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Original article

An *in vitro* Prosthodontics Study on the Impact of Mouth rinses on the Color Stability of Monolithic and Multilayered Yttria –Stabilized Zirconia

Sireen Meheshi[1]*, Milad Eshah[2], Mohamed Zeglam[1], Saleha Alalwani[1]

[1]*Department of Fixed Prosthodontics, Faculty of Dentistry, University of Tripoli, Tripoli, Libya.*
[2]*School of Medical Science, Academy for Postgraduate Studies, Tripoli, Libya.*
Corresponding Email: S.Meheshi@uot.edu.ly

ABSTRACT

The diverse array of restorative materials utilized in computer-aided design/computer-aided manufacturing (CAD/CAM) technology necessitates a comprehensive understanding of their aesthetic properties and color stability. This study aimed to evaluate the color stability of two different types of zirconia after immersion in Chlorhexidine and ANTIPLACA mouthwashes. We prepared 30 zirconia specimens (n = 15) as follows: Group 1 consisted of monolithic zirconia and group 2 consisted of KATANA™ YML Zirconia. Groups 1 and 2 were divided into three subgroups (n = 5). Each subgroup was immersed in one of the following three solutions: distilled water (control), CHX, or ANTIPLACA 0%Alcohol. We recorded the samples' color values at baseline and after immersion according to the CIELab system by using a color spectrophotometer operated by an experienced operator. All data were collected and analyzed using Graph Pad Instat (Graph Pad, Inc.) software for windows. Irrespective of group totally it was found that immersion solutions significantly affected on mean values as revealed by two-way ANOVA test (p=<0.0001< 0.05) where (0% Alcohol > CHX ≥ DW). Mouthwashes staining had a marked effect on the color of the tested zirconia materials. The color change was material and staining solution-dependent, with Monolithic Zirconia showing the greatest color stability.

Keywords: Color, Chlorhexidine, Multilayer Zirconia, CAD/CAM, Mouthwashes

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تتطلب المجموعة المتنوعة من المواد الترميمية المستخدمة في تقنية التصميم بمساعدة الكمبيوتر/التصنيع بمساعدة الكمبيوتر فهمًا شاملاً لخصائصها الجمالية واستقرار اللون. هدفت هذه الدراسة إلى تقييم استقرار اللون لنوعين مختلفين من الزركونيا بعد الغمر في غسولات الفم الكلورهيكسيدين و ANTIPLACA. قمنا بإعداد 30 عينة من الزركونيا (ن = 15) على النحو التالي: تتكون المجموعة 1 من الزركونيا المتجانسة وتتكون المجموعة 2 من الزركونيا KATANA™ YML. تم تقسيم المجموعتين 1 و2 إلى ثلاث مجموعات فرعية (ن = 5). تم غمر كل مجموعة فرعية في أحد المحاليل الثلاثة التالية: الماء المقطر (التحكم)، أوCHX ، أو ANTIPLACA 0% كحول. سجلنا قيم لون العينات في البداية وبعد الغمر وفقًا لنظام CIELab باستخدام مطياف الألوان الذي يديره مشغل ذو خبرة. تم جمع جميع البيانات وتحليلها باستخدام برنامج Graph Pad Instat (Graph Pad, Inc.) لنظام التشغيل Windows. وبغض النظر عن المجموعة الكلية، فقد وجد أن حلول الغمر أثرت بشكل كبير على القيم المتوسطة كما كشف عنها اختبار تحليل التباين ثنائي الاتجاه (p = <0.0001 <0.05) حيث (0% كحول > CHX ≥ DW). كان لصبغة غسول الفم تأثير ملحوظ على لون مواد الزركونيا المختبرة. كان تغير اللون معتمدًا على المادة ومحلول الصبغ، حيث أظهرت الزركونيا الأحادية أكبر قدر من ثبات اللون.

INTRODUCTION

All-ceramic restorations can mimic the optical properties of natural teeth; they are the best material to use when aesthetics is a top priority [1]. Zirconium oxide (ZrO2), the foundation material for ceramic prosthetics, is notable for its exceptional mechanical qualities and the special transformation toughening phenomena [2]. Bilayered core-ceramic and monolithic zirconia are the two primary types of all-ceramic zirconia restorations. Interestingly, compared to bilayered veneered Y-TZP crowns, monolithic Y-TZP crowns had a greater fracture resistance [3]. Monolithic zirconia restorations have several advantages, such as a simplified fabrication procedure that improves time and cost_ effectiveness and eliminates the requirement for a veneering layer, which successfully stops chipping. Their inferior aesthetic qualities in comparison to other ceramic materials, however, constitute a significant disadvantage.

In order to replicate the natural shade gradient of teeth, multi-layered monolithic zirconia is either pigmented within each blank of the same generation or uses zirconia with a higher translucency in the incisal/occlusal area and a high flexural strength in the body/dentin area [5]. Even though tooth-colored restorations are becoming more and more popular, they might become discolored if things like mouthwash or colored drinks are consumed. As a supplement to mechanical plaque management, mouthwashes are crucial for chemical plaque control, especially in those who are at high risk for dental cavities or are susceptible to periodontal illnesses [6-7]. Despite its shown antibacterial effectiveness, chlorhexidine mouthwash has been linked to adverse effects include taste loss and discoloration of teeth, mucous membranes, and dental restorations [8]. Significant effectiveness has been seen in reducing plaque and gingivitis in mouthwashes with essential oils, such as antiplaque, which supplement mechanical plaque control in attempts to study the antibacterial properties of these products [9].

Discoloration is currently the most common clinical cause for replacing prosthesis, accounting for 38% of cases. Digital tools or visual inspection can be used to evaluate discoloration. Because it is noticeable to normal eyes, a color shift of more than 3.4 is considered clinically undesirable and may necessitate restorative replacement [4]. Physiological and psychological elements, such as the observer's emotional state and the object's or observer's location in relation to illumination, the visual evaluation of color is intrinsically subjective. A spectrophotometer, which measures color by measuring all three-color components (L*, a*, and b*), regardless of the surface type, can remove this subjectivity and the related mistakes [10]. The wavelength at which light scatters defines translucency. A ceramic appears opaque if the majority of light wavelengths are scattered and transparent if the majority is transmitted [11].

In contrast to immersion in distilled water, Derafshi et al. [12] found that monolithic zirconia and feldspathic ceramics soaked in 0.2% chlorhexidine digluconate and Listerine for two minutes each day for seven days discolored both restorative materials. However, another study found that CAD-CAM zirconia ceramics did not exhibit noticeable discoloration after a week of immersion in an acidic beverage [13]. The purpose of this study was to assess the color stability of monolithic zirconia and Yttria multilayered Zirconia after immersion in various staining liquids. The null hypothesis was that immersion in ANTIPLACA 0% Alcohol and chlorhexidine, would have no effect on the color stability of both types of the Zirconia.

METHODS

Fabrication of specimens

A total of 30 zirconia specimens were prepared from the 2 tested CAD/CAM ceramic material groups (n = 15). The specimens from each group were divided into 3 subgroups (n = 5) according to the assigned staining solution (ANTIPLACA 0%Alcohol, CLORHEXIDINA Mouthwash and distilled water (control) (Health Aqua, Alexandria, Egypt) as shown in table (1), Figure (1). The samples were immersed in plastic vials containing either 20 mL of the solution, The vials were sealed to prevent the evaporation of

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the solutions and kept for seven days at 37ºC in an incubator (CBM. Torre Picenardi (CR), Model 431/V, Italy) Figure (2). The immersion mediums were refreshed every day to prevent the growth and proliferation of microorganisms as bacteria or yeast. The solutions were agitated twice a day to prevent the precipitation of staining solution particles. Samples were washed with distilled water, dabbed with gauze, and dried with absorbent paper after the immersion period.

Table 1. Composition and manufacturer of the tested oral rinse solutions

Oral rinse solution	Composition	Manufacturer
CLORHEXIDINA Mouthwash	Aqua, Glycerin, PEG 40, Hydrogenated Castor Oil, Poloxamer407, Chlorhexidine Digluconate, Sodium Floride, SodiumSaccharin, Aroma, Allantoin, SodiumBenzoate, Alcohol, CI 16035, Limonene	Foramen SL Cantabria, Spain
ANTIPLACA 0% Alcohol	Aqua, Propylene glycol, Hydrogenated Castor Oil, PEG 40, Citric acid, CetylpyridiniumChloride, Sodium Floride, SodiumSaccharin, SodiumBenzoate, CI 42090, CI18965, Cinnamal	Foramen SL Cantabria, Spain

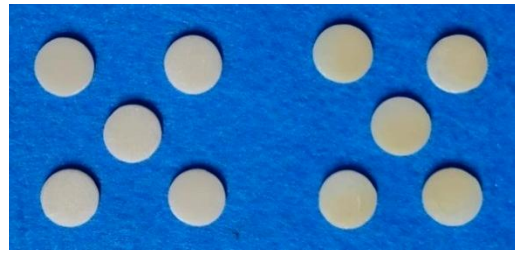

Figure 1. Zirconia samples of each group before immersion in mouthwashes G1, G2

Figure 2. Plastic vials containing samples

The color of the materials was assessed before and after staining. Fifteen disc-shaped specimens (10 mm × 1.5 mm) were prepared from the 2 CAD/CAM restorative materials using a water-cooled low-speed diamond saw (IsoMet®; Buehler, Lake Bluff, USA). The thickness of all specimens was confirmed using a digital micrometer (Mastercraft Electronic Caliper; Canadian Tire Corporation Ltd., Toronto, Canada) to be 1.5 ±0.01 mm. After that, each specimen was ultrasonically cleaned for ten minutes in distilled water. Color values (L*, a*, b*) of samples was measured using a reflective spectrophotometer (model RM200QC; X-Rite GmbH, Neu-Isenburg, Germany).

The specimens were placed in the middle of the measurement port, and the aperture size was adjusted to 4 mm. A white background (Commission internationale de l'éclairage (CIE) L* = 88.81, a* = −4.98, b* = 6.09) was selected and the measurements were made according to the CIE L*a*b* color space with relation to the CIE standard illuminant D65, where a* indicates the color coordinate on the red/green axis, b* denotes the color coordinate on the yellow/blue axis, and L* denotes the degree of brightness (0–100). Prior to each measurement, the spectrophotometer was calibrated.

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All measurements were performed and repeated three times by one operator before (baseline) and after immersion in mouth rinses. The color difference ΔE was calculated from the mean ΔL*, Δa*, Δb* values for each sample using the following formula: ΔE= [(ΔL*) 2+ (Δa*) 2+ (Δb*) 2]1/2. The variations in L*, a*, and b* values before and after immersion are represented by ΔL*, Δa*, and Δb*.

Statistical analysis

The mean and standard deviation were used to express the data. Following confirmation of homogeneity of variance and normal distribution of errors, a one-way analysis of variance was conducted, and if significant results were found, Turkey's post-hoc test was used. Between the main groups, a student t-test was conducted. The impact of each component (surface finish immersion solution) was compared using a two-way ANOVA. Software called Graph Pad Instat (Graph Pad, Inc.) was used for analyzing the findings for windows. A value of P < 0.05 was considered statistically significant. Sample size (n=15/group) was large enough to detect large effect sizes for main effects and pair-wise comparisons, with the satisfactory level of power set at 80% and a 95% confidence level.

RESULTS

Color change (ΔE)

Table (2, 3) and figure (3) provide a summary of the color change (ΔE) data (Mean±SD) for both groups following immersion in treatment solutions.

For Gr_1, it was found that the highest mean ± SD values of color change were recorded with 0 alcohol immersed subgroup (3.4± 0.98 ΔE) followed by Chlorhexidine immersed subgroup mean ± SD values (2.22 ± 0.39 ΔE) meanwhile the lowest mean ± SD values were recorded with DW immersed subgroup (1.55 ± 0.33 ΔE). The difference among subgroups was statistically significant as indicated by ANOVA test (P=0.0018<0.05). Turkey's post-hoc pair-wise test showed non-significant (p>0.05) difference between (Chlorhexidine and DW) immersed subgroups as shown in table (2).

For Gr_2, it was found that the highest mean ± SD values of color change were recorded with 0 alcohol immersed subgroup (3.99 ± 0.68 ΔE) followed by Chlorhexidine immersed subgroup mean ± SD values (3.58 ± 0.81 ΔE) meanwhile the lowest mean ± SD values were recorded with DW immersed subgroup (2.95 ± 0.49 ΔE). The difference among subgroups was statistically non-significant as indicated by ANOVA test (P=0.0875>0.05) as shown in table (3).

Gr_1 vs. Gr_2

Chlorhexidine immersion, it was found that Gr_2 recorded statistically significant higher mean value (3.58 ± 0.81 ΔE) than Gr_1 (2.22 ± 0.39 ΔE) as revealed with student t-test (p = 0.0089 < 0.05). Table (4) and figure (3) 0% Alcohol immersion, it was found that Gr_2 recorded statistically non-significant higher mean value (3.99 ± 0.68 ΔE) than Gr_1 (3.4± 0.98 ΔE) as proved with student t-test (p = 0.3448> 0.05). Table (4) and figure (3)

Distilled water immersion, it was found that Gr_2 recorded statistically significant higher mean value (2.95 ± 0.49 ΔE) than Gr_1 (1.55 ± 0.33 ΔE) as proved with student t-test (p = 0.0007< 0.05). Table (4) and figure (3)

Total effect of main group, regardless to immersion solution totally it was found that the differences between both groups were statistically significant as revealed by two-way ANOVA test (p=<0.0001 < 0.05) where (Gr2 > Gr1).

Total effect of subgroups (immersion solution), irrespective of group totally it was found that immersion solutions significantly affected on mean values as revealed by two-way ANOVA test (p=<0.0001< 0.05) where (0% Alcohol > CHX ≥ DW).

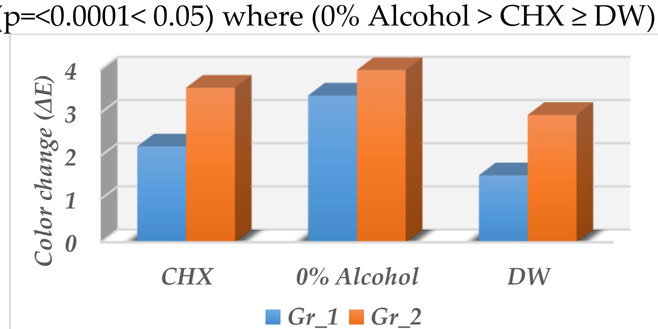

Figure 3. Column chart of the mean values of color change for both groups after immersion in treatment solutions

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Table 2. ΔE of monolithic zirconia samples in different mediums; values are expressed as the mean (SD).

Gr_1	BEFORE			AFTER			difference				
	L*	a*	b*	L*	a*	b*	◎L	◎a	◎b	◎E	
Chx	79.5	3.9	29	77.4	5.6	27.9	-2.10	1.70	-1.10	2.92	2.22
	78.7	5.2	24.9	77.2	5.3	26.8	-1.50	0.10	1.90	2.42	
	75.7	8.1	28.2	74.3	8.1	26.8	-1.40	0.00	-1.40	1.98	
	77.6	6	28.6	75.85	6.85	27.35	-1.75	0.85	-1.25	2.31	
	77.2	6.65	26.55	75.75	6.7	26.8	-1.45	0.05	0.25	1.47	
Anti	79	3.9	30	74.4	8.9	26.4	-4.60	5.00	-3.60	7.69	3.93
	78.5	5.8	26.5	77.8	5.5	26.8	-0.70	-0.30	0.30	0.82	
	75.9	8.6	28.3	79.2	3.2	30.9	3.30	-5.40	2.60	6.84	
	77.45	6.25	29.15	76.8	6.05	28.65	-0.65	-0.20	-0.50	0.84	
	77.2	7.2	27.4	78.5	4.35	28.85	1.30	-2.85	1.45	3.45	
DW	79.25	3.9	29.5	78.2	4.2	30.3	-1.05	0.30	0.80	1.35	1.55
	78.6	5.5	25.7	77.8	5.4	25.2	-0.80	-0.10	-0.50	0.95	
	75.8	8.35	28.25	74.4	8	26.5	-1.40	-0.35	-1.75	2.27	
	77.525	6.125	28.875	76.325	6.45	28	-1.20	0.33	-0.88	1.52	
	77.2	6.925	26.975	77.125	5.525	27.825	-0.08	-1.40	0.85	1.64	

Table 3. ΔE of Yttria multilayered zirconia samples in different mediums; values are expressed as the mean (SD).

Gr_2	BEFORE			AFTER			difference				
	L*	a*	b*	L*	a*	b*	◎L	◎a	◎b	◎E	
Chx	80.6	0.4	30.55	82.9	-1.3	26.7	2.30	-1.70	-3.85	4.80	3.73
	78.15	2.7	30.7	75.5	4.8	26.6	-2.65	2.10	-4.10	5.31	
	71.45	8.3	39.65	70.1	9.2	37	-1.35	0.90	-2.65	3.11	
	76.025	4.35	35.1	74.65	3.375	37.375	-1.38	-0.98	2.28	2.83	
	74.8	5.5	35.175	72.7	5.35	36.725	-2.10	-0.15	1.55	2.61	
Anti	82.4	-0.3	29.5	79	-0.5	32.4	-3.40	-0.20	2.90	4.47	3.99
	79.5	2.2	31.9	75.3	3.9	29.3	-4.20	1.70	-2.60	5.22	
	71.4	9	41.8	69.6	6.9	43.9	-1.80	-2.10	2.10	3.47	
	76.9	4.35	35.65	74.3	3.2	38.15	-2.60	-1.15	2.50	3.79	
	75.45	5.6	36.85	72.45	5.4	36.6	-3.00	-0.20	-0.25	3.02	
DW	78.8	1.1	31.6	80	-0.4	29.2	1.20	-1.50	-2.40	3.07	3.29
	76.8	3.2	29.5	75.9	3.1	29.7	-0.90	-0.10	0.20	0.93	
	71.5	7.6	37.5	70	7.5	44	-1.50	-0.10	6.50	6.67	
	75.15	4.35	34.55	75	3.55	36.6	-0.15	-0.80	2.05	2.21	
	74.15	5.4	33.5	72.95	5.3	36.85	-1.20	-0.10	3.35	3.56	

Table 4. Color change (ΔE) results for both groups after immersion in treatment solutions

Variable	**Treatment solution**	**ANOVA test**			
		Chlorhexidine	0% Alcohol	Distilled water	**P value**
Gr_1	Mean±SD	2.22^{B} ± 0.39	3.4^{A}± 0.98	1.55^{B} ± 0.33	0.0018*
	95% CI (low-high)	1.73 – 2.71	2.22 – 4.68	1.15 – 1.96	
Gr_2	Mean±SD	3.58^{A} ± 0.81	3.99^{A} ± 0.68	2.95^{A} ± 0.49	0.0875 ns
	95% CI (low-high)	2.57 – 4.59	3.14 – 4.84	2.34 – 3.56	
t-test	P value	0.0098*	0.3448 ns	0.0007*	

Different subscript letter in the same row indicating statistically significant difference between subgroups (p < 0.05), CI; confidence intervals
**; significant (p < 0.05) ns; non-significant (p>0.05)*

DISSCUSION

Since both mouthwashes had an impact on the color stability of the two varieties of zirconia, the null hypothesis was rejected. The multilayered zirconia and monolithic zirconia groups exhibited the greatest and lowest color changes, respectively, irrespective of the mouthwashes. However, color variations in every group stayed within the range that is clinically acceptable ($\Delta E < 3.7$).

Numerous studies have evaluated the impact of mouthwashes on monolithic zirconia regarding color stability [12, 14, 15]. In line with this study, Derafshi et al. [12] discovered that while submerging monolithic zirconia and feldspathic ceramic in distilled water had no discernible effect on color, Listerine and chlorhexidine did, although color changes were still below the threshold and considered clinically acceptable. Comparatively speaking to the current investigation, Alnassar [16] found that of the staining liquids examined, coffee exposure for 28 days resulted in the most deterioration in high-translucency monolithic zirconia. After 14 days, there was a noticeable shift in chlorhexidine's color, though it was still within the range that was considered clinically appropriate. The longer exposure duration may be the cause of the greater discoloration as compared to the current research.

Differences in chemical structures, grain size and shape, crystalline phase distribution, porosity, and thickness are some of the variables that may be responsible for the variances in ΔE among the various zirconia materials in the current investigation [17]. Materials of the same thickness were used in this investigation; multilayered zirconia replicates the shade gradient of real teeth [18]. The various material characteristics of the individual layers are linked to the layered structure of multilayered zirconia [19].

Similar research revealed that greater 5Y-TZP cubic zirconia produced lower ΔE compared to 3Y-TZP tetragonal specimens, which is in contrast to our study's finding of the least color change in monolithic zirconia specimens. Increased yttria concentration may reduce surface-level low-temperature deterioration, which might lessen surface roughness and solution penetration, according to existing research [21, 22].

It is often advised to use chlorhexidine mouthwash for 7–14 days [23, 24]. However, as previously noted, extended usage of it for 28 to 42 days is linked to increased tooth discoloration [25]. The current investigation used seven days of brief exposure to mimic the clinical setting of chlorhexidine usage. It's yet unknown exactly how chlorhexidine causes tooth discoloration. However, it is thought that the chlorhexidine molecules break down in the oral cavity to generate parachloranilin, which may cause metal sulfides to develop and proteins to get denaturated, coloring teeth and restorations [26, 27].

The current study evaluated color-difference using a CIELAB-based formula that included lightness, chroma, and hue weighting functions, an interactive term that addressed chroma and hue differences to improve the accuracy of a scaling factor for the CIELAB a* scale to enhance performance for gray color and an assessment for blue color. Due to its improved application and dependability in dentistry, the CIEDE2000 color difference formula has surfaced in recent years and is advised. Additionally, by resolving non-uniformities in the CIELAB formula, it provides better adaptations for identifying color discrepancies [28].

The in-vitro aspect of the study, which permitted staining on both sides of the specimens in contrast to clinical settings, was one of its shortcomings. Additionally, this feature made it unable to take into account dental hygiene habits like brushing, which might have an impact on the color stability of restorations in vivo [29]. Additionally, rather than using the more contemporary CIEDE2000 color.

difference formula, the CIELAB color difference formula was utilized in the current investigation to quantify color differences. It is advised that future research use the sophisticated CIEDE2000 color difference formula to evaluate how mouthwashes affect the color stability and translucency of various monolithic zirconia types under oral circumstances.

The spectrophotometer used in this study is one of several devices that have been developed to assess the color of dental materials. By measuring the quantity of light reflected from an item at intervals of 1 to 25 nm along the visible spectrum, spectrophotometers are said to be the most helpful instruments since they are accurate and versatile enough to be utilized for the entire color scheme. According to one study, spectrophotometers had an accuracy of 33% higher than other instruments and a 93.3% objective match rate when compared to human color perception. [30].

Contrary to our research, Haralur et al. [31] showed that monolithic zirconia is more prone to color changes brought on by aging. They found that the lithium disilicate ceramic offers greater aesthetics than monolithic zirconia in terms of color stability and translucency. The monolithic zirconia is exposed to water and body fluids within the mouth if it is not protected by a ceramic veneer.

When water is subjected to 37 °C, it undergoes a phase transition from a tetragonal to a monoclinic structure, which results in low temperature deterioration (LTD). [32] The phase transition to monoclinic, which results in surface roughness, microcrack development, and structural breakdown, caused a 4% increase in volume. [33] Yellow and orange stains show relatively limited color stability at different baking temperatures, according to Lund and Piotrowski et al. [30] and Crispin et al. [34].

The impact of two mouthrinses on the color stability of two distinct zirconia materials was evaluated in the current investigation. It is possible to convert the spectrophotometry data into numerical values.

"Accuracy, ability to analyze the principal components of a series of spectra, and the ability to convert data to various color measuring systems" are among the spectrophotometer's benefits. However, the equipment is mostly utilized by researchers and is costly and challenging to use [35].

The current study's findings indicate that after being submerged in CHX or ANTIPLACA 0%Alcohol mouthrinses, groups 1 and 2 differed significantly. This result was consistent with another study that looked at resin composites' color stability [36]. According to Festuccia et al., Listerine® caused more discolorations of two resin composites than Plax alcohol free and Periogard CHX [37].

The materials used in this investigation had varying mean ΔE. Light transmission and translucency in entire ceramic crowns are often determined by the "crystal content, its chemical nature, particle size, and the thickness of the core" [12]. We utilized materials of the same thickness in each group for the current investigation. The zirconia group's high physical characteristics, such as its grain and microscopic particles, may affect the relative color stability by lowering surface roughness and discoloration susceptibility. Furthermore, Zirconia's crystalline structure may lessen color fluctuations [38]. Instrumental analysis and visual inspection are used to detect if restorative materials are discolored.

Because subjective mistakes have been eliminated, the latter is more accurate [39]. We used a CIELab system to measure the color shifts in this investigation. For most patients with normal color vision, $\Delta E < 1$ is clinically acceptable and undetectable in this system. On the other hand, $\Delta E \geq 3.3$ signifies a hue shift that is clinically noticeable and necessitates replacing the restoration [38, 40].For both materials, we computed a $\Delta E < 3.3$ in all solutions, which was not noticeable to the naked eye. Contrary to the results of the current work, Baig et al. observed lower ΔE values for nanofilled resin composites submerged in Listerine® as opposed to non-alcohol CHX [41].

Their study's ΔE values, however, were higher than those of the current investigation. Conversely, Soygun et al. found that mouthrinses with a greater alcohol concentration cause bioceramic materials to change color more often [42]. The types of materials (ceramic vs. resin composite) exposed to the mouthrinse solutions, the length of time spent in contact with the solutions, and the surface texture after various surface treatments might all be contributing factors to the disparities across studies [43]. Both the surface's real color and the lighting circumstances affect the measured color.

Standard illumination against a white backdrop was employed in this investigation [40]. Both alcohol-free and alcohol-based mouthrinses, in which alcohol serves primarily as the solvent, are commercially available [44].

Limitations

The fact that this is in vitro study could not replicate clinical settings, salivary pellicle, and the possibility that the susceptibility to color changes may be influenced by the ingestion of various meals and drinks were some of the study's possible drawbacks.

Recommendation

The color stability of ceramics with various mouthrinses in clinical settings should be compared in future studies. More research is necessary to confirm the results of the current study.

CONCLUSION

Concerning the limitations of the present study and with respect to the evaluated materials, it can be concluded that, the immersion of MLZ and Monolithic zirconia samples in ANTIPLACA 0% Alcohol caused a more significant discoloration (ΔE values > 3.3, clinically unacceptable) than chlorhexidine and distilled water. And that multilayered zirconia is more susceptible to color change when exposed to both chlorhexidine and ANTIPLACA 0% Alcohol mouthwashes than monolithic zirconia.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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