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IN VITRO EFFECT OF ALCOHOL AND NON-ALCOHOL BASED MOUTH RINSES ON COLOR STABILITY OF CAD/CAM RESIN CERAMIC AND FELDSPATHIC CERAMICS

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ABSTRACT

Objectives: The aim of this study was to evaluate in vitro color stability of resin ceramic and feldspathic porcelain with two different mouth rinses: non-alcohol based 0.12% Chlorhexidine digluconate (CHX), and alcohol-based Listerine®.

Methods: Two types of CAD/CAM ceramic-blocks: Hybrid resin ceramic (VITA ENAMIC® for CEREC®/ inLab®, VITA Zahnfabrik H. Rauter GmbH & Co.KG., Germany, VE) and Feldspathic (Vitablocks MarkII, VITA Zahnfabrik H. Rauter GmbH & Co.KG., Germany, VM) were included in the study. A total of 36 samples of each material were prepared. Groups VE and VM were divided into three subgroups (n = 12 per group) based on the immersion medium: distilled water (control, W), non-alcohol-based mouth rinse, 0.12% Chlorhexidine digluconate (NA), or alcohol-based mouth rinse (A), Listerine®. Samples were stored in 20 mL in one of the mouth rinses for 120 hours, which was reported as the equivalent time to 10 year of 2-min daily mouth rinse use. Samples' baseline color values were recorded according to the CIE Lab system by using a color spectrophotometer. Color measurements were subsequently obtained following immersion for 120 hours and after samples rinsing with distilled water and allowed to dry. CIE L*, a*, and b* were measured. Color difference (ΔE), were calculated and analyzed using one-way ANNOVA (P<0.05).

Results: Immersion in either Non-Alcohol, or distilled water resulted in significantly higher color change values for VE compared to VM, while no significant difference in color change existed between both materials following immersion in Alcohol based Listerine mouth rinse.

INTRODUCTION

Tooth color restorative materials present a challenging problem as a result of discoloration. The color of tooth colored restorative materials may be influenced by plaque accumulation, stains from solutions, surface roughness, and chemical degradation, as a result of exposure and consumption of different beverages, food or the use of mouth rinses [1, 2].

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Prevention of dental caries and/or gingivitis is basically maintained by routine and proper oral hygiene. The routine mechanical dental plaque removal in addition to the use of chemical therapeutic agents are considered the usual daily practice for proper oral hygiene maintenance. Chemical plaque control agents are prescribe by dentists for patients susceptible to periodontal disease and/ or dental caries such as those receiving fixed prosthodontics treatments[3].

Chlorhexidine digluconate (CHX) is one of the frequently prescribed antibacterial agent that reduces periodontal disease and dental caries. It is presented in many forms as gel, spray, or mouth rinse. CHX administration has been associated with side effects such as, enamel and restorative materials staining, formation of calculus, and temporary unpleasant taste[4, 5]. As reported by the findings of many research, that there is discoloration of restorative materials following their immersion in CHX mouth rinse[6].

Listerine® is another mouth rinses which is frequently prescribed and used as an anti-plaque agent to treat gingivitis. Initially it contained four essential oils - peppermint, eucalyptus, thyme, and wintergreen, they were later replaced by menthol, eucalyptol, thymol, and methyl salicylate. 24%–27% of the Listerine component volume is ethanol as a vehicle to maintain the phenolic component solvents. Listerine®[7]. Discoloration of the composite resin has been reported following the use of Listerine® mouth rinse[8]. Researchers have also reported ceramic discoloration following the use of Mouth rinses containing fluoride ingredients as a result of surface roughness after the use of fluoride products[9].

Commission International de l'Eclairage introduced a new scientific system- CIE Lab* that described color by number and calculated color differences. The CIE Lab system is a uniform color scale where L represents lightness and b describes chromatic characteristics. In this system, "a" is the green/red coordinate and "b" represents the blue/yellow coordinate (-a = green, +a = red, -b = blue, and +b = yellow). The color differences are reported by delta values - ΔL*, Δa*, and Δb* compared with standard conditions.

The total color differences (ΔE) indicate differences between L*, a*, and b* of the sample and the standard values. These differences are calculated according to the following formula[10]:

$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$. If ΔE is ≤ 3.3, the color changes in the restoration are acceptable on clinical assessment,[11].

For better human perceptibility and acceptability of color differences between tooth colors CIE developed new formula ΔE00[12], where Perceptibility is defined as the color difference detected by the human eye whereas acceptability refers to tolerable differences between colors. A better assessment of color differences among dental ceramics is provided by another formula, CIEDE2000[13].

The thresholds for perceptibility and acceptability of different dental materials has been a controversial issue where Douglas et al. have reported a lower threshold for perceptibility (mean ΔE = 0.4 unit, ΔE = 2.6 unit) than acceptability (1.7-unit ΔE, 5.5-unit ΔE) for PFM and acrylic denture teeth, respectively[14]. while, Lindsey reported no significant difference between them[15]. Ghinea et al.[13] reported a significant difference between perceptibility and acceptability thresholds for dental ceramics by using ΔE and the new ΔE00 formula for color calculation.

Recently devices were introduced to measure color following, the scientific approach to tooth color matching. A simple, inexpensive instrument to measure color on three axes or stimuli such as the human eye is the colorimeter. While other devices developed to measure color by reflection or transmission of an observed object is the spectrophotometer which is used to measure changes in the color of the restorative materials more accurate. Other electronic instruments were introduced such as CCDs and fiber optics[11].

The combination of composite resins, ceramics, and CAD/CAM technology have led to the introduction of a resin ceramic hybrid CAD/CAM blocks (VITA ENAMIC) which combines the advantages of both ceramics and composites[16-18].

VITA ENAMIC, was reported to have high flexural strength values, and elasticity close to dentin due to their fine ceramic structure and the polymer network [19]. The minimal invasive restorations are possible with these material as a result of acquiring high strength after adhesive bonding. In addition. VITA ENAMIC had better internal and marginal adaptation than feldspathic ceramics as reported by pervious researches [20]. In terms of color matching, the manufacturer stated that VITA ENAMIC offers material properties that are almost identical to those of natural teeth.

Mouth rinses together with the mechanical means of oral hygiene helps in preventing and control of caries, periodontal diseases, through cessation of plaque, moreover for diminishing oral malodor. Alcohol and non-alcoholbased mouth rinses are varieties used popularly by patients as a mean for regularly maintaining oral hygiene on daily basis [21].

Color stability of restorative materials could be affected by both alcoholcontaining and alcoholfree mouth rinses as reported by some studies [22-24].

Therefore, this study was directed to evaluate the in vitro effect of alcohol or non-alcohol-based mouth rinses on color stability of resin ceramic and feldspathic ceramic crowns. The null hypothesis was that after immersion in either NA or A mouth rinses, the color stability of VITA ENAMIC is not significantly different from this of Vitablock Mark II.

Aim of the study

The aim of this study was directed to evaluate the in vitro effect of alcohol or non-alcohol-based mouth rinses on colour stability of resin ceramic and feldspathic ceramic crowns.

MATERIALS AND METHODS

Specimens' preparation:

A total number of seventy two disc shaped samples of 2 mm thickness were produced, Thirty-six-disc for each tested material by sectioning the CAD/CAM blocks using a slow speed diamond saw (Buehler, IL, USA) under copious water irrigation. The discs were then cleaned in ultrasonic bath for 10 min containing distilled water and then dried. The chemical composition and manufacturer of the mouth rinses used are shown in table 1.

Grouping of specimens

Samples of each material were distributed into three subgroups (n=12) as shown in table (2) according to the staining solution as follows:

TABLE (1) Showing the chemical composition and manufacturer of the mouth rinses used.

Mouth rinse	Composition	Manufacturer
DG-care (non- alcohol based)	Chlorhexidine gluconate %0.12 + Propolis %1 + Clove Oil %1, sodium bicarbonate & calcium carbonate.	Alesraa Pharmaceuticals, Cairo, Egypt.
Listerine (alcoholbased)	Purified water, sorbitol, alcohol, benzoic acid,saccharin, mouthwash flavor, eucalyptol, methyl salicylate, thymol, sodium benzoate, menthol	Johnson & Johnson, Italy.

1. The distilled water subgroup (control group, W).
2. The non-alcohol-based subgroup (DG-care mouth wash, Chlorhexidine gluconate 0.12%, Alesraa Pharmaceuticals, Egypt, non-alcohol-based mouth rinse, NA) at a pH of 5.1 and 37°C.
3. The alcohol-based subgroups (Listerine® Tooth Defense Antic, Johnson & Johnson, Italy, alcohol-based mouth rinse, A) that had a pH of 4.2 and 37 °C.

Samples groupings and subgrouping are shown in table (2)

A Total number of 72 samples					
VITA ENAMIC 36 samples			Vitablocks MarkII 36 samples		
W Distilled water 12 samples	N A mouth rinse 12 samples	A mouth rinse 12 Samples	w Distilled water 12 samples	N A mouth rinse 12 samples	A mouth rinse 12 samples

Samples were immersed in 20 ml of each solution. the solutions were replenished every 12 hours, and immersion was continued up to 120 hours, that represents 10 years exposure to mouth rinse solution twice daily for 2 minutes [21]

Color change measurements

Specimens were taken out of their vials, rinsed with distilled water and wiped with gauze at the end of the immersion period, Color was then re-measured [25, 26] .

Measurements of all specimen's colors, were made at two steps, both baseline and after 120 hours of immersion. Color measurement were performed by the same operator using the same spectrophotometer (UV-Shimadzu 3101 PC Spectrophotometer, Japan). Color change was measured according to the (CIE) L*a*b* color system. Measurements were carried out under the same light source and the same white background. According to the L*, a* and b* values, the color change (ΔE) was calculated as: $\Delta E= [(\Delta L^*)^2 +(\Delta a^*)^2 +(\Delta b^*)2]^{1/2}$.

Statistical analysis

All measured data of color changes before and after immersion were statistically analyzed using SPSS 21 for windows statistical package. Descriptive statistics were presented as means, standard deviations and mean percentage changes. To assess significant changes within each group one-way analysis of variance ANOVA and Bonferroni t-test for pairwise comparison were conducted and independent t-test was conducted to compare the two groups. Significance levels of 0.05 were used throughout all the statistical tests.

RESULTS

Color changes values (ΔE) of the two materials (VE and VM) after immersion in the three-immersion media NA, A and W) for 120 hours are presented in Table 3, Vita Enamic showed significantly higher color change values (5.05± 0.6 and 1.52± 0.2 respectively), compared to Vitablocks Mark II (3.92± 0.3 and 1.07±0.1 respectively) after

TABLE (3) Showing values of color change (ΔE) of the two materials (VE and VM) after immersion in the three solutions (NA, A and W).

	NA		A		W		F-value	P-value
	mean± SD		mean± SD		mean± SD			
VE	5.05	0.6	0.864	0.2	1.52	0.2	272.73	<0.001*
VM	3.92	0.3	0.898	0.05	1.07	0.1	717.73	<0.001*
t- value	- 4.6		0.7		- 4.4			
p- value	≤0.001*		0.49		0.002*			

SD= Standard Deviation; *: Significant difference at P<0.05

immersion in NA or W. The highest color change was presented after immersion in NA for both materials. However, no significant difference was observed between the color change values of both materials (VE and VM) after immersion in alcohol (0.864± 0.2 and 0.898 ± 0.05 respectively).

DISCUSSION

Patient awareness and needs has been increased not only for an aesthetic material but also color stable ones [27]. Hybrid ceramics were developed to overcome the problematic properties associated with resin and ceramic block materials when solely used.

The current study assessed the effect of two mouth rinses on color stability of two different esthetic ceramic materials using spectrophotometer which is an instrument that detects color changes. The spectrophotometry data can be translated into quantitative values. The advantages of the spectrophotometer include "accuracy, ability to analyze the principal components of a series of spectra, and the ability to convert data to various color measuring systems. CIE lab system was used in the present study to detect minor color differences [28].

The ability of human eyes to perceive color changes starts from values $\Delta E > 1$ cause values $\Delta E < 1$ were undetectable by the human eye. $\Delta E < 3.3$ was appreciated only by a skilled person and considered clinically acceptable, whereas $\Delta E > 3.3$ are considered easily observed and not clinically acceptable [29].

Consequently, according to the results of this study, both Vita Enamic and Vita blocs Mark II showed a clinically unacceptable color change after immersion in NA mouth rinse group (ΔE = 5.05 and 3.92 respectively). On the other hand, after immersion in A mouth rinse group of samples (ΔE = 0.864 and 0. 898 respectively) and W (ΔE = 1.52 and 1.07 respectively), both materials, Vita Enamic and Vitablocs Mark II revealed a clinically unperceivable change.

Following immersion in either NA or W, Mark II exhibited superior color stability compared to Vita Enamic; as evident from the ΔE values listed in table 3. On the contrary, no change was detected between both materials after immersion in A group. Therefore, the null hypothesis was partly rejected.

Our results revealed that NA group of mouth rinses rendered the two main groups of material surfaces more liable for staining. As reported by number of researchers, that the ability of mouth wash solutions to change the color of restorative materials depends on the type of restorative materials chemical and physical properties and the capability of resin matrixes to absorb water, in addition to the type of filler and filler content in resin composite restorations [22, 30, 31].

The liability of ceramic to staining compared to CAD/CAM resin composites were less than methacrylate based direct composite as reported in previous research [32]. Whereas Arocha et al., have reported the liability staining and color changes of two indirect CAD/CAM processed composites more than two conventionally laboratory-processed [33].

In the present study the materials showed different mean ΔE. That could be comparatively attributed to the differences in the sample shape as in the case of full ceramic crowns, light transmission and translucency depend on the "crystal content, its chemical nature, particle size, and the thickness of the core" [34]. Whereas the in the current study, sample thickness of materials in each group were standardized. Vichi A et al., reported the values of $\Delta E \geq 3.3$ indicates clinically perceptible color change that requires replacement of the restoration (11, 35). Also, in the current study the recorded value of ΔE of both VE and VM after immersion in CHX was 5.05 and 3.92 which is more than the clinically acceptable value (3.3) that necessitates replacement of restoration if this stain cannot be removed.

Mouth rinses are commercially available in two forms–alcohol-free or alcohol-based in which the alcohol mainly acts as the solvent[9], In this study alcohol based mouth rinse (A) against non-alcohol based mouth rinse (NA) was used

The ΔE of both VE and VM after immersion in Alcohol storage mouth rinse was 0.864 and 0. 898 respectively which was lower than values recorded after immersion in Non-alcohol storage medium (5.05 and 3.92 respectively). These findings agreed with those obtained by Baig et al. who recorded lower values of ΔE for Nano-filled resin composites immersed in Alcohol based mouth rinse compared to those stored in non-alcohol mouth rinse[36].

The results of the current study are not in agreement with Soygun et al. who reported increased color changes in bio-ceramic materials with mouth rinses with higher alcohol content [37]. The lower ΔE values recorded in the current study might be attributed to the differences between the types of materials (resin composite vs. ceramic) and duration of contact with the solutions and surface texture quality[38, 39].

The greater color change of both VE and VM after immersion in NA with pH value of 5.1 rather than A which has pH value of 4.2m could be explained by the higher staining ability after immersion in solution with higher pH values as reported in other studies [26, 40].

The measured color depends on both the object color and the quality of lighting conditions. In the present study a standard lighting against a white background was used [41].

Vita Enamic consists primarily of 66 wt. % hydrophobic urethane dimethacrylate (UDMA) and 33 wt. % hydrophilic triethylene glycol dimethacrylate (TEGDMA) as stated by the manufcturer. Water uptake by Bis GMA-based resins increased from 3 to 6% as the proportion of TEGDMA was increased from 0 to 1%, respectively as reported by Previous studies.

Water sorption by the resin component of the material is one of the main causes behind discoloration. Resin matrix type plays a vital role in the color sustainability of the material. Accordingly, the high wt% of TEGDMA in Vita ENAMIC could be possibly the reason behind water sorption which may have resulted in penetration of any hydrophilic colorant into the resin matrix.

More over dimethacrylats part of (UDMA) forms crosslinked networks with entrapped unreacted monomers as a plasticizer, that may facilitate added water sorption through the former plasticization causing more opened structure, that interpreted the role of resin matrix in the higher discoloration values obtained by Vita Enamic [26, 29, 40, 42, 43].

Although color changes were in the range of clinical acceptability, the color change values after immersion in distilled water for Vita Enamic (1.52 ± 0.2) and Vitablocs Mark II (1.07 ± 0.1) were significantly different that could be related to the resin part confined in Vita Enamic [27].

Potential limitations of the current study was that, this in-vitro study does not reflect clinical situations such as salivary pellicle, consumption of different foods and beverages might influence the color change susceptibility [44]. Further investigations should be done to evaluate and compare the effect of different types of mouth rinses and other parameters such as surface roughness and microhardness of the materials and finally the effect of bleaching on removal of stains on the ceramic restorations to avoid restoration replacement.

CONCLUSIONS:

Within the limitations of this study, the following could be concluded:

1. Non-alcohol-based mouth rinses may adversely affect the color of Vita ENAMIC and Vitablocks Mark II which may consequently compromise esthetics.

2. The quantitative assessment of color stability of ceramic, can help clinicians to predict the performance of these materials in-vivo.

Clinical recommendations

1. Mouth rinses with chlorhexidine gluconate active ingredient should be avoided with patients having hybrid ceramic or feldsphatic ceramic restorations in the esthetic zone.
2. New mouth rinses should be evaluated for their impact on tooth colored restoration properties before being introduced into the market.
3. Further investigations such as bleaching to remove stains in order to avoid restoration replacement and further cost.

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