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Color Stability of Lithium Disilicate and Monolithic Zirconia in Various Staining Liquids: An Invitro Study

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KEYWORDS

lithium disilicate, zirconia, color stability

ABSTRACT:

Introduction The demand for aesthetic dental services is on a constant upsurge due to an aesthetic conscious society. Aesthetic dental practice has brought numerous innovative clinical procedures and a revolution in dental materials.Zirconia has been used to develop crowns, bridges, posts, and implants due to its high biocompatibility, increased toughness, and improved fracture resistance. Lithium disilicate is the commonly used glass-ceramic because of its exceptional optical properties, superior strength and ease of fabrication.**T**he color stability of the restoration is critical for the long-term success of the aesthetic restorations.

Objectives: To compare the color stability of monolithic zirconia and lithium disilicate after immersion in various staining liquids. The null hypothesis was that immersion in coffee, green tea and chlorhexidine, would have no effect on the color stability of the ceramics.

Methods: Total thirty specimens (n=30) were made of monolithic zirconia and lithium disilicate. Each group was divided into 3 subgroups depending on the staining solutions (coffee, green tea and chlorexidine). After the immersion period of 28 days, the specimens were removed from the testing solution. The color measurements were performed via a spectrophotometer. The results were analyzed using statistical software (SPSS, version 22; SPSS Inc., Chicago, IL, USA). The means and standard deviations were compared using analysis of variance (ANOVA) and a multiple comparisons test.

Results: The greatest ΔE value (5.6) was observed for zirconia and the lowest ΔE was observed for the lithium disilicate samples immersed in chlorhexidine (1.42).

Conclusions: Within the limitations of this in vitro study, the following conclusions were drawn: (1) Discoloration from coffee was more significant in monolithic zirconia compared to lithium disilicate ceramic. (2) Lithium disilicate ceramic was found to have better color stability compared to monolithic zirconia. (3) Monolithic zirconia displayed the least color stability among all the tested discoloring agents.

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1. Introduction

The demand for aesthetic dental services is on a constant upsurge due to an aesthetic conscious society. Aesthetic dental practice has brought numerous innovative clinical procedures and a revolution in dental materials. Esthetic and color stability of natural teeth would be one of the prime factors for esthetic dental ceramic restorations. The color stability is one of most important factors as the mechanical properties of a restoration. The lifespan and quality of dental restorations depend partially on the color stability of a restorative material over time.[1,2] Consequently, restorative material should have a good color stability to be able to resist any stains from solutions, chemical degradation, and surface roughness.[3,4]

All-ceramic restorations are recommended in the front region due to deeper translucency adjacent to the native tooth.The most widely used glass-ceramic is lithium disilicate (LD) because of its remarkable optical qualities, high strength, and simplicity of manufacture.[5]Greater marginal strength, reduced porosity, and net-shaped manufacturing by pressing are further benefits of LD.[6] Full contour fabrication of LD prosthesis eliminates the problem of physical-mechanical compatibility among two incompatible materials. Therefore, relative to bilayer ceramic repair, the probability to break or for the veneer to crack is smaller. Even though LD is one of the many flexible indirect restorative materials, due to its 2.8–3.5 MPa fracture toughness, caution is required when treating bruxism subjects with significant occlusal stress and non-vital teeth.[7] Clinical applications include front fixed prosthesis, anterior veneers, posterior inlay or onlay, and toothimplant supported single crowns.[8] The development of yttrium stabilized trigonal zirconia polycrystalline (YTZP) ceramics is the result of the pursuit for a material with both mechanical capabilities, like the resistance provided by metallic restoration, and the distinctive optical characteristics of glass-ceramic. The main drawback is the fragile veneering ceramics, which are prone to chipping, debonding, and breakage. These medical issues hastened the modification of translucency and microstructure.[9]

There is evidence that extrinsic variables such beverages, mouthwashes, acid solutions, dental brushing, and increased temperatures might cause ceramic surfaces to deteriorate.[10]The composition and surface shape of ceramic materials have an impact on the extrinsic pigment absorption or adsorption from the oral cavity. [11] It is recommended to use mouthwash ingredients with antibacterial qualities, such as benzydamine and chlorhexidine gluconate, in addition to mechanical oral hygiene techniques. Chlorhexidine is known to leave dark stains on the tongue's dorsum, various restorative materials, and teeth when used for an extended period of time. The staining of teeth and restorations is linked to nonenzymatic browning and colored metal sulfide production. [12]Supragingival calculi development is also seen to rise with prolonged use of chlorhexidine.[13]Few scholars have suggested that the precipitation of food chromogens and locally adsorbed chlorhexidine is what causes the coloring. The main causes for the clinical replacement of anterior restorations, according to prior research, are poor color matching and color instabilities.

2. Objectives

This study was carried out to compare the color stability of monolithic zirconia and lithium disilicate after immersion in various staining liquids.

The null hypothesis was that immersion in coffee, green tea and chlorhexidine, would have no effect on the color stability of the ceramics.

3.Materials and Methods

Specimens' Preparation:

Total thirty specimens (n=30) were made of monolithic zirconia and lithium disilicate. Disc shaped Specimens of prestained monolithic zirconia (upcera dental) were fabricated with milling system (ceramil motion 2) in A2 shade. in the dimension of (20mm X 15mm 2mm) as shown in (Figure 1). Disc shaped Specimens of prestained Lithium disilicate (upcera dental) were fabricated with milling system (ceramil motion 2)in A2 shade in the dimension of (20mm X 15mm 2mm) as shown in (Figure 1).

Immersion in Staining Liquids

Each group was divided into 3 subgroups depending on the staining solutions (coffee, green tea and chlorexidine).The coffee (Nescafe) and green tea (Lipton tea) staining solutions were prepared by adding 15 g to 250 ml of boiled distilled water.For the purpose of immersion, 0.2% chlorhexidine digluconate oral mouthwash was used.Each ceramic disc was immersed within 15 ml of test solution for 28 days in a dark environment.The test solutions were changed daily and were stirred once every 12 hours to maintain the homogeneity of the solution. After the immersion period

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of 28 days, the specimens were removed from the testing solution. They were rinsed with distilled water and blot dried with tissue papers.

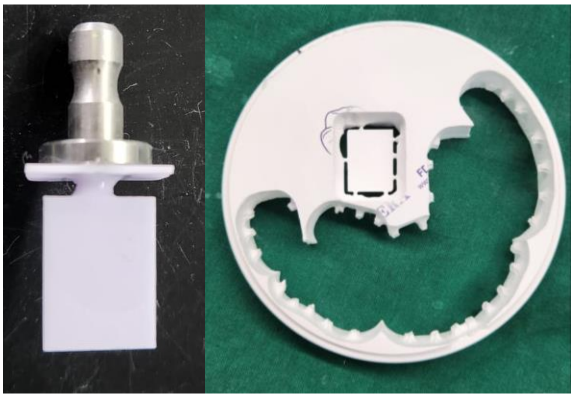

Figure 1 : Lithium disilicate specimens on the left side monolithic zirconia specimens on the right side.

Color Measurements:

The color measurements were performed via a spectrophotometer (Hunterlab, Reston). These measurements were taken at the baseline (before immersion experiments) and 28 days post-immersion. Before taking color measurements at each time point, the samples were cleaned with water and a soft-bristled toothbrush (Oral B®, Procter and Gamble Co). These measurements were performed using the CIELAB formula. Three color measurements were taken at each time point, then mean values were calculated for L (lightness of the color), a* (chromaticity of red-green), and b* (chromaticity of yellow-blue). The formula used for the measurement of color difference (ΔE*) was as follows:

$$\Delta E^*ab = [(\Delta L^*)2 + (\Delta a^*)2 + (\Delta b^*)2]1/2$$

Conversion of ΔE Values to National Bureau of Standards (NBS) Units The ΔE values were converted to NBS units by utilizing the following formula:

$$\text{NBS units} = \Delta E^* \times 0.92$$

The NBS units, color change remarks, and clinical interpretation are shown below (Table 1).

Table 1. NBS interpretation of color changes.

NBS Unit	Color Change Remarks	Clinical Interpretation
0.0–0.5	Trace	Extremely slight change
0.5–1.5	Slight	Slight change
1.5–3.0	Noticeable	Perceivable
3.0–6.0	Appreciable	Marked change
6.0–12.0	Great	Extremely marked change
>12.0	Very great	Change to another color

Statistical Analysis: The results were analyzed using statistical software (SPSS, version 22; SPSS Inc., Chicago, IL, USA). The means and standard deviations were compared using analysis of variance (ANOVA) and a multiple comparisons test. A p-value < 0.05 was considered significant.

3. Results

The ΔE values for LD samples are presented in Table 2 and Figure 1. The greatest ΔE was observed for coffee (2.5), followed by green tea (1.84). The lowest ΔE was observed for the samples immersed in chlorhexidine (1.42).

The ΔE values for zirconia samples are presented in Table 3 and Figure 1. The greatest ΔE was observed for coffee (5.6), followed by green tea (5.1). The lowest ΔE was observed for the samples immersed in chlorhexidine (4.52).

Intergroup comparison of mean colour change (ΔE) between both groups is shown in table 4. lithium disilicate group had a lower level of color change ΔE compared to zirconia.least color change observed in lithium disilicate in chlorhexidine and highest colour change (ΔE) in monolithic zirconia in coffee.

Table 5 shoews Intragroup comparison of mean colour change (ΔE) in Group 1 (Lithium Disilicate) in different solvent respectively. Coffee group showd highest colour change (ΔE) followed by green tea and chlorhexidine.

Table6 shoews Intragroup comparison of mean colour change (ΔE) in Group 2 (Monolithic Zirconia) in different solvent respectively. Coffee group showd highest colour change (ΔE) followed by green tea and chlorhexidine.

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The means of color change (ΔE) for both groups in three different staining solutions of the study were perceptible by human eyes because it was greater than 1.

Table 2: The ΔE values for LD samples

	coffee	green tea	ch
1	2.5	1.9	1.2
2	2.8	1.8	1.1
3	2.2	1.7	1.9
4	2.9	1.6	1.5
5	2.1	2.2	1.4
	2.5	1.84	1.4

Table 3:The ΔE values for zirconia samples

	coffee	green tea	c
1	5.9	5.1	4.9
2	6.2	4.9	4
3	5.5	5.7	4
4	5.3	4.8	4
5	5.1	5	4
	5.6	5.1	4

Table 4:Intergroup comparison of mean colour change (ΔE) between both groups – Group 1 (Lithium Disilicate) and Group 2 (Monolithic Zirconia) respectively in each solvent respectively

Colour change (ΔE)	Coffee Mean (SD)	Green Tea Mean (SD)	CHX Mean (SD)
Group 1 (Lithium Disilicate)	2.5 (0.35)	1.84 (0.23)	1.42 (0.31)
Group 2 (Monolithic Zirconia)	5.6 (0.44)	5.1 (0.35)	4.52 (0.3)
Mean Difference (SE)	3.1 (0.25)	3.26 (0.18)	3.1 (0.19)
Unpaired t test	t = 12.159	t = 17.278	t = 15.945
P value, Significance	p< 0.001**	p< 0.001**	p< 0.001**

**P< 0.001 – highly statistical significant difference

Table5: Intragroup comparison of mean colour change (ΔE) in Group 1 (Lithium Disilicate) in different solvent respectively

Group 1 (Lithium Disilicate)	Mean	SD	One way Anova F test	P value, Significance
Coffee	2.5	0.35	F = 16.167	P<0.001**
Green Tea	1.84	0.23		
CHX	1.42	0.31		
Tukey's post hoc test to find pairwise comparison				
Group	Comparison Group		Mean Difference	P value
Coffee vs	Green Tea		0.66	p = 0.012*
	CHX		1.08	p<0.001**
Green Tea vs	CHX		0.42	p=0.113

p>0.05 – no significant difference   *p<0.05 – significant   **p<0.001 – highly significant

Table 6: Intragroup comparison of mean colour change (ΔE) in Group 2 (Monolithic Zirconia) in different solvent respectively

Group 2 (Monolithic Zirconia)	Mean	SD	One way Anova F test	P value, Significance
Coffee	5.6	0.44	F = 10.508	p=0.002*
Green Tea	5.1	0.35		
CHX	4.52	0.3		
Tukey's post hoc test to find pairwise comparison				
Group	Comparison Group		Mean Difference	P value
Coffee vs	Green Tea		0.5	p = 0.049*
	CHX		1.08	P=0.002*
Green Tea vs	CHX		0.58	p=0.072 (NS)

p>0.05 – no significant difference   *p<0.05 – significant   **p<0.001 – highly significant

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4. Discussion

Most commonly used ceramic lithium disilicate and monolithic zirconia (upcera dental) were selected to be tested. The aim of this study was compare the color stability of monolithic zirconia and lithium disilicate after immersion in various staining liquids.The null hypothesis was that immersion in coffee, green tea and chlorhexidine, would have no effect on the color stability of the ceramics. Intergroup comparison of mean colour change (ΔE) between both groups is shows that lithium disilicate group had a lower level of color change ΔE compared to zirconia. Least color change observed in lithium disilicate in chlorhexidine (ΔE=1.42) and highest colour change (ΔE=5.6) in monolithic zirconia in coffee.

Several machines have been invented to measure the color of dental materials, in the current study, the spectrophotometer utilized. It has been stated that the most useful instruments areSpectrophotometers as they are accurate and have the flexibility to be used for the overall color scheme,[by measuring the amount of light reflected from an object at 1 to 25 nm intervals along the visible spectrum.One study showed that the accuracy of spectrophotometers was 33% more than other devices and 93.3% matching objective of the cases as compared with human interpretation of color. [15]

A color change of dental ceramics as result of aging was reported in many studies.[16,17,18,19,20] In general, there are several factors affect the color of ceramic material such as, ceramic stain, thickness, surface crack, roughness, and method of sintering.[21,22]Therefore, when increased the temperature time, the increase in grain size, and a decrease in porosity, thus forming a highly ordered crystalline structure that allows light reflection, which may be the main factor affecting the color difference.[22,23,24,25]

The findings showed that lithium disilicate ceramic has superior color stability when compared to monolithic zirconia. Statistically, a significant difference in ΔE was observed between zirconia and lithium disilicate. These findings are in line with those of Kurt, et al. [26]and Haralur, et al. [27] who demonstrated that monolithic zirconia is more susceptible to aging-related color changes. In terms of color stability and translucency, they discovered that the lithium disilicate ceramic provides more esthetic compared to monolithic zirconia. Without a ceramic veneer to protect it, the monolithic zirconia is subject to water and bodily fluids inside the mouth. Low-temperature degradation (LTD) is caused by the phase transformation from a tetragonal to a monoclinic structure that occurs when water is exposed to a 37 °C environment [28] Volume increased by 4% as a result of the phase transformation to monoclinic, which causes structural disintegration, surface roughness, and the formation of microcracks. [29] According to Lund and Piotrowski, et al.[30]and Crispin et al. [31] at various baking temperatures, yellow and orange stains have very little color stability. Furthermore, Mulla, et al. [32] showed that orange stain has the maximum color stability at various baking temperatures, whereas in ceramic systems the lowest color stability accounts for blue stain. The recommended tooth preparation for monolithic zirconia crowns is 2 mm of occlusal clearance, according to the literature. [33]As in the studies by Hamza, et al. [34] and Koseoglu, et al. [35] after artificial aging, there was a color shift in the present study for 2 mm thickness monolithic zirconia that was below the clinically acceptable threshold. In our study discoloration due to coffee was more as compared to green tea and cxh.Coffee comprises tannin and chlorogenic acids, which are thought to be responsible for its discoloration potential. Limitation of the current study was its in vitro design.Under clinical conditions, as the restorations are bonded to the tooth, they are exposed to the staining liquids unequally (more on one side than the other).Oral hygiene maintenance habits (toothbrushing, use of mouthwash) could also affect the color stability of restorations in vivo.The present report evaluated color stability, but in the future, other variables should be evaluated such as flexural strength and hardness.Hence, further investigations are warranted to validate the current study’s findings.

Conclusion

Within the limitations of this in vitro study, the following conclusions were drawn:

(1) Discoloration from coffee was more significant in monolithic zirconia compared to lithium disilicate ceramic.

(2) Lithium disilicate ceramic was found to have better color stability compared to monolithic zirconia.

(3) Monolithic zirconia displayed the least color stability among all the tested discoloring agents.

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