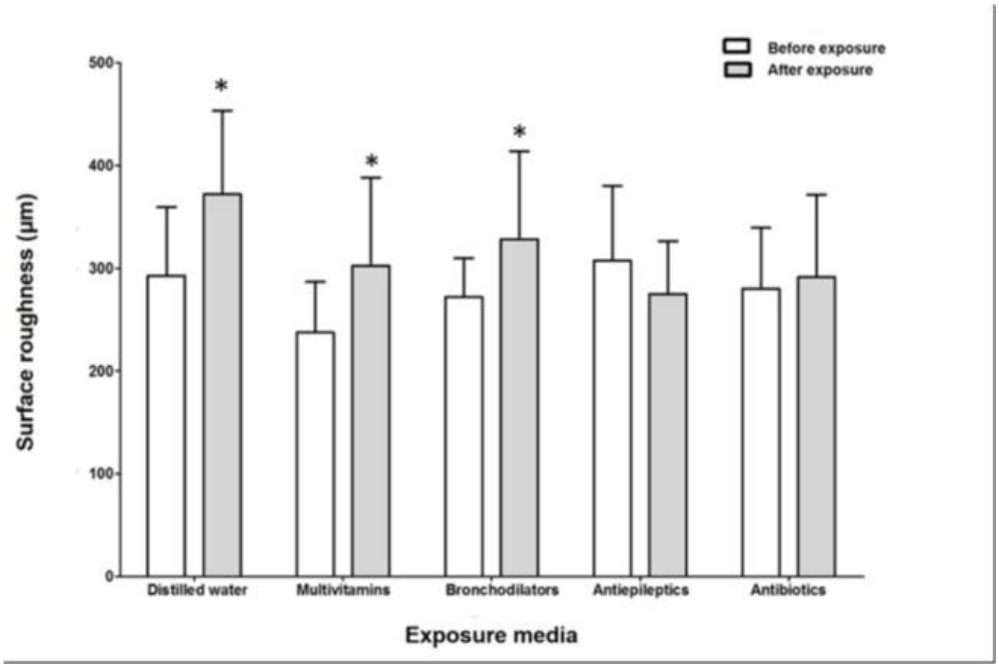

Figure 3 surface changes of restorative materials after exposure to medications

*: significance versus before

4. DISCUSSION

This study sought to determine the changes in aesthetic restorative materials induced by immersion in various oral liquid medications. Most oral liquid medications prescribed to medically compromised children are used for a long periods of time, e.g., up to two years or more. These drugs are mostly rich in sugar and have a low pH, which results in decreasing plaque pH that could initiate caries formation and have an erosive effect on primary teeth (Mentes, 2001; Nunn et al., 2001; Costa et al., 2006; Maguire et al., 2007; Xavier et al., 2013; Scatena et al., 2014; Tupalli et al., 2014). In the current study, color stability and roughness of different

restorations were investigated after 24h exposure to some medications commonly used by medically compromised patients (Tuzuner et al., 2017). Storage for 24 h has been estimated to be the equivalent of two minutes of everyday usage for two years (Al-Samadani, 2017). Tooth-colored restorations, including a composite, resin-modified glass ionomer cement (RM-GIC), and compomer were used in the present study due to their popularity as esthetic treatment options available to restore defects or caries in children's anterior teeth (Waggoner, 2002; Tran and Messer, 2003). Color stability and surface quality were selected in this study because of their influence on the esthetic appearance and reflection of dental restorations. Furthermore, the roughness of restorations can affect bacterial adhesion to the outer surface (Quirynen and Bollen, 1995; Bollenl et al., 1997; Park et al., 2019).

The results of the current study showed that all the restorations considered induced significant discoloration with exposure to nearly all medications. Filtek showed higher clinically significant values, while Photac showed higher statistically significant values with most medications compared to the compomer. Clinically significant values of color change for Filtek, with a ΔE greater than 3.3, were seen with all medications except Ospen Syrup. In accordance with our findings, another study also stated that the color change according to ΔE was more significant and clinically unacceptable in RM-GIC (Ketac molar), followed by the composite group (Filtek) (Ayaz et al., 2014; Guler and Unal, 2018). Photac presented a statistically significant color change with all the medications. In accordance with these findings, a previous experimental study determined that RM-GICs (Fuji II) presented higher color changes compared to conventional GIC (Fuji IX) and polyacid-modified resin composite (PM-RC) (Photac). This shift was due to its water-rich structure (Mentes 2001; Nunnet al., 2001; Costa et al., 2006).

Our results indicated that Compoglass showed the lowest color change, while Filtek restorations showed the highest color change. This can be rationalized by the following two mechanisms: first, through Maillard's reaction, which is the interaction between preservatives and sugar contained in media in the presence of heat that leads to a brown discoloration of the product (Chowdhury et al., 2018); second, the high water sorption of resin-based dental restorations (Waggoner 2002; Correr et al., 2006). Particularly with materials containing monomers such as BisGMA and BisEMA, it has been observed that restorations with those types of monomers have a higher water sorption and lower color stability (Fonseca et al., 2017).

In the present study, for all restorative materials, the surface roughness change was only significant for Photac, while that of Filtek changed with some of the medications. However, Compo glass showed insignificant differences with all the medications. The findings of this study also showed that even though there was a large surface change in some of the restorations when compared to each other, the change was statistically insignificant. Our results also indicated that Compoglass showed better surface stability when compared with the other restoration materials. This could be partly explained by the higher water sorption seen with some restorations, and partly by the incomplete removal of the resin-rich layer, which was among the limitations of using the Mylar strip to provide a smooth surface (Tuzuner et al., 2017). Unfortunately, this could not be avoided to ensure standardization of the samples' finish.

In the present study, even though most values were considered statistically significant only with some of the medications, most restorations showed clinically significant values, especially Filtek and Photac, with significant ΔE and Ra values, respectively. However, because the present study was an *in vitro* study and only one brand of each restoration material was considered, these findings cannot be generalized to all materials, which is a limitation of this study. Finally, only a few research have been carried to estimate the effects of liquid medications, especially over an extended period of time, on dental materials. To improve the stability of direct restorations, further clinical studies with different surface treatments are required.

5. CONCLUSION

The outcomes of this investigation support the following conclusions: All the pediatric medications tested can induce significant changes, either in terms of the color stability, surface roughness, or both, in all the dental restoration materials evaluated. Compared to Photac and Filtek, the Compoglass restoration showed superior discoloration resistance and better resistance to surface alterations against almost all the oral liquid medications considered in this study.

Abbreviations

BisGMA	Bisphenol A glycidyl methacrylate
GIC	Glass Ionomer Cement
EGDMA	Ethylene glycol dimethacrylate
HA	Hydroxyapatite
HEMA	Hydroxyl ethyl methacrylate
PM-RC	Polyacid-Modified Resin Composite

RM-GIC Resin-Modified Glass Ionomer Cement

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Ethics

The study protocol was approved by the Research Ethics Committee, Faculty of Dentistry, King Abdulaziz University (# 058-02-19).

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Conflict of interests

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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