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The Effect of Some Common Children's Drinks on Color Stability of Nanocomposite and Nanoglass Ionomer

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ABSTRACT

The purpose of this study was to evaluate the effect of some common children's drinks on color stability of nanocomposite and nanoglass ionomer. A hundred test specimens of two restorative materials (Filtek Z350; 3M and Ketac N100; 3M were prepared using a Teflon mold (8x2 mm). Baseline measurements of color and surface roughness of each specimen were made and specimens (n=10) were immersed in 5 groups: G1: orange juice, G2: guava juice, G3: Strawberry milk; G4: Chocolate milk, and G5: Distilled water (control. Final measurements of color and surface roughness were performed and the results submitted to statistical analysis (2-way ANOVA, $p<0.05$). Their was no statisically significant difference between mean color change for both materials and the most significant color change was observed for specimens when immersed in orange juice ($p<0.05$). With regard to roughness, nanoglass ionomer showed the most significant changes when immersed in orange juice ($p<0.05$). It was concluded that color changes were dependent on the immersion media rather than the material used while surface roughness was dependent on both material type and immersion media.

INTRODUCTION

The use of tooth colored restorative materials in pediatric dentistry has increased over the past decade not only to meet patients' esthetic needs but also to preserve the tooth tissue. [1]

It is well known that the consumption of certain drinks among children has proved to cause staining in both tooth surfaces and esthetic restorations. Many researchers have investigated the staining effect of these beverages on restorative materials. This is particularly important in pediatric dentistry where replacement of discolored restorations might consume time and effort of both dentist and patient. [2]

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Three types of discolorations are generally described: external discoloration due to the accumulation of plaque and surface stains (extrinsic stain), surface or sub-surface color alteration implying superficial degradation or slight penetration and reaction of staining agents within the superficial layer of the restoration (absorption), body, or intrinsic discoloration due to physical–chemical reactions in the deeper portion of the restoration.[3].

In order to improve properties of restorative materials, nanotechnology was introduced to dentistry. One of the achievements in nanotechnology is the development of nanofillers ranging in size from 0.1 to 100 nm. The main purpose of using fillers with nanometric dimension is the improvement in the strength, wear resistance and ability to polish. The materials used to restore teeth must have enough strength to resist again applied forces during chewing and remain strongly on the related part of the teeth. [4] Nanocomposites have shown physical properties comparable to or better than those of later generation microhybrid composite and significant improvement in surface smoothness/polish retention compared to conventional microfills. Nanofilled resin-modified glass ionomer demonstrated the least microleakage and proved to be better than the conventional and resin-modified glass ionomer cements, consequently it reduces hypersensitivity of restored tooth, tooth discoloration, recurrent caries, pulpal injury and deterioration of the restorative material.[5]

MATERIALS AND METHODS

Two esthetic restorative materials were used in this study :

Group I: Filtek™ Z350 XT nanocomposite 3M ESPE.

Group II: Ketac N100 Nanoglass Ionomer Restorative 3M ESPE.

A total of 100 disc shaped specimens were prepared from both materials using a specially fabricated teflon mold. The underside of each specimen was labelled for the specimen number while the top was polished with a rubber cup so that it would be assessed for color and surface roughness. All specimens were immersed in distilled water for 24 hours before the baseline measurements of color and surface roughness were taken. [6] Color measurements were carried out by spectrophotometer and surface roughness values were taken by surface roughness tester.

Each group was randomly divided into 5 subgroups according to the immersion solution.

1. Group IA and IIA: orange juice.
2. Group IB and IIB: guava juice.
3. Group IC and IIC: strawberry milk.
4. Group ID and IID: chocolate milk
5. Group IE and IIE: distilled water (control group).

Over a period of 2 weeks, each subgroup was immersed in the corresponding beverage for 3 hours /day then washed thoroughly and stored in distilled water for the rest of the day. A control group of ten specimens of each material was continuously immersed in distilled water during the test period. [7]

Color stability:

The color of treated samples was measured by spectrophotometer (Jasco V-570 U.S.A). Three measurements of color were taken for each sample and the mean of the reading was calculated by use of CIE lab color scale. (Commision Internationale de l'Eclairage).[8] The magnitude of total color difference E before and after specimens immersion was calculated from the following equation:

$$E = (L^2 + a^2 + b^2)^{1/2}$$

These differences are interpreted as follows:

$L = L_2 - L_1$ — Where + ve values denote "lighter"; -ve values denote "darker"

$a = a2 - a1$ — Where +ve values denote "less green"; -ve values denote "less red"

$b = b2 - b1$ — Where +ve values denote "less blue"; -ve values denote "less yellow" [(3)]

To determine the color difference, it was necessary to compute and record the difference in all three color space values L, a, b.

Surface roughness assessment

The surface roughness of the samples was measured by TR100 Surface Roughness Tester performing three readings in different locations of the sample surface. The cut-off value for surface roughness was 0.8 mm and the tracing length of the stylus was 6.0 mm. The radius of the tracing tip was 5 µm .The average roughness value (Ra, µm) of an individual disc was taken as the mean of the Ra (average of peaks and valleys of a surface) values measured in 3 different positions.[(9)] The change in surface roughness was measured as follows:

$Ra = Ra_2 - Ra_1$

The obtained results were analysed with statistical analysis. Data were presented as mean and standard deviation (SD) values.

RESULTS

Color stability

The mean values and standard deviations for color stability (ΔE) changes are presented in Table(1). Regarding restorative materials there was no statistically significant difference between Nano-composite and Nano-GI when immersed in all storage media. With Nano-composite as well as Nano-GI: Orange juice showed the statistically significantly highest mean (ΔE) followed by guava juice and chocolate milk respectively. Both strawberry milk and distilled water showed the statistically significantly lowest mean (ΔE) values.

Table (1) *Comparison between (ΔE) of different variables' interactions*

Material	Storage media	Mean	SD	*P*-value
Nano-composite	Orange juice	3.32^{a}	0.44	0.035*
	Guava juice	2.89^{b}	0.45	
	Strawberry milk	1.24^{d}	0.30	
	Chocolate milk	1.66^{c}	0.28	
	Distilled water	0.88^{d}	0.19	
Nano-GI	Orange juice	3.12^{a}	0.26	
	Guava juice	2.61^{b}	0.29	
	Strawberry milk	1.12^{d}	0.21	
	Chocolate milk	1.55^{c}	0.24	
	Distilled water	1.06^{d}	0.18	

**: Significant at $P \leq 0.05$, Different superscripts are statistically significantly different*

Surface roughness

The mean values and standard deviations for surface roughness (R_a) changes are presented in Table (2). For both materials, the greatest change in R_a occurred when the samples were immersed in orange juice followed by guava juice, with statistically significant difference compared with strawberry milk and chocolate milk ($p<0.05$). When compared to each other, Nano-GI showed statistically significantly higher mean (Ra) than Nano-composite.

Table (2) *Comparison between (Ra) of different variables' interactions*

Material	Storage media	Mean	SD	*P*-value
Nano-composite	Orange juice	0.39 [a]	0.05	0.048*
	Guava juice	0.30 [c]	0.03	
	Strawberry milk	0.26 [d]	0.02	
	Chocolate milk	0.28 [d]	0.03	
	Distilled water	0.20 [e]	0.02	
Nano-GI	Orange juice	0.38 [a]	0.03	
	Guava juice	0.33 [b]	0.03	
	Strawberry milk	0.29 [d]	0.03	
	Chocolate milk	0.27 [d]	0.09	
	Distilled water	0.25 [d]	0.03	

**: Significant at $P \leq 0.05$, Different superscripts are statistically significantly different*

DISCUSSION

Restorative materials are susceptible to discoloration in patients' mouth due to intrinsic or extrinsic factors. Intrinsic factors include material composition and alterations in the chemical structure in the deeper portions of the material,[10] while extrinsic factors are mainly due to absorption or adsorption of colorants as a result of contamination from exogenous sources such as food and beverages.[11]

In the present study, two nanofilled esthetic restorative materials Filtek™ Z350 XT and Ketac N100 were studied regarding color stability and surface roughness since the latter can also alter the outcome of a restoration.[12]

In the present study materials samples were immersed for 3 hours per day at room temperature then stored in an incubator at 37C for the rest of the day and over a period of two weeks. This regimen is called dynamic ph cycling model and was also followed in some previous studies.[6,7] and was carried out in order to mimic oral cavity environment where colorants are not in direct contact with restorative materials for the whole day but rather for intermittent periods.[13]

The CIEL*a*b system was chosen to evaluate color variation because it is appropriate for small color changes and have advantages such as repeatability, sensitivity and objectivity.[14]

Regarding color measurements, results of the current study showed that there was no statistically significant difference between mean color change (ΔE) of the Filtek Z350 and Ketac N100 both performed the same under the effect of the used beverages. This finding is in agreement with **Yousef and Abo El Naga (2011)** and could be attributed to similar composition of the two materials regarding the nanofillers.[15] Both KN100 and Filtek Z350 materials contain non agglomerated nanofillers (5-25 nm in size) and nanoclusters (agglomerated with an average size of 1 to 1.6 microns)

In this study, it was observed that all staining beverages affected the color of the specimens. Orange juice showed the most statistically significant color change followed by guava juice and chocolate milk, respectively. While strawberry milk and distilled water showed the least significant color change. It has been reported that values of ΔE^* greater than or equal to 3.3 are visually perceptible and clinically unacceptable to 50% of the trained observers.[6] The reason why juices affected color of restorative materials the most could be attributed to acidity present in fruits. Both orange juice and guava juice contain citric acids and malic acids which may lead to softening of the resin matrix and surface degradation and help in adsorption of pigments and more staining.[16] The reason why chocolate milk caused more discoloration than strawberry milk could be due to darker color or pigments related to flavor content.

Previous studies showed the staining effect of fruit juices. **Topcu et al., (2009)** found that the color of nanocomposite was affected by different fruit juices more than other coloring solutions like cola or wine[17]

In addition, **Tunc et al., (2009)** found that exposure of different restorative materials to grape juice resulted in significantly higher rates of color change than exposure to chocolate milk or control and explained his findings by differences in pH value among these drinks which may affect the structure of the materials tested.

On the other hand, **Catelan et al., (2011)** observed that orange juice (pH 3.39) caused more color change than cola soft drink despite the lower pH value of cola (2.36). This was attributed to different main acids rather than pH. of the staining solution[19].

In this study the effect of distilled water (control solution) on both materials was insignificant. This could be due to absence of coloring agents in water and suggests that water sorption itself doesn't cause significant discoloration.[20,21]

Regarding surface roughness measurements, results of this study showed that Nano-GI had statistically significantly higher mean (Ra) than Nanocomposite. This is in accordance with Sfalcin et al who found that Ketac N100 was more sensitive to immersion in acidic solutions than Filtek Z350 showing more surface roughness.[22].

In this study, when different beverages were compared, orange juice was found to have the most degrading effect on both materials (Ra>0.3u) followed by guava juice. No significant change was seen in strawberry milk, chocolate milk or distilled water. This is supported by the findings of **Khatri and Nandlal (2013)** who reported that the effect of milk on surface roughness of restorative materials is insignificant and comparable to that of water.[23] Moreover, **Hamouda (2011)** found that mango juices have more degrading effect than milk on different restorative materials and attributed this to difference in pH values since pH of water and milk is higher than fruit juices.[24]

In this study, a positive correlation exists between color stability and surface roughness. The smoother the surface, the more resistant the material was to staining.

CONCLUSIONS

Within the limitations of the present study, the following can be concluded:

1- The color stability was not affected by the material type but was affected by storage sloutions.

2- Surface roughness was affected by both material type and storage solutions.

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