INFLUENCE OF WAX AND RESIN PATTERNS ON THE COLOR OF IPS E.MAX PRESS CERAMIC: AN IN VITRO STUDY.

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ABSTRACT

INTRODUCTION. Different pattern materials were found to affect the marginal accuracy and internal fit of pressed restorations. However, whether using different pattern materials would influence the color of pressed lithium disilicate ceramics is unclear.

OBJECTIVE. The aim of this study was to evaluate the color of IPS e.max Press ceramic fabricated from wax and resin patterns.

MATERIAL AND METHODS. Fourteen pattern discs, 1.5 mm thick and 14 mm wide, were fabricated from each pattern material, wax and resin. IPS e.max Press discs were then fabricated using the lost wax technique. A spectrophotometer (VITA Easyshade Compact) was then used to measure the CIELab values. The ΔE_{00} values were calculated and compared to interpret the color differences with a perceptibility threshold of 0.8 and an acceptability threshold of 1.80 units.

RESULTS. In relation to the reference, the color difference (ΔE_{00}) values of the wax pattern group (0.76 ± 0.04) were significantly lower than those of the resin pattern group (1.95 ± 0.34). There was no significant difference in the mean L* values of the 2 groups. The mean value of the a* parameter of the wax pattern group (-0.03 ± 0.13) was significantly higher than that of the resin pattern group (-0.29 ± 0.15). The mean value of the b* parameter of wax pattern group (14.9 ± 0.61) was significantly lower than that of the resin pattern group (16.7 ± 0.85).

CONCLUSIONS. The color of IPS e.max Press was influenced by the use of wax and resin pattern materials. The wax pattern group showed clinically imperceptible color differences and the resin pattern group showed color differences that were clinically perceptible and not acceptable.

KEYWORDS. wax pattern, resin pattern, e.max Press, color, spectrophotometer.

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INTRODUCTION

Providing naturally appearing, functional dental restorations is the aim of esthetic dentistry. In order to achieve this goal, natural appearing teeth in terms of surface form, translucency, outline form, and color should be established (1).

Lithium disilicate glass-ceramics are used to fabricate veneers and crowns due to their highly mechanical and esthetic properties (2,3). They can be fabricated by using either pressing through the lost-wax techniques or CAD-CAM (computer-aided designed and computer-aided manufactured) techniques (4). Pressed restorations have been reported to have better marginal accuracy and lower laboratory costs than milled restorations (4).

In the lost wax technique, restorations are contoured to desired patterns (5,6). These patterns are then sprued, invested and burnt out, creating a mold within the investment (5,6). The ceramic ingots are heat pressed into the molds in a porcelain furnace (5,6). Finally, restorations are devested, polished, characterized, and glazed (6,7).

Dental laboratories can also use the lost-wax technique to generate ceramic crowns. This technique can cope with errors in preparation and design better than CAD/CAM systems.

For this technique, ingots of lithium disilicate are subjected to heat-pressingthat uses a pneumatic ram within a porcelain furnace to press ceramic material into the mold Dental laboratories can also use the lost-wax technique to generate ceramic crowns. This technique can cope with errors in preparation and design better than CAD/CAM systems.

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The patterns used to generate pressed restorations are conventionally fabricated with wax shaped by laboratory technicians. Despite the advantages of convenient laboratory manipulation and precise shaping, this approach has inherent drawbacks related to thermal sensitivity and the high coefficient of the thermal expansion of wax (6). Manufacturers of pressed ceramics recommend fabricating patterns from organic waxes that leave residue-free molds after burnout. Some waxes may leave residues, in the form of carbon or ash, resulting in dark areas on the pressed restorations (8-11).

As an alternative to wax, resin materials have been proposed (12-14). They are strong, rigid, and dimensionally stable when immediate investment is not possible. They also allow for easy manipulation using rotary instruments, but their main drawback is polymerization shrinkage. Previous studies reported that different pattern materials may affect the marginal adaptation and internal fit of pressed ceramic restorations (12,15-17). However, the authors are unaware of studies regarding their effect on the color of pressed lithium disilicate restorations.

Several color specification systems have been suggested to for quantifying color (18). The Commission Internationale de l'Eclairage (CIE) established a refined formula in 2001, the CIEDE2000 (ΔE_{00}), to calculate color differences, in an attempt to advance the conventional CIE Lab formula (19). The CIEDE2000 formula better compares perceptibility and acceptability judgments to instrumental color differences (18,20).

A ΔE_{00} value of 0.8 or higher can be perceived by the human eye under controlled conditions, while a ΔE_{00} value of 1.8 is found to be acceptable using the reliable TSK Fuzzy Approximation fitting procedure (21). In the oral cavity, distractions such as the mucosa and lip shadowing increase the value for color difference detection (22).

This study aimed to evaluate the effect of pattern materials on the color of a pressed lithium disilicate ceramic. The null hypotheses was that there will be no color differences between the IPS e.max Press discs that were fabricated from wax or resin patterns.

MATERIAL AND METHODS

Twenty-eight discs were allocated into 2 groups, wax pattern group and resin pattern group. Wax and resin pattern materials were used to fabricate discs 14 mm in diameter and 1.5 mm in thickness (n=14 per group) (23).

Discs were fabricated manually using custom metal molds (Figure 1) designed to the desired dimensions (24). The molds were composed of 2 compartments and coated with liquid separator (Multi-Sep separating film; GC America) to facilitate pushing out the fabricated patterns (25).

For the wax pattern group, wax (IQ Compact ash-free wax; Yeti Dentalprodukte GmbH) was melted in a wax melting heater pot beyond its solidification point at 62 degrees Celcius and transferred into the mold using a heated wax melting spoon. Excess wax was removed using a blade no. 11 mounted on a scalpel handle.

For the resin group, resin (Pattern Resin LS; GC America) pattern discs were fabricated by the bead-brush technique using brush no.4. A microscope slide was pressed over the mold after addition of the last bead to push away the excess resin, flattening the disc surface to the desired thickness. Discs were pushed out of the molds 20 minutes after the last bead (26). The dimensions of the pattern discs (Figures 2 and 3) were checked using a digital caliper (Hogetex) (24).

Following the manufacturer's instructions, the pattern discs were sprued then invested in phosphate-bonded investment (IPS PressVEST Premium; Ivoclar VivadentAG), which was vacuum mixed (EasyMix; BEGO GmbH&Co) for 90 seconds. The preheating and burnout process for the investment ring was completed at 900°C for 40 minutes. After removal from the furnace, the ring was left to bench cool.

The lithium disilicate (IPS e.max Press; Ivoclar VivadentAG) discs were acquired from low translucency (LT) ingots, VITA A2 color (24,27). Ingots were pressed at 920°C in a pressing furnace (Programat Furnace EP 3010; Ivoclar VivadentAG) for 15 minutes. Next, the investment ring was broken and the sprues were detached from the discs using a diamond disk. The resultant 28 discs were finished according to the manufacturers' recommendations. Discs were not glazed to prevent introducing thickness discrepancies between (28,29).

For comparison of results, a reference disc had to be fabricated. An ingot was placed in an investment ring that was fabricated through pouring the investment material directly into the silicone ring without any pattern material. An ingot was placed in a preheated ring and pressed as mentioned earlier. In this manner, the IPS e.max Press ceramic underwent crystallization without being pressed into a mold. Next, the pressed button was sliced using a microtome (Isomet 4000, Buehler) into a 1.5 mm thickness disc.

A digital spectrophotometer (VITAEasyshade Compact; VITA Zahnfabrik) was used for measurement of color parameters of the discs (30,31). All measurements were taken at the same time of day and on a black background (1,27,32,33). Prior to each measurement, calibration of the spectrophotometer was done according to recommendations of the manufacturer. Three readings were taken for each disc on one side at the center of the disc. The mean value for each parameter was calculated.

Color differences (ΔE_{00}) were measured between the wax and resin discs and between each group and the reference disc using the CIEDE2000 formula (19):

$$\Delta E_{00} = \left[\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2 + R_T\left(\frac{\Delta C'}{k_C S_C}\right)\left(\frac{\Delta H'}{k_H S_H}\right)\right]^{\frac{1}{2}}$$

ΔL', ΔC', and ΔH' represent differences in lightness, chroma, and hue. The S_L, S_C, S_H represent the weighting functions that adjust the total color difference for deviation in the lightness, chroma, and hue components. The rotation function, R_T, represents the interface between hue and chroma in the blue region. The k_L, k_C and k_H are the parametric factors, which represent the modification for experiments, and were set to 1 in this study (19,20).

STATISTICAL ANALYSIS

Results obtained from the color differences were interpreted according to a perceptibility threshold of 0.8 ΔE_{00} units and an acceptability threshold of 1.8 ΔE_{00} units (21). A spreadsheet (Excel 2010; Microsoft Corp) was used to make the calculations and a statistical software (IBM SPSS Statistics v20.0; IBM Corp) was used to analyze the data. The Shapiro-Wilk test was used to test continuous data for normality. Quantitative data were expressed in terms of range (minimum and maximum), mean and standard deviation. Student t-test was used to compare the two groups for quantitative variables that were normally distributed. The One way ANOVA test was used for associating the two groups with the reference, followed by pairwise comparison using the Post Hoc (Tukey) test. Significance of the acquired results was set at $P < 0.05$.

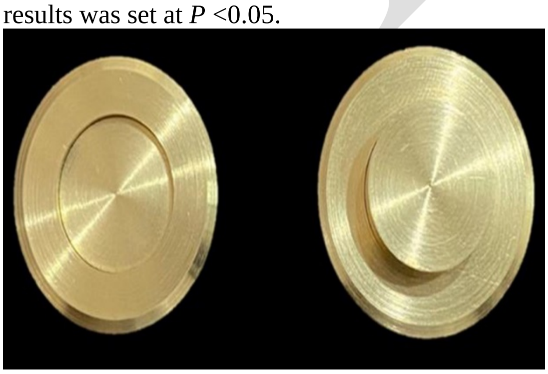

Figure 1. Custom metal molds for pattern fabrication in desired dimensions.

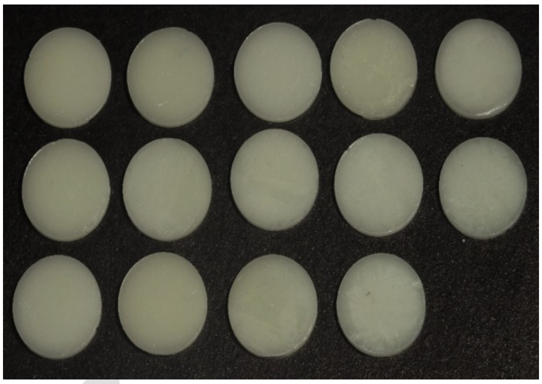

Figure 2. Wax pattern discs.

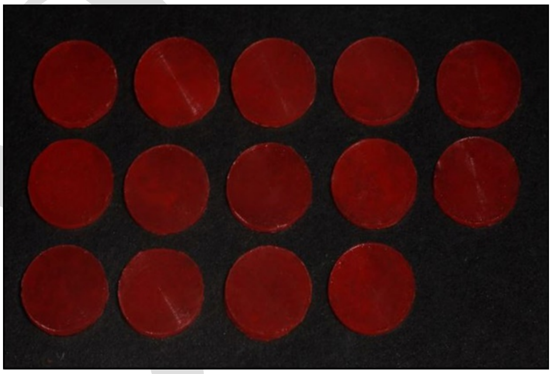

Figure 3. Resin pattern discs.

RESULTS

The range and mean±standard deviation of the color parameters of both groups are shown in Table 1. The reference color parameters were (L*=77.1, a*=−0.7, and b*=13.8). The mean value of the L* parameter was (76.99 ± 0.79) for the wax pattern group and (77.01 ± 1.13) for the resin pattern group with no significance between the 2 groups. Regarding the a* parameter, the mean value of the wax pattern group (-0.03 ± 0.13) was significantly higher than that of the resin pattern group (-0.29 ± 0.15). Concerning the b* parameter, the mean value of the wax pattern group (14.9 ± 0.61) was significantly lower than that of the resin pattern group (16.7 ± 0.85).

In relation to the reference color parameters, the wax pattern group showed a mean ΔE_{00} value of (0.76 ± 0.04), which was below the clinical perceptibility threshold. The resin pattern group showed a mean ΔE_{00} value of (1.95 ± 0.34) in relation to the reference parameters, which was above the clinical acceptability threshold. The mean ΔE_{00} value between the 2 studied groups was (1.51 ± 0.41), which was clinically perceptible, yet below the acceptability threshold. A significant difference was found between each of the calculated ΔE_{00} values as shown in Table 2.

Table 1. Comparison between the two studied groups regarding L*, a* and b* color parameters.

	Wax pattern group (n = 14)	Resin pattern group (n = 14)	t	*P*
L*				
Min. – Max.	75.3 – 78.4	74.9 – 79.5	0.058	0.954
Mean ± SD.	76.99 ± 0.79	77.01 ± 1.13		
a*				
Min. – Max.	-0.30 – 0.10	-0.60 – 0.10	4.955*	<0.001*
Mean ± SD.	-0.03 ± 0.13	-0.29 ± 0.15		
b*				
Min. – Max.	14.1 – 16	15.6 – 17.7	6.594*	<0.001*
Mean ± SD.	14.9 ± 0.61	16.7 ± 0.85		

n: Number of specimens
Min-Max: Minimum – Maximum
SD: Standard deviation t: Student t-test
*: Statistically significant at $P \leq 0.05$

Table 2. Color difference between the wax and resin pattern groups.

	Wax pattern group vs reference (n = 14)	Resin pattern group vs reference (n = 14)	Wax pattern group vs resin pattern group (n = 14)	F	*P*
ΔE_{00}					
Min. – Max.	0.71 – 0.83	1.15 – 2.33	0.93 – 2.04	54.182*	<0.001*
Mean ± SD.	0.76 ± 0.04	1.95 ± 0.34	1.51 ± 0.41		
Sig. bet. groups.	P_1<0.001*, P_2<0.001*, P_3=0.001*				

n: Number of specimens
Min-Max: Minimum – Maximum
SD: Standard deviation
F: F for One way ANOVA test, significance between each 2 using Post Hoc Test (Tukey)
P_1: Significance between wax pattern group vs reference and resin pattern group vs reference
P_2: p value for comparing between wax pattern group vs reference and wax pattern group vs resin pattern group
P_3: p value for comparing between **resin pattern group vs reference** and **wax pattern group vs resin pattern group**
*: Statistically significant at $p \leq 0.05$

DISCUSSION

The aim of this in vitro study was to evaluate the effect of pattern materials on the color of a pressed lithium disilicate ceramic. Based on the results of the present study, the IPS e.max Press discs fabricated from wax and resin patterns showed significant color differences. Hence, the null hypothesis was rejected.

The two commonly used pattern materials, wax and resin, were studied (11,12). Due to its high esthetic properties and ability to match natural teeth shades, pressed lithium disilicate was the material chosen for this study (16). The IPS e.max Press ceramic was found to show the highest color difference values among other ceramic systems (33).

Additionally, discs were fabricated at 1.5 mm thickness since color difference detection is higher when ceramic thickness is less than 2.5 mm (24,28). Discs were 14mm in diameter to eradicate possible edge loss during spectrophotometric measurement (33). Color measurements were taken on a black background to mimic the oral cavity and for standardization of results (1,27,32).

The Easy Shade spectrophotometer was used for being more precise and accurate than other spectrophotometers, colorimeters, and digital cameras (22,31). The CIEDE2000 color difference formula reflects the color differences between tooth colors more accurately than the traditional CIELab formula (18). The perceptibility threshold was found to be 0.8 units and the acceptability threshold was 1.8 units according to Paravina et al (21).

To allow for interpretation of results, a reference disc was customized from the same material as the test discs. Because the ingot obtains its color after crystallization,(30) it had to be pressed. However, pressing the ingot into a mold formed through the burnout of any pattern material would introduce a test variable. For that reason, the ingot was directly placed in the investment ring in the porcelain furnace to crystallize and simulate the pressing process, then sliced using a microtome into a 1.5 mm thickness disc.

The use of different pattern materials had no significant effect on the lightness (L*) of the resultant discs. Regarding the red-green axis (a* parameter), discs of the resin pattern group were significantly more greenish than those of the wax pattern group. Concerning the yellow-blue axis (b* parameter), discs of the resin pattern group were significantly more yellowish than the wax pattern group, whose color parameter values were closer to those of the reference disc. This may be attributed to the original red color of the resin, contrary to the white wax. The presence of these pigments, although not essentially green and yellow, might have left residues in the mold into which the lithium disilicate ceramic was pressed.

In relation to the reference disc, the wax group showed a clinically imperceptible color difference (ΔE_{00}) as it is the pattern material recommended by the manufacturer (8). The resin pattern group showed color difference values beyond the clinical acceptability threshold. This means that the conventional resin material left ash or carbon residue in the mold altering the color of the resultant ceramic as suggested by some manufacturers (8-10).

A previous study testing the influence of burnout temperature of dewaxing on copper alloy castings found that pattern materials may leave residues in the form of carbon inside the mold cavities. This residual carbon, which was a result of inadequate burnout time, stained the metal and discolored the casting and could only be removed through sanding (34). This can explain the color change exhibited in the present study. The same burnout time, 40 minutes, was used for both wax and resin patterns according to manufacturers' instructions. It is possible that this time was adequate to allow complete wax pattern elimination, but insufficient for the burnout of resin patterns. Further studies are recommended to test the effect of different burnout times and milled wax and resin patterns of the color of the pressed ceramics.

CONCLUSIONS

Within the limitations of the present study, it was concluded that the color of IPS e.max Press ceramic was influenced by the use wax and resin pattern materials. The wax pattern group showed color differences below the selected clinically perceptible threshold (ΔE_{00}=0.8) and the resin pattern group showed color differences beyond the clinically acceptable threshold (ΔE_{00}=1.8).

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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