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COLOR STABILITY OF GLAZED AND POLISHED LITHIUM DISILICATE PRESSABLE GLASS CERAMIC AFTER IMMERSION IN MOUTH RINSES: AN IN VITRO STUDY.

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ABSTRACT

BACKGROUND: The optical characteristics of ceramic dental restorations are of prime importance in esthetic rehabilitation. Lithium- disilicates are being widely used to create a full contoured restoration. Glazing and polishing are recommended to achieve a highly esthetic restoration. Dentists usually prescribe chemical plaque control agent, especially for those undergoing fixed prosthodontic procedures. There is lack of data about the effect of these chemical agents on the color stability of glass ceramics.

AIM OF THE STUDY: The objective of this laboratory study was to assess the effect of mouth rinses on the color stability of lithium-disilicate pressable glass ceramic.

MATERIALS AND METHODS: Twenty-eight discs were fabricated using the heat pressing technique and then subjected to two different surface treatments: polishing and glazing (n=14 each). After that, specimens were immersed in two different types of mouth rinses: chlorhexidine (CHX) and Listerine (LST) (n=7 each). Color coordinates were measured using a digital spectrophotometer. Color differences (ΔE) were evaluated using CIE-LAB color system.

RESULTS: ΔE was affected significantly by the type of surface treatments and mouth rinses ($P<0.001$). All ΔE values were less than the selected acceptability threshold (ΔE=3.48). Glazed specimens (ΔE =0.95) were more resistant to discoloration than polished specimens (ΔE =1.61). The immersion in CHX (ΔE =1.44) showed more discoloration than the immersion in LST (ΔE =1.11).

CONCLUSION: The type of surface treatment significantly affects the color stability of lithium-disilicate pressable glass ceramics. The color stability of glass ceramics is improved by glazing. CHX mouth rinses must be used with cations.

KEYWORDS: Color, Lithium-disilicate, Pressed ceramics, Glazing, Polishing, Mouth rinses, Spectrophotometer, Esthetics.

RUNNING TITLE: Color stability of LDS after immersion in mouth rinses.

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INTRODUCTION

The demand for aesthetic dental restorations has increased in accordance with the introduction of new technologies. All-ceramic materials have gained lot of interest in the past few decades owing to their strength, esthetics, and ease of fabrication (1). Lithium disilicate is often used due to its excellent optical characteristics, durability, and ease of manufacturing (2,3). It also allows the manufacture of full contour anterior and premolar region restorations without adding veneering material (4).

Lithium-disilicate can be processed utilizing both the computer aided design and computer aided manufacturing (CAD-CAM) technology or heat-pressing technique. Heat-pressed restorations have been reported to have higher fracture toughness than CAD restorations. Also, in terms of porosity and marginal fit, heat pressing is better than sintering and slip casting (5–7).

The size, shape, and shade of the teeth to be restored must be replicated in the prosthesis. Additionally, color stability is essential for long-term success of ceramic restorations. Ceramics are prone to discoloration despite great improvements in their physico-mechanical characteristics (8,9). Extrinsic elements such as mouthwashes have been reported to cause ceramic surface deterioration (10).

Chlorhexidine (CHX) is a well-known antibacterial substance that helps to prevent gum disease and teeth decay. The active ingredient of CHX mouth rinse is Chlorhexidine HCI and the inactive ingredients are Glycerin, Propylene Glycol, Alcohol 96%, Peppermint Red. The disadvantages of CHX administration include discoloration of the natural teeth and restorative materials. According to studies, restorative materials discolor after being immersed in CHX mouth rinse (11,12).

Listerine (LST) is a mouth rinse that is widely used nowadays to treat gingivitis by acting as an anti-plaque agent. Four essential oils were used in the formulation of the Listerine mouthwash in the nineteenth century. Later, the main components of these oils were separated and mixed to replace the four essential oils. 24-27% ethanol was used as a carrier to keep these components dissolved .The discoloration of composite restorations have been also reported after using LST mouth rinse (13,14).

Discoloration has been identified as one of the primary clinical reasons for replacing dental prosthesis (15). Consequently, the aim of the present laboratory research was to assess the influence of mouth rinses on the color stability of pressable lithium-disilicate glass ceramic using different surface treatments. The null hypothesis stated that surface treatments and immersion in mouth rinses would not affect the color stability of pressable lithium-disilicate glass ceramic.

MATERIAL AND METHODS

Power analysis was performed by using a statistical software program (G*Power 3.0.10; Heinrich Heine University Düsseldorf). Sample size was estimated based on assuming confidence level= 95% and study power= 80%. According to Derafshi et al. the mean ΔE of VMK 95 feldspathic-ceramic, which is comparable to lithium disilicate glass-ceramic, was 1.15 when immersed in CHX and 0.90 when immersed in LST (8). Based on the comparison of means and using the highest standard deviation to ensure study power, the sample size was calculated to be seven per subgroup.

Twenty-eight lithium-disilicate pressed disc shaped specimens with dimensions of 12mm diameter and 1.5mm thickness were prepared following the heat-pressing technique from IPS e.max press ingots (Ivoclar Vivadent) shade A2 LT. (Figure 1)

Specimens were first digitally designed with the determined dimensions using computer-aided design software (Auto CAD; Autodesk Inc). The specimens were dry-milled in CAD-CAM wax (Ceramill wax; Amman Girrbach) using a milling machine (Ceramill Motion 2; Amann Girrbach).

Sprued wax discs were then invested using phosphate bonded investment material (Bego USA, Boston, United states) which was mixed following manufacturer's instructions. Following the investment material setting time, the ring was heated to 850 ºC in a burn-out furnace for 60 minutes. Then the heat pressing process was performed using a pressing furnace (Programat Furnace EP 3010; Ivoclar AG) at 925 ºC for 25 minutes.

The discs were finished using silicon carbide paper under cooling water, and then the dimensions of the specimens were confirmed with a digital calliper. For 10 minutes, all the discs received ultrasonic cleaning in distilled water and then randomly divided according to the surface treatment into two groups (n=14), the glazed group (G) and the polished group (P).

For the glazed group, the glaze powder and liquid (IPS e.max Ceram Glaze; Ivoclar Vivadent AG) were used. Glaze firing (770 ºC) was performed in the vacuum furnace (Programat Furnace, Ivoclar Viva- dent AG).

For the polished groups, the discs were polished using diamond-impregnated rubber discs using a low-speed handpiece. The discs were polished by applying very light pressure for 30 seconds in one direction, rotated 90 º, and then polished for additional 30 seconds (16). The used polishing system (Diapro Twist, Eve, Germany) had 2 steps using 2 different rubber discs (brown: pre-polishing and yellow: high-shine polishing). Each disc was polished for a total of two minutes. To ensure standardization, the same operator performed both glazing and polishing procedures. After the surface treatment procedures, for ten minutes, all the discs received ultrasonic cleaning in distilled water.

For the immersion solutions, 0.12% chlorhexidine hydrochloride mouthwash (CHX) and Listerine cool mint mouthwash (LST) were used. Each of the two groups was divided randomly into two subgroups (n=7) based on the chosen mouth rinse, with a total of four subgroups: glazed in CHX (G-CHX), glazed in Listerine (G-LST), polished in CHX (P-CHX), polished in Listerine (P-LST).

Each disc was submerged in 15 ml of test solution in a sealed container at a temperature of 37 ± 10 ºC in complete darkness for 7 days. To keep the solutions homogeneous, they were agitated once every 12 hours and replaced every day (17). After the 7 days immersion period, the discs were washed using distilled water and dried using tissue.

Using a digital spectrophotometer (VITA Easyshade Advance; VITA Zahnfabrik), the color of discs was measured. Prior to each measurement, the spectrophotometer has been calibrated. Measurements were taken using "Tooth single" mode and by holding the tip of the probe at 90° to the surface in the center of the specimens. For each disc, three readings were taken, and then mean values for all parameters were calculated and noted. For standardization, the same operator performed each measurement on a black background at the same time of day (18,19).

The color of each disc was determined and stated in terms of the three coordinates (L*, a*, b*), which were established by the international color space CIE-Lab (Commission International de l'Eclairage) (Figure 2). Color difference (ΔE) between the base line color measurement before the immersion procedure and the color measurement after the immersion procedure was calculated by the following formula (20):

ΔE= [(Δ L*) 2+ (Δ a*)2 + (Δ b*) 2]1/2

Where, Δ L*, Δ a*, and Δ b* are the difference in color parameters before and after the immersion procedure. The acceptability threshold (ΔE = 3.48) and perceptibility thresholds (ΔE = 1.74) were used to evaluate color difference.

STATISTICAL ANALYSIS

Statistical analysis was done using IBM SPSS 20.0. Data were checked for normality using Shapiro-Wilk test. Data was expressed as mean, and standard deviation. Two-way (ANOVA) was assessed to show the effect of each factor: Surface treatments and Mouth rinses. To compare between the two Surface treatments and between the two Mouth rinses, a student t-test was performed. The three coordinates (L*, a*, and b*) were compared before and after the immersion procedure using a paired t-test. The results were considered significant at a p-value < 0.05.

RESULTS

Mean value and standard deviations of color difference (ΔE) of all the subgroups are presented in (Table 1). The mean values of (ΔE) for the glazed and polished groups were (0.95 ± 0.17) and (1.61 ± 0.29) respectively. The mean values of (ΔE) for the CHX and LST groups were (1.44 ± 0.43) and (1.11 ± 0.32) respectively. The P-CHX subgroup showed the highest color difference (1.82 ± 0.24), and the G-LST subgroup showed the lowest color difference (0.82 ± 0.04). The mean values of all the subgroups were lower than the selected clinically acceptable threshold (ΔE =3.48). However, the mean value of the P-CHX subgroup was above the perceptible threshold (ΔE =1.74).

The 2-way ANOVA showed that the type of surface treatments and mouth rinses significantly affected the color stability of lithium-disilicate pressable glass ceramic (p <0.001) (Table 2).

The findings of this study revealed significant changes in the three coordinates (L*, a*, b*). The L* values of all the subgroups decreased, which means that specimens became darker. Concerning the a* coordinate (green-red axis), the mean values of the LST group were increased, this means that specimens became more greenish after immersion in LST mouth rinse. Regarding the b* coordinate (yellow-blue axis), the mean values of all the subgroups increased, which means that specimens became more yellowish. (Table 3).

Table (1): Mean ±standard deviation (SEM) ΔE values of the studied groups.

Surface treatment	No.	Mouth rinse CHX	Mouth rinse LST	Total
Glazed	7	1.07 ± 0.15 (0.06)	0.82 ± 0.04 (0.01)	0.95 ± 0.17 (0.04)
Polished	7	1.82 ± 0.24 (0.09)	1.40 ± 0.17 (0.06)	1.61 ± 0.29 (0.08)
Total	14	1.44 ± 0.43 (0.12)	1.11 ± 0.32 (0.09)	1.28 ± 0.41 (0.08)

SEM: Standard error of mean.

Table (2): Two-way ANOVA for the effect of surface treatments and mouth rinses on ΔE.

	Type III sum of squares	Degree of freedom	Mean square	F	P
Surface treatments	3.053	1	3.053	111.845	<0.001*
Mouth rinses	0.776	1	0.776	28.431	<0.001*

*: Statistically significant at $p \leq 0.05$

Table (3): Comparison between before and after the immersion procedure according to color coordinates (L*, a*, b*) in each group.

Variable	Surface treatments	Mouth rinses	Before	After	p
L*	Glazed	CHX	77.61 ± 0.25 (0.10)	76.92 ± 0.29 (0.11)	0.001*
		LST	77.53 ± 0.22 (0.08)	76.82 ± 0.25 (0.10)	<0.001*
	Polished	CHX	76.73 ± 0.54 (0.20)	75.24 ± 0.75 (0.28)	<0.001*
		LST	76.77 ± 0.40 (0.15)	75.56 ± 0.41 (0.15)	<0.001*
a*	Glazed	CHX	-1.043 ± 0.079 (0.030)	-1.000 ± 0.112 (0.042)	0.111
		LST	-1.057 ± 0.098 (0.037)	-1.114 ± 0.069 (0.026)	0.030*
	Polished	CHX	-1.100 ± 0.180 (0.068)	-1.143 ± 0.259 (0.098)	0.370
		LST	-1.186 ± 0.135 (0.051)	-1.350 ± 0.132 (0.050)	0.002*
b*	Glazed	CHX	18.46 ± 0.22 (0.08)	19.10 ± 0.61 (0.23)	0.012*
		LST	18.46 ± 0.24 (0.09)	18.86 ± 0.22 (0.08)	<0.001*
	Polished	CHX	18.17 ± 1.10 (0.41)	19.08 ± 1.47 (0.55)	0.003*
		LST	18.17 ± 0.76 (0.29)	18.69 ± 1.08 (0.41)	0.029*

Data was expressed using Mean ± SD(SEM)
SD: Standard deviation.
SEM: Standard error of mean.
*: Statistically significant at $p \leq 0.05$

DISCUSSION

Based on the findings of the present research the null hypothesis was rejected, as the type of surface treatments and mouth rinses significantly altered the color of the specimens.

The choice of the materials in this study was based on the widespread clinical use of IPS e.max press, in addition to their excellent optical characteristics, high aesthetic qualities, and their ability to closely mimic the colors of natural teeth (2,3).The diameter of the specimens was 12mm to be broader than the tip diameter of the spectrophotometer to eliminate edge loss during measurements (21). To resemble the clinical condition, the thickness of specimens was 1.5mm to resemble the amount of reduction in tooth preparation.

In a standardised setting, Kim-Pusateri et al. examined the accuracy and reliability of four dental shade matching devices, and they came to the conclusion that the Vita Easyshade had reliability and accuracy that were both better than 90% (18). In this study, the perceptibility and acceptability thresholds of ΔE were selected to be 1.74 and 3.48, respectively, following Ghinea et al (22).

Considering the popularity of LST and CHX mouthwashes, those were the mouthwashes used in this study. Also, several researchers have stated that this mouthwash solution can affect the color of restoration materials (12,14).

Continuous exposure to mouth rinses for 12 hours was stated to be similar to one year of every-day use (1 minute twice daily) (23,24). Therefore, in the present study, discs were immersed in 15 ml of mouth rinse for 7 days to simulate exposure to mouth rinses used every-day for approximately 14 years.

The findings of this research revealed that the type of surface treatments and the type of mouth rinse significantly affect the color of lithium-disilicate pressable glass ceramic. Mean values of ΔE of all the groups were lower than the selected clinically acceptable threshold (ΔE =3.48). However, the mean value of ΔE of the P-CHX subgroup was above the selected perceptible threshold (ΔE=1.74).

Regarding the surface treatment techniques, the glazed groups showed less color changes compared to the polished groups. This finding corresponds with those of earlier research, which stated that glazing procedure provide more color stability compared to polishing for lithium disilicate glass ceramic (25). Also, Atay et al discovered that after aging, the polished group experienced the greatest color change followed by the glazed group (26). This could be explained by Palla et al, who reported that the unglazed ceramic's rough surface allows water penetration and silica network breakdown, which increases the absorption of colouring pigments. While glazed ceramics inhibit water penetration and silica network breakdown due to the lack of surface imperfection and microcracks (27).

Regarding the mouth rinses used, the LST groups showed less color changes compared to the CHX groups. Earlier studies supported the findings of this study; in 2021, a study that tested the stainability of various ceramics materials with mouth rinses stated that CHX induced the highest discoloration (28). Also, another study that tested the effect of mouth rinses on the color stability of the monolithic zirconia and the feldspathic ceramics found that for these two materials, in CHX, the color change was the highest (8).This could be related to the higher alcohol content in CHX compared to Listerine, as the surface roughness and changes in color of the restorative materials increase as the alcohol concentration rises. (23).

CONCLUSION

Glazing is essential for the color stability of lithium-disilicate glass ceramic. Moreover, the color stability of ceramic restorations can be impacted by the continuous use of mouth rinses, particularly those that contain CHX.

CONFLICT OF INTEREST
The authors declare that they have no conflict of interest.
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