Brazilian Dental Science

unesp
UNIVERSIDADE ESTADUAL PAULISTA
"JÚLIO DE MESQUITA FILHO"
Instituto de Ciência e Tecnologia
Campus de São José dos Campos

ORIGINAL ARTICLE

DOI: https://doi.org/10.4322/bds.2022.e3226

Color and translucency of repressed lithium disilicate glass ceramic subjected to multiple firings and aging

Cor e translucidez da vitrocerâmica de dissilicato de lítio reprensada submetida a múltiplas queimas e ao envelhecimento

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ABSTRACT

Objective: The aim of this study is to evaluate the effect of multiple firings and aging on color and translucency of repressed lithium disilicate glass ceramic (IPS e.max press). **Material and Methods:** A total of 42 lithium disilicate discs (15 mm x 1 mm) were fabricated using heat press technique following the manufacturers' instructions. They were divided into three groups according to the number of pressing cycles (n=14): Group P1 (pressed once), Group P2 (pressed twice) and Group P3 (pressed thrice). Each group was subdivided into two subgroups according to the number of firing cycles (n=7): Subgroup (F2): 2 firing cycles, Subgroup (F4): 4 firing cycles. Then all specimens were subjected to thermocycling. Color and translucency parameter (TP) were evaluated by spectrophotometer; after pressing, firing (ΔE1: color difference between pressing and firing) and aging (ΔE2: color difference between pressing and aging). **Results:** ΔE1 for subgroup F2 (3.38) showed statistically significant lower value than ΔE1 for subgroup F4 (3.94). After aging, group P3 showed the statistically significant highest ΔE2 (6.41). A statistically significant lower ΔE2 was found with group P2 (5.55). Group P1 showed the statistically significant lowest ΔE2 (4.28). TP for subgroup F2 (18.27) showed higher value than subgroup F4 (17.78). There was a statistically significant decrease in TP after aging for all tested groups. **Conclusion:** Increasing the number of firing cycles and aging affected color and translucency of repressed lithium disilicate.

KEYWORDS

Aging; Ceramics; Color; Repressing; Translucency.

RESUMO

Objetivo: O objetivo deste estudo é avaliar o efeito de múltiplas queimas e envelhecimento na cor e na translucidez da vitrocerâmica de dissilicato de lítio reprensada (IPS e.max press). **Material e Métodos:** Um total de 42 discos de dissilicato de lítio (15 mm x 1 mm) foram fabricados usando a técnica de prensa térmica seguindo as instruções dos fabricantes. Eles foram divididos em três grupos de acordo com o número de ciclos de prensagem (n=14): Grupo P1 (pressionado uma vez), Grupo P2 (pressionado duas vezes) e Grupo P3 (pressionado três vezes). Cada grupo foi subdividido em dois subgrupos de acordo com o número de ciclos de queima (n=7): Subgrupo (F2): 2 ciclos de queima, Subgrupo (F4): 4 ciclos de queima. Em seguida, todos os corpos de prova foram submetidos à termociclagem. Os parâmetros de cor e translucidez (TP) foram avaliados por espectrofotômetro; após a prensagem, queima (ΔE1: diferença de cor entre prensagem e queima) e envelhecimento (ΔE2: diferença de cor entre prensagem e envelhecimento). **Resultados:** ΔE1 para o subgrupo F2 (3,38) apresentou menor valor estatisticamente significante do que ΔE1 para o subgrupo F4 (3,94). Após o envelhecimento, o grupo P3 apresentou o maior ΔE2 estatisticamente significante (6,41). Um ΔE2 estatisticamente inferior foi encontrado no grupo P2 (5,55). O grupo P1 apresentou o menor ΔE2 estatisticamente significante (4,28). O TP para o subgrupo F2 (18,27) apresentou valor superior ao subgrupo F4 (17,78). Houve uma diminuição estatisticamente significante no TP após o envelhecimento para todos os grupos testados. **Conclusão:** O aumento do número de ciclos de queima e de envelhecimento afetaram a cor e a translucidez do dissilicato de lítio reprensado.

PALAVRAS-CHAVE

Cerâmica; Cor; Envelhecimento; Reprensagem; Translucidez.

INTRODUCTION

Over the last few decades, the usage of all ceramic restorations has been dramatically increased owing to the recent ceramic materials of superior esthetic properties that have been introduced and the increased demands for restorations that mimic natural teeth [1]. The fabrication of restorations that mimic natural teeth in color and translucency is a great challenge as it can be affected by many factors as: number of firing cycles [2-5], thickness of the ceramic material [2,4,6,7] firing temperature and surface glaze [8], structure of the ceramic material, surface finishing protocols, stains, the resin cement used, the polymerization efficiency through ceramics [9] and the fabrication techniques [10,11].

Moreover, there are many challenging conditions in the oral cavity that may influence the long-term success of an all–ceramic restoration. These conditions include: variable PH, cyclic loading and humidity [12]. Artificial accelerated aging simulates the long-term exposure to these oral conditions that may cause significant influence on the color and translucency of all-ceramic materials [13-16].

Heat pressing technology has become a common technique to fabricate glass-ceramic restorations because of its simplicity, better crystalline dispersion in the glassy matrix, better marginal adaptation and less porosity if compared to the sintering technique [17]. *IPS Empress 1* was the main glass ceramic. It consists of 45 vol % tetragonal leucite crystals having a flexural strength of 120 MPa and characterized by high esthetic properties [18]. *IPS Empress2* was then introduced as SiO_2-Li_2O [19,20]. It contains 60 vol % lithium disilicate crystals and smaller secondary lithium orthophosphate crystals [21]. Its flexural strength ranged from 350-450 MPa resulting in high mechanical properties and less esthetic properties [18]. *IPS e.max Press* was then launched by Ivoclar Vivadent in 2005, in which the translucency and the physical properties were improved through different firing process [22]. It has high flexural strength (470 - 520 MPa) [17]. In spite of the high crystalline content, the IPS e.max press possess high translucency due to the low refractive index of the lithium disilicate crystals [23]. It is composed of 70% needle-shaped lithium disilicate crystals (length: 3 to 6 μm) embedded in the glassy matrix. The material is provided by the manufacturer in the form of ingots in two sizes (small one weighs 3.2 g and a larger one weighs 6.1 g) [24,25].

After pressing of the lithium disilicate ingots, divesting is done. Then, buttons and sprues are separated and discarded. But nowadays, the buttons and sprues (leftover material) are reused by many laboratories for economical reasons as sometimes an ingot is used to press a single restoration that will lead to a considerable amount of leftover material [10], decreasing the cost of treatment and protection of the natural resources from depletion [26].

The effect of reusing the leftover material on biaxial flexural strength, fracture toughness, hardness, surface roughness and microstructure of the pressable ceramics was evaluated in many studies [10,20,27-29]. For the effect of repressing on color and translucency; Zaghloul et al. in 2013 [30] appraised the effect of repeated pressing on color and translucency of IPS e.max zirpress, IPS Empress Esthetic and IPS e.max press. Leftover buttons and sprues were used to construct the repressed group. It was concluded that color changes after repeated pressing were clinically acceptable but it’s better to be used in less esthetic zones. After second press, translucency of e.max Press and Esthetic press was non-significantly decreased.

Another research was done by El-Etreby in 2017 [31] assessed the effect of repeated pressing on color, translucency and surface roughness of IPS e.max Press. Leftover buttons only (no sprues to produce pores-free structure) were used in fabrication of the repressed group. Results revealed that regarding color, translucency and surface roughness, there was no significant difference between pressed and repressed group. It was concluded that repressing - using only the buttons to produce pore-free structure – has no significant influence on color, translucency and surface roughness.

Mimicking natural tooth requires the use of layering and/or staining technique with multiple firing cycles. Several studies have assessed the influence of repressing on color of lithium disilicate [30,31] yet non has investigated the effect of multiple firing cycles and aging on the color and translucency of repressed lithium disilicate.

The aim of this study was to evaluate the influence of multiple firings and aging on color and translucency of repressed IPS e.max press by using leftover buttons only to fabricate the repressed group. Null hypotheses: Neither the number of firing cycles nor thermocycling aging will affect the color and translucency of repressed lithium disilicate.

MATERIALS AND METHODS

Specimen preparation

A total of 42 wax discs (1 mm thickness X 15 mm diameter) were fabricated by using a Teflon mold. For fabrication of discs of the 1st press group (P1) (n=14): spruing, investing, preheating, pressing using IPS e.max Press ingots (LT A1) (Ivoclar vivadent) were done according to the manufacturer instructions [17].

For the fabrication of discs of 2nd press group (P2) (n=14) and 3rd press group (P3) (n=14), the wax discs were sprued, invested and pressed according to the manufacturer instructions using the leftover button material from previous pressings;

For group P2: leftover button material that has been previously pressed one time was used.

For group P3: leftover button material that has been previously pressed two times was used.

Exposure to firing cycles

According to number of firing cycles, samples of each group were subdivided into two subgroups; subgroup F2 (n=7): samples were subjected to two firing cycles simulating staining and glazing technique and subgroup F4 (n=7): samples were subjected to four firing cycles simulating layering technique (wash firing, dentin, staining and glazing).

Samples of both subgroups were subjected to the firing schedule of IPS e.max Press (Table 1 and Table 2; Ivoclar Vivadent) [17] by using Ivoclar programat 3000 hot press furnace.

Aging (Thermocycling)

For all tested groups, specimens were subjected to 10000 cycles of thermocycling [13,32,33] (equivalent to one year intra-orally) using Thermocycler Willytec THE- 1100. Samples were immersed in 5 °C cold bath and then in 55 °C hot bath for a dwell time of 30 seconds in each bath with a transfer time of 10 seconds.

Evaluation of color and translucency

Color and translucency were assessed three times; 1st: after pressing and repressing, 2nd: after exposure to firing cycles and 3rd: after aging.

Color was evaluated in a black chamber using ‘Agilent Cary 5000 UV-Vis-NIR spectrophotometer. It is double beam direct ratio recording system. It consists of a photometer unit and a pc computer. The light beam from a tungsten halogen lamp after passing through the double monochromator (to be monochromatic) is chopped by a chopper mirror into the sample beam and reference beam,

Table 1 - Firing schedule for 2 firing cycles simulating the staining technique

*IPS e.max ceram on IPS e.max press (staining technique)	Stand-by temperature B(°C / ° F)	Closing time S (min)	Heating rate t↗(°C/°F/min)	Firing temperature T1 (°C/°F)	Holding time H(min)	Vaccum 1 V1(°C/°F)	Vaccum 2 V2(°C/°F)	L* L(°C/°F)
1st firing cycle	403/757	6:00	60/108	770/1418	1:00	450/842	769/1416	500/932
2nd firing cycle	403/757	6:00	60/108	770/1418	1:00-2:00	450/842	769/1416	500/932

Table 2 - Firing schedule for 4 firing cycles simulating the layering technique

*IPS e.max ceram on IPS e.max press (layering technique)	Stand-by temperature B(°C / ° F)	Closing time S (min)	Heating rate t↗ (°C/°F/min)	Firing temperature T1 (°C/°F)	Holding time H(min)	Vaccum 1 V1(°C/°F)	Vaccum 2 V2(°C/°F)
1st firing cycle	403/757	4:00	50/90	750/1382	1:00	450/842	749/1380
2nd firing cycle	403/757	4:00	50/90	750/1382	1:00	450/842	749/1380
3rd firing cycle	403/757	6:00	60/108	725/1337	1:00	450/842	724/1335
4th firing cycle	403/757	6:00	60/108	725/1337	1:00	450/842	724/1335

and then passes through the sample compartment to the detector. The light beam is detected by a photomultiplier which is sensitive to the visible/ultraviolet region. The wavelength scan in these measurements were carried out from 380 nm to 780 nm. CIE-Lab color values for each sample were then calculated.

The color difference (ΔE) was then calculated by using the following formula:

$$\Delta E = \left[(L*1 - L*2)2 + (a*1 - a*2)2 + (b*1 - b*2)2\right]1/2 \quad (1)$$

Where ΔE1 is the color change between pressing and firing, ΔE2 is the color change between pressing and aging.

Mean ΔE values below 3.0 were considered "clinically imperceptible", ΔE values between 3.0 and 5.0 were considered "clinically acceptable" and ΔE values above 5.0 were considered "clinically unacceptable". [34]

The translucency parameter (TP) was obtained by calculating the color difference between the specimen over the white background and that over the black background [35]

$$TP = \left((L*_B - L*_W)^2 + (a*_B - a*_W)^2 + (b*_B - b*_W)^2\right)^{1/2} \quad (2)$$

Where: 'B' refers to the color coordinates over the black background and 'W' refers to those over the white background.

Three-way Analysis of Variance (ANOVA) was used to study the effect of firing cycles, pressing, aging and their interaction on mean TP and color change (ΔE). Bonferroni's post-hoc test was used for pair-wise comparisons when ANOVA test is significant. Repeated measures Analysis of Variance (ANOVA) was used to study the effect of firing cycles, pressing, aging and their interaction on mean TP. The significance level was set at P ≤ 0.05.

RESULTS

Color change

Effect of number of firing cycles (ΔE1)

The mean ΔE1 after two firing cycles showed statistically significant lower value than four firing cycles as shown in Table 3.

Whether with two or four firing cycles; third press showed the statistically significant highest mean ΔE1. A statistically significant lower mean ΔE1 was found with second press. First press showed the statistically significant lowest mean ΔE1 as shown in Table 4.

Whether after first, second or third press; two firing cycles showed statistically significant lower mean ΔE1 than four firing cycles as shown in Table 5, Figure 1.

Effect of aging (ΔE2)

Third press showed the statistically significant highest mean ΔE2. A statistically significant lower mean ΔE2 was found with second press. First press showed the statistically significant lowest mean ΔE2 as shown in Table 6.

Table 3 - The mean, standard deviation (SD) values and results of two-way ANOVA test for comparison between ΔE1 of firing cycles

Two cycles		Four cycles		*P*-value	Effect size *(Partial eta squared)*
Mean	SD	Mean	SD		
3.38	0.72	3.94	0.62	<0.001*	0.801

*: Significant at P ≤ 0.05

Table 4 - The mean, standard deviation (SD) values and results of two-way ANOVA test for comparison between ΔE1 after different numbers of pressing

First press		Second press		Third press		*P*-value	Effect size *(Partial eta squared)*
Mean	SD	Mean	SD	Mean	SD		
2.81 ^{C}	0.39	3.81 ^{B}	0.32	4.36 ^{A}	0.27	<0.001*	0.955

*: Significant at P ≤ 0.05. Different superscripts are statistically significantly different. Third press showed the statistically significant highest mean ΔE1. A statistically significant lower mean ΔE1 was found with second press. First press showed the statistically significant lowest mean ΔE1.

Table 5 - The mean, standard deviation (SD) values and results of two-way ANOVA test for comparison between ΔE1 values of different interactions of variables

Pressing	Two cycles		Four cycles		*P*-value (Between firings)	Effect size *(Partial eta squared)*
	Mean	SD	Mean	SD		
First press	2.46 ^{C}	0.09	3.17 ^{C}	0.16	<0.001*	0.491
Second press	3.55 ^{B}	0.15	4.06 ^{B}	0.2	<0.001*	0.336
Third press	4.13 ^{A}	0.13	4.58 ^{A}	0.14	<0.001*	0.280
P-value (Between pressings)	<0.001*		<0.001*			
Effect size *(Partial eta squared)*	0.847		0.797			

*: Significant at P ≤ 0.05.

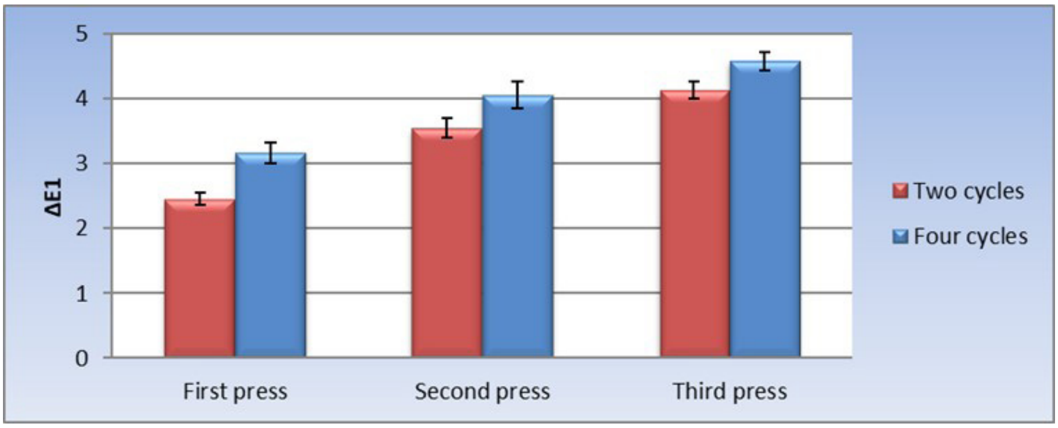

Figure 1 - Bar chart representing mean and standard deviation values for ΔE1 of different interactions of variables.

Table 6 - The mean, standard deviation (SD) values and results of two-way ANOVA test for comparison between ΔE2 after different numbers of pressing

First press		Second press		Third press		*P*-value	Effect size *(Partial eta squared)*
Mean	SD	Mean	SD	Mean	SD		
4.28 ^{C}	0.45	5.55 ^{B}	0.31	6.41 ^{A}	0.36	<0.001*	0.969

*: Significant at P ≤ 0.05. Different superscripts are statistically significantly different.

The mean ΔE2 after two firing cycles showed statistically significant lower value than four firing cycles as shown in Table 7.

Whether with two or four firing cycles; third press showed the statistically significant highest mean ΔE2. A statistically significant lower mean ΔE2 was found with second press. First press showed the statistically significant lowest mean ΔE2.

Whether after first, second or third press; two firing cycles showed statistically significant lower mean ΔE2 than four firing cycles as shown in Table 8, Figure 2.

Translucency parameter

The mean TP after zero firing cycles showed the statistically significant highest value. Two firing cycles showed statistically significant lower mean TP. Four firing cycles showed the statistically significant lowest mean TP as shown in Table 9.

Effect of number of firing cycles; after first as well as second press; the mean TP before firing showed the statistically significant highest value. Two firing cycles showed statistically significant lower mean TP. Four firing cycles showed the statistically significant lowest mean TP. After third press, the mean TP before firing showed the statistically significant highest value. There was no statistically significant difference between two and four firing cycles; both showed the statistically significant lowest mean TP values as shown in Table 10.

Table 7 - The mean, standard deviation (SD) values and results of two-way ANOVA test for comparison between ΔE2 of firing cycles

Two cycles		Four cycles		*P*-value	Effect size *(Partial eta squared)*
Mean	SD	Mean	SD		
5.09	0.95	5.73	0.88	<0.001*	0.807

*: Significant at P ≤ 0.05.

Table 8 - The mean, standard deviation (SD) values and results of two-way ANOVA test for comparison between ΔE2 values of different interactions of variables

Pressing	Two cycles		Four cycles		*P*-value (Between firings)	Effect size *(Partial eta squared)*
	Mean	SD	Mean	SD		
First press	3.87 [C]	0.11	4.68 [C]	0.18	<0.001*	0.694
Second press	5.32 [B]	0.13	5.78 [B]	0.26	<0.001*	0.425
Third press	6.09 [A]	0.16	6.73 [A]	0.13	<0.001*	0.581
P-value (Between pressings)	<0.001*		<0.001*			
Effect size *(Partial eta squared)*	0.946		0.935			

*: Significant at P ≤ 0.05.

Table 9 - The mean, standard deviation (SD) values and results of repeated measures ANOVA test for comparison between TP of firing cycles

Zero cycles		Two cycles		Four cycles		*P*-value	Effect size *(Partial eta squared)*
Mean	SD	Mean	SD	Mean	SD		
20.25 [A]	0.65	18.27 [B]	0.78	17.78 [C]	0.65	<0.001*	0.317

*: Significant at P ≤ 0.05. Different superscripts are statistically significantly different.

Table 10 - The mean, standard deviation (SD) values and results of repeated measures ANOVA test for comparison between TP values of firing cycles with different interactions of variables

Aging	Pressing	Zero cycles		Two cycles		Four cycles		*P*-value	Effect size *(Partial eta squared)*
		Mean	SD	Mean	SD	Mean	SD		
Before aging	First press	19.8 [A]	0.56	19.21 [B]	0.27	18.55 [C]	0.19	<0.001*	0.342
	Second press	20.32 [A]	0.6	18.73 [B]	0.21	18.14 [C]	0.19	<0.001*	0.647
	Third press	20.64 [A]	0.54	17.83 [B]	0.22	17.43 [B]	0.19	0.001*	0.818
After aging	First press	19.8 [A]	0.56	18.89 [B]	0.25	18.26 [C]	0.17	<0.001*	0.460
	Second press	20.32 [A]	0.6	17.92 [B]	0.15	17.56 [B]	0.19	<0.001*	0.773
	Third press	20.64 [A]	0.54	17.04 [B]	0.21	16.73 [B]	0.21	<0.001*	0.877

*: Significant at P ≤ 0.05. Different superscripts in the same row are statistically significantly different.

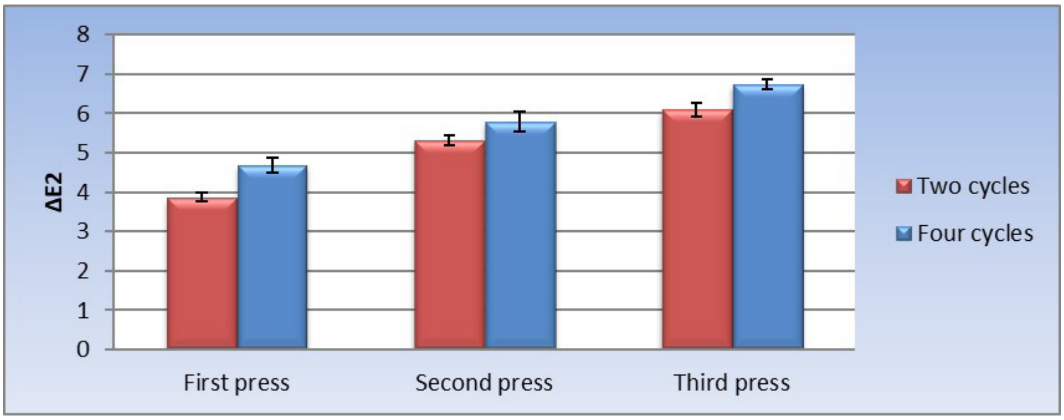

Figure 2 - Bar chart representing mean and standard deviation values for ΔE2 of different interactions of variables.

Effect of aging; after first press; the mean TP before firing showed the statistically significant highest value. Two firing cycles showed statistically significant lower mean TP. Four firing cycles showed the statistically significant lowest mean TP. After second and third press, the mean TP before firing showed the statistically significant highest value. There was no statistically significant difference between two and four firing cycles; both showed the statistically significant lowest mean TP values as shown in Figure 3.

DISCUSSION

The mean ΔE1 (color change between pressing and firing) after two firing cycles showed statistically significant lower value than four firing cycles. Regarding the translucency, the mean TP after zero firing cycles showed the statistically significant highest value. Two firing cycles showed statistically significant lower mean TP. Four firing cycles showed the statistically significant lowest mean TP. Third press showed the statistically significant highest mean ΔE1. A statistically significant lower mean ΔE1 was found with second press. First press showed the statistically significant lowest mean ΔE1. Regarding the translucency, with zero firing cycles; there was no statistically significant difference between second and third press; both showed statistically significant higher mean TP than first press.

Third press showed the statistically significant highest mean ΔE2 (color change between pressing and aging). A statistically significant lower mean ΔE2 was found with second press. First press showed the statistically significant lowest mean ΔE2. The mean ΔE2 after two firing cycles showed statistically significant lower value than four firing cycles. Regarding the translucency, there was a statistically significant decrease in TP after aging.

Effect of firing cycles

As repeated firing was proven to affect the color and translucency of IPS e.max Press [3,5,36,37], So, effect of repeated firing on color and translucency of repressed IPS e.max press was assessed in this study. Half of specimens of each group was then exposed to two firing cycles (simulating the staining technique) in which the first cycle simulating the stain firing and the second cycle simulating the glaze firing. The other half of specimens was exposed to four firing cycles (simulating layering technique) in which the first cycle simulating wash firing (foundation) characterization, the second cycle simulating dentin and incisal firing, the third cycle simulating the stain firing and the fourth cycle simulating the glaze firing. The firing cycles were done following the manufacturer recommendations [17].

The results showed that; the mean ΔE1 after two firing cycles showed statistically significant lower value than four firing cycles and both are

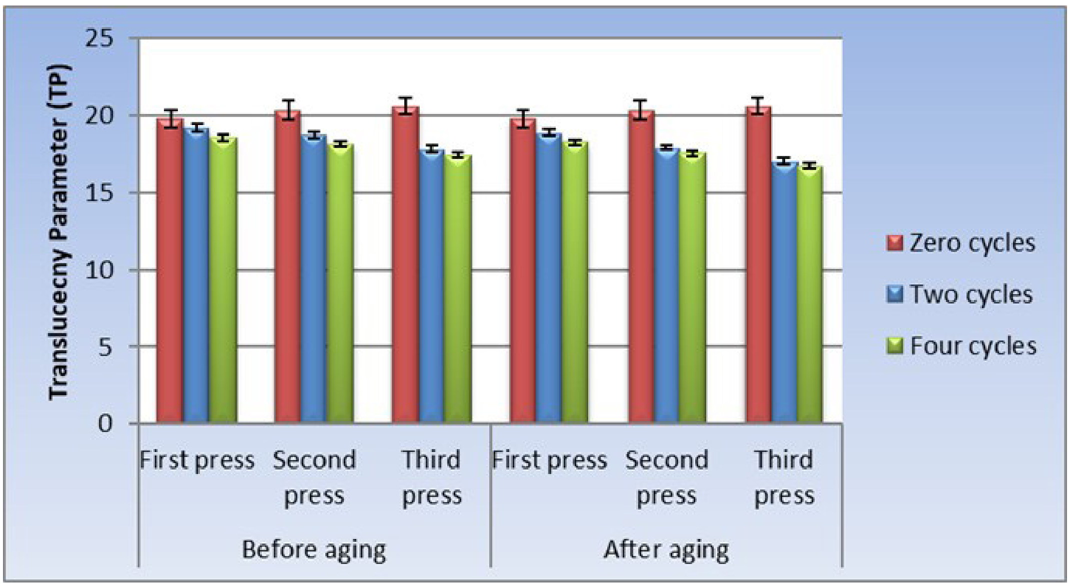

Figure 3 - Bar chart representing mean and standard deviation values for TP of firing cycles with different interactions of variables.

within the clinically acceptable range. This results coincides with **Uludag et al.** [2] **and Ozturk et al.** [4] as they attributed the increase in color difference as the number of firing cycles increased to the color instability of metal oxides after exposure of the ceramics to firing temperatures.

Regarding the translucency, the mean TP after zero firing cycles showed the statistically significant highest value. Two firing cycles showed statistically significant lower mean TP. Four firing cycles showed the statistically significant lowest mean TP. This result coincides with Yılmaz et al. [3] and Uludag et al. [2]. This could be justified as the increase in number of firing cycles leads to exposure of the dense crystalline structure of the lithium disilicate material to high temperature which had a detrimental effect and lead to damage of the surface of the ceramic structure. The continuous and/or high temperature firings of the material caused pyroclastic stream with accumulation on the surface. This lead to loss of contours, recrystallization and devitrification so the refractive index of the material was changed and light transmission was affected so the translucency decreased [3].

Third press showed the statistically significant highest mean ΔE1. A statistically significant lower mean ΔE1 was found with second press (both are within the clinically acceptable range). First press showed the statistically significant lowest mean ΔE1 and it is clinically imperceptible. This is attributed to the color instability of metal oxides after repeated pressing [30].

Regarding the translucency, with zero firing cycles; there was no statistically significant difference between second and third press; both showed statistically significant higher mean TP than first press. This result coincides with Zaghloul et al. [30] This could be justified as repeated heat pressing only lead to slight increase in the size of lithium disilicate crystals and subsequently didn't reveal negative effect on translucency [10,20,30]. Also, this result could be attributed to using only the leftover buttons and not using the leftover sprues so trapping of air in between the repressed material was prevented thus producing a repressed ceramic with nearly pore-free structure [31].

Effect of aging

The thermocycling procedure performed in this study was supported by Alp et al. [13], Acar et al. [32] and **Gürdal et al.** [33],but they have established less number of thermal cycles (5000) which is equivalent to 6 months intra-orally only.

Third press showed the statistically significant highest mean ΔE2 (color change between pressing and aging). A statistically significant lower mean ΔE2 was found with second press (both are within the clinically unacceptable range). First press showed the statistically significant lowest mean ΔE2 which is clinically acceptable. The mean ΔE2 after two firing cycles showed statistically significant lower value than four firing cycles and both are within the clinically unacceptable range. Regarding the translucency, there was a statistically significant decrease in TP after aging.

These results coincide with Alp et al. [13] They attributed the increase in color change and the decrease of translucency after thermocycling to the water sorption and surface properties (glazing or polishing) of the lithium disilicate glass ceramic. Also in their study, thermocycling affected surface roughness of ceramic materials that might be the cause of the color change and the decrease of translucency after aging. Also, these results coincide with Palla et al. [14] and this was attributed to water penetration inside the rough surface of the material and thus resulted into dissolution of silica network. This caused decrease in crystallinity of the material.

According to the results obtained from this study, by the increase in number of firing cycles, the color change increased and translucency decreased especially on the long-term evaluation. In order that the color change would be within the clinically acceptable range for optimum esthetics, it is suggested to minimize the number of firing cycles of the repressed IPS e.max press. Moreover, as the second press group showed mean ΔE2 (5.55), so it may be used in less esthetic zones. Further investigations regarding the use of third press group as a core material and to evaluate the effect of firing and aging on its color and translucency after being veneered are needed.

Recommendation

Further investigations regarding the use of third press group as a core material and to evaluate the effect of firing and aging on its color and translucency after being veneered are needed.

Limitations

This study was conducted in vitro in which the effect of abutment shade and cement shade on the final color of the restoration after repressing and multiple firings wasn't evaluated.

CONCLUSIONS

Within the limitations of the present study, the following conclusions could be made:

1) By increasing the number of firing cycles, the color change of repressed lithium disilicate increased and translucency decreased
2) Aging affected color and translucency of repressed lithium disilicate.
3) Null hypotheses were rejected as both the number of firing cycles and thermocycling aging affected the color and translucency of repressed lithium disilicate (IPS e.max press). This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' Contributions

HAE: Practical work, acquisition of data of the study and writing the manuscript. AE: Practical work and revising the article critically for important intellectual content. TS: Revising the article critically for important intellectual content.

Conflict of Interest

The authors have no conflict of interest.

Funding

The authors have no funding for this article.

Regulatory Statement

The authors have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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Date submitted: 2021 Aug 21
Accepted submission: 2021 Nov 30