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RESEARCH AND EDUCATION

Effects of accelerated artificial aging on the translucency and color stability of monolithic ceramics with different surface treatments

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ABSTRACT

Statement of problem. Different surface finishing procedures can be applied to monolithic restorations. However, information is limited regarding the long-term performance of these procedures.

Purpose. The purpose of this in vitro study was to evaluate the effect of aging on the translucency and color stability of monolithic ceramics with different surface finishing procedures.

Material and methods. Disk-shaped (14×1.5 mm) specimens of monolithic zirconia (Zirkonzahn Prettau [ZZ]) and lithium disilicate glass-ceramic (IPS e.max Press [IPS]) were fabricated. The specimens were divided into 3 subgroups according to the surface treatments (n=9, G: glazing, R: rubber polishing system, and P: rubber polishing system followed by polishing paste). Color measurements were made by using a spectrophotometer before and after an ultraviolet aging process. L*, a*, and b* parameters were recorded. ΔE and translucency parameter (TP) values were calculated. One specimen from each subgroup was examined by scanning electron microscopy (×30 000). The data were statistically analyzed using the Mann-Whitney U, Kruskal-Wallis, and post hoc tests (α=.05).

Results. ΔE values of group ZZ (5.03) exceeded the clinically acceptable level (3.5); however, the color change was not clinically perceptible for IPS (0.41). The ΔE value of the subgroup P was found to be higher than that of the others for ZZ (*P*<.001). The ΔE value was not affected by the surface treatment for IPS. Group IPS showed significantly higher translucency than the ZZ group (*P*<.001). TP values were not affected by the surface treatment in either material and decreased after aging. However, changes in the TP values were too slight to be clinically perceptible.

Conclusions. Lithium disilicate ceramic was found to be more esthetic than monolithic zirconia ceramic in terms of color stability and translucency. (J Prosthet Dent 2019;121:712.e1-e8)

Zirconia ceramics have been used as core materials to fabricate ceramic restorations because of their high mechanical properties.[1-3] However, because of the opacity of zirconia, the framework needs to be veneered with feldspathic ceramic to obtain acceptable esthetics. This bilayered structure of the core-ceramic system combines the strength of zirconia with the esthetics of ceramic.[4,5] Nevertheless, veneered-zirconia systems are susceptible to ceramic chipping,[6,7] leading to the development of monolithic zirconia restorations with a modified microstructure with higher translucency and the addition of characterization pigments.[8-10]

Lithium disilicate glass-ceramics exhibit better mechanical properties than feldspathic ceramic and have excellent optical properties with higher translucency than zirconia. However, their mechanical properties are inferior. Lithium disilicate ceramics, which can be produced with different translucency levels and colors, are widely used in monolithic restorations with surface characterization.[11-14] Monolithic restorations provide additional advantages including reduced tooth preparation and higher fracture strength than bilayered restorations. Fewer manufacturing steps and less laboratory work are required because they are produced by using computer-aided design and computer-aided manufacturing (CAD-CAM) systems and can be delivered in a single visit.[9,10,15-19] However, occlusal adjustment may be

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Clinical Implications

Lithium disilicate glass-ceramics with high translucency and color stability may be a better choice than zirconia for monolithic restorations, especially in the esthetically critical anterior region.

needed during placement, and the adjusted surfaces must be polished or glazed effectively.[6,20-24] Surface texture alters the optical properties of dental restorations[25,26] because a flat surface reflects the incoming light regularly, whereas a rough surface diffuses light.[27] However, the relationship between light and different surface textures is not fully understood, and information about the effects of surface treatments on the optical properties and surface texture of monolithic ceramics is lacking.[6,22,25]

Translucency should be considered in the selection of restorative material,[28-32] but studies comparing the translucency and color stability of recently introduced zirconia materials with lithium disilicates are sparse.[12,33,34] Factors such as temperature, nutritional habits, and humidity can cause color and translucency changes in restorations.[35-40] If these changes exceed an acceptable level, the restoration fails and may need to be replaced.[35] However, data are limited on the influence of aging on monolithic zirconia and lithium disilicate in a humid environment.[40-43] Therefore, the purpose of this study was to evaluate the effect of accelerated artificial aging on the translucency and color stability of monolithic zirconia and lithium disilicate ceramics with different polishing procedures. The null hypothesis was that the accelerated aging would have no effect on the translucency and color stability of monolithic zirconia and lithium disilicate with different surface treatments.

MATERIAL AND METHODS

The materials used in the study are described in Table 1. Disk-shaped specimens (14 mm in diameter and 1.5 mm in thickness) were fabricated from each monolithic material: lithium disilicate glass-ceramic (IPS e.max Press; Ivoclar Vivadent AG) and zirconia (Zirkonzahn Prettau; Zirkonzahn GmbH). A2 was selected for the ceramic shade. An autopolymerized acrylic resin pattern was prepared and scanned by using a scanner (Tizian Smart Scan; Schütz Dental GmbH) to design the specimens by using the integrated software (TizianCAM v6.03.90; Schütz Dental GmbH). The zirconia specimens were fabricated by using a presintered zirconia block (Zirkonzahn Prettau; Zirkonzahn GmbH) in a milling unit (Tizian Cut 5 smart; Schütz Dental GmbH). To compensate for the sintering shrinkage, the specimens were milled 20% larger than the resin pattern. The specimens were carefully separated from the milled block. The specimens were colored by using shade A2 coloring liquid (Color Liquid Prettau Aquarell; Zirkonzahn GmbH) and dried under a heat lamp (Zirkonlamp 250; Zirkonzahn GmbH) for 30 minutes as recommended by the manufacturer. After coloring, the zirconia specimens were sintered (Zirkonofen 600 V/2; Zirkonzahn GmbH) according to the manufacturers' instructions.

Table 1. Materials used

Material	Brand Name	Manufacturer
Monolithic zirconia	Zirkonzahn Prettau: ZrO_2 (92.27), Y_2O_3 (4-6), Al_2O_3 (<1), SiO_2 (0.02), Fe_2O_3 (0.01), and Na_2O (0.04)	Zirkonzahn GmbH
Monolithic lithium disilicate	IPS e.max Press LT (low translucency) A2: SiO_2 (57-80), Li_2O (11-19), K_2O (0-13), P_2O_5 (0-11), ZrO_2 (0-8), ZnO (0-8), other oxides, and ceramic pigments (0-10)	Ivoclar Vivadent AG
Glaze	IPS e.max Ceram Glaze powder, IPS e.max Ceram Glaze, and stain liquid	Ivoclar Vivadent AG
Coloring liquid	Color Liquid Prettau Aquarell A2	Zirkonzahn GmbH
Diamond rotary cutting instrument	Varenkor (ISO:807/104/143/513/037)	Varenkor Diamond Tools
Rubber polishing system	Master Zirkon (ø/L 260/2.0 mm), extracoarse (green, 140-104-ZAXC, medium (red, 140-104-ZAN), fine (yellow, 140-104-ZAF)	G&Z Instrumente GmbH
Polishing paste	Zircon-Brite: diamond (C), corundum (Al_2O_3), pumice (SiO_2), wax	Dental Ventures of America Inc

The lithium disilicate specimens were produced by the heat pressing technique. Disk-shaped (14 mm in diameter and 1.5 mm in thickness) wax patterns were prepared and invested in a phosphate-bonded investment (SheraFina 2000/Sheraliquid; Werkstoff Technologie). The investment cylinders were heated in a furnace (Programat EP 5000; Ivoclar Vivadent AG), and the specimens were heat-pressed using IPS e.max Press low-translucency (LT) ingots (Ivoclar Vivadent AG). After cooling, the remnants of the investment material were removed by using airborne-particle abrasion.

All surface treatments were performed by the same operator (M.K.) according to the manufacturers' recommendations. All the specimens from both materials were ground by using a fine-grit diamond rotary instrument with a red band (Varenkor Diamond Tools) by using a low-speed laboratory handpiece (UM50TM + UHR50T, Ultimate 500K; NSK Inc) before polishing procedures to simulate a clinical adjustment. The thickness of each specimen was evaluated by using a digital caliper (Powertec Tools). To standardize the abrasive conditions for all test groups, a new diamond rotary instrument was used for each group, and the rotation speed was fixed at 20 000 rpm. After the grinding procedure, the specimens were divided into 3 subgroups according to surface treatments: G, glazing; R, rubber polishing system; and P, rubber polishing system followed by polishing paste (n=9).

In subgroup G, the appropriate amounts of glaze powder (IPS e.max Ceram Glaze powder; Ivoclar Vivadent AG) and liquid (IPS e.max Ceram Glaze and stain liquid; Ivoclar Vivadent AG) were mixed according to the manufacturer's recommendations. After applying a thin layer of glazing material onto the specimens, glaze firing was carried out in the vacuum furnace. In subgroup R, the specimens were polished by using diamond-impregnated rubber disks (Master Zirkon; G&Z Instrumente GmbH) by using the same low-speed handpiece with a rate of 10 000 rpm. The specimens were polished in 1 direction for 30 seconds, rotated 90 degrees, and polished for another 30 seconds. The polishing system had 3 steps using 3 different rubber disks (green: extracoarse grit, red: medium grit, and yellow: fine grit). Three minutes of polishing was performed for each specimen in total. In subgroup P, the specimens were polished by using the rubber polishing system that was used in subgroup R, followed by a diamond polishing paste. The paste (Zircon-Brite; Dental Ventures of America Inc) was applied by using a brush (DVA Soft Bristle Brush, white; Dental Ventures of America Inc) for 60 seconds at a rate of 10 000 rpm. The specimens were cleaned ultrasonically in distilled water for 10 minutes before the measurements.

The colors of all the numbered specimens were measured according to the CIELab color scale under a standard illuminant D65 (MASTER TL-D Super 80 18W/865 1SL; Philips) and on a neutral gray background by using a dental spectrophotometer (VITA Easyshade Advance 4.0; VITA Zahnfabrik). Measuring characteristics of the spectrophotometer were standard illuminant D65, illumination geometry d0/0 degrees, 2 degrees colorimetric standard observer, and measurement area of 5 mm in diameter. The spectrophotometer was calibrated by using a white tile before each measurement. The measurements were performed in the single-tooth mode, and the spectrophotometer's tip was held in contact with the center of the polished surface of the disk. The mean value of 3 sequential measurements of L*, a*, and b* were recorded. In the color space, L* indicates lightness, the a* coordinate represents the green to red range, and the b* coordinate represents the blue to yellow range.[44-46] Color differences were calculated by using the following formula after accelerated aging[44,45]:

$\Delta E = ([L_1^* - L_2^*]^2 + [a_1^* - a_2^*]^2 + [b_1^* - b_2^*]^2)^{1/2}$, where L_1^*, a_1^*, and b_1^* represent the color coordinates before aging and L_2^*, a_2^*, and b_2^* represent the color coordinates after aging of each specimen. Based on the CIELab system, the translucency parameter (TP) is used to identify the translucency of a material. The color difference observed when each specimen is placed on a black (B) and white (W) background is called TP.[47-51] If a material is totally opaque, the TP value is 0. As the TP value increases, the translucency of the material also increases.[47-49] The same spectrophotometer was used for measuring TP values of the specimens before and after accelerated aging. The TP values were calculated using the following equation[48,50]:

$$TP = \left[\left(L_B^* - L_W^*\right)^2 + \left(a_B^* - a_W^*\right)^2 + \left(b_B^* - b_W^*\right)^2 \right]^{1/2}.$$

The specimens were exposed to artificial aging in an artificial aging chamber after the first color measurements (Atlas UV 2000; Atlas Material Testing Technology LLC). Water spray and ultraviolet (UV) light were applied to the specimens in the test machine for 300 hours and run for a total radiant energy of 150 kJ/m^2. This aging procedure corresponded to 1 year of clinical service.[48,52] One representative specimen from each subgroup was examined by using a scanning electron microscope (SEM) (FEI Nova NanoSEM 430; Thermo Fisher Scientific) at 10 kV and ×30 000 magnification.

The primary aim of this study was to identify the differences in ΔE levels among polishing systems within each material type. A total sample size of 54 (9 per subgroup) was required to detect at least 0.30 difference in ΔE levels between any of 2 polishing systems, with a power of 80%. The optimum effect size (d) of 2-tailed analyses was 1.87, and Type I (alpha) error was set at .83% significance level according to the Bonferroni correction. The difference of 0.30 was taken from both our pilot study and clinical experiments. The sample size estimation was performed by using the G* Power (v3.0.10; Kiel University) software. The obtained data were analyzed using a statistical software program (SPSS Statistics v17.0; SPSS Inc). Normality of the data distribution was checked by the Kolmogorov-Smirnov test, and the homogeneity of the variances was investigated by the Levene test. Owing to the violations of parametric test assumptions, descriptive statistics for continuous data were shown as median and interquartile range

Table 2. Descriptive statistics of experimental groups

Group (Material)	Mean ±SD	Median ±IQR
ΔE		
ZZ	5.07 ±1.08	5.03 ±1.59
IPS	0.47 ±0.20	0.41 ±0.31
TP before aging		
ZZ	8.85 ±0.50	8.71 ±0.69
IPS	14.82 ±0.78	14.75 ±1.39
TP after aging		
ZZ	8.65 ±0.33	8.64 ±0.35
IPS	14.63 ±0.86	14.64 ±1.70
TP change		
ZZ	0.20 ±0.38	0.16 ±0.47
IPS	0.19 ±0.36	0.16 ±0.32

ΔE, color change; IPS, IPS e.max Press; IQR, interquartile range; SD, standard deviation; TP, translucency parameter; ZZ, Zirkonzahn Prettau.

Table 3. ΔE values of experimental groups

Group (Material)	G	R	P	P*
ZZ	4.91 ±1.23[a,A]	4.59 ±1.42[a,A]	6.03 ±0.78[b,A]	.005
IPS	0.36 ±0.19[B]	0.37 ±0.31[B]	0.61 ±0.36[B]	.147
P†	<.001	<.001	<.001	

ΔE, color change; G, glazing; IPS, IPS e.max Press; IQR, interquartile range; P, rubber polishing system followed by polishing paste; R, rubber polishing system; ZZ, Zirkonzahn Prettau. Data shown as median ±IQR. Difference between surface treatments is indicated by different lowercase letters in same row, statistically significant *P*<.001. Difference between materials is indicated by different uppercase letters in same column, statistically significant *P*<.001. *Comparisons among polishing systems within each material, Kruskal-Wallis test, according to Bonferroni correction, *P*<.025 considered as statistically significant. †Comparisons between materials within each polishing system, Mann-Whitney U test, according to Bonferroni correction, *P*<.017 considered as statistically significant.

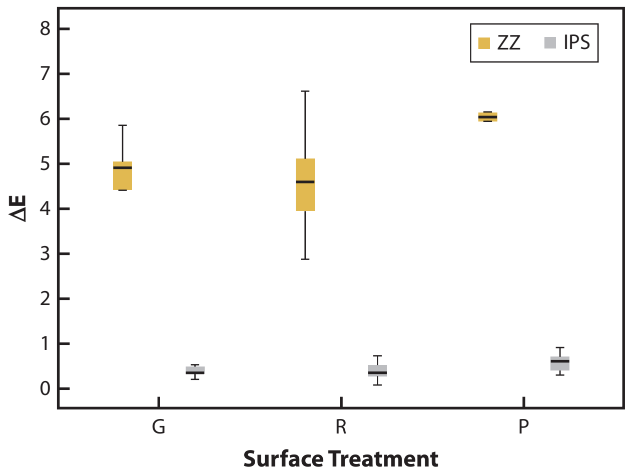

Figure 1. ΔE values of tested ceramic materials after aging. ΔE, color change value; G, glazing; IPS, IPS e.max Press; R, rubber polishing system; P, rubber polishing system followed by polishing paste; ZZ, Zirkonzahn Prettau.

(Table 2), and therefore, the data analyses were performed using nonparametric test statistics. The significance of the color change and TP difference among the surface treatments within the material groups was evaluated by the Kruskal-Wallis test. When the *P* values from the Kruskal-Wallis test statistics were statistically significant, the Conover Multiple Comparison test was used to determine which surface treatment differed from which others. The Mann-Whitney U test was used to determine the significance of color change and TP difference between the materials within each surface treatment. The Wilcoxon signed-rank test was used to evaluate the effects of aging within the groups (α=.05 unless otherwise stated). However, in all possible multiple comparisons, the Bonferroni correction was performed to control for Type I error.

RESULTS

A statistically significant difference was found between the ΔE values of IPS e.max Press (IPS) and Zirkonzahn Prettau (ZZ) groups (*P*<.001). The color change in the ZZ specimens (ΔE=5.03) exceeded the clinically acceptable level, that is, ΔE=3.5.[45] However, IPS specimens showed a slight color change (ΔE=0.41), which was not clinically perceptible. For the ZZ, the highest color difference was observed in the subgroup P among the groups, whereas no significant difference was found between the subgroups R and G. However, in the IPS group, no statistically significant difference was found among the ΔE values of the P, R, and G subgroups (Table 3; Fig. 1). IPS showed significantly higher translucency values than group ZZ before and after the aging procedure. No significant difference was found in the TP values among the ZZ subgroups before and after aging (*P*>.012). Similarly, no significant difference in TP values was found among the subgroups of the IPS before and after aging (*P*>.012). The TP values of all the groups decreased after aging, but the changes in TP values were not statistically significant (*P*>.008) (Tables 4 and 5; Fig. 2).

SEM images of the specimens revealed that different surface treatments resulted in different surface topographies, which did not change substantially after the aging procedure. The surface morphology of the glazed specimen of the IPS group appeared to be smoother than that of the polished specimens. The deep grooves and scratches from the polishing procedure, which were not seen on the glazed surface, were found on the polished

Table 4. TP values of materials according to surface treatments and aging

Group (Material)	G	R	P	P[a]
Before aging				
ZZ	9.27 ±1.16	8.67 ±0.29	8.54 ±0.49	.152
IPS	15.63 ±1.29	14.67 ±1.73	14.81 ±0.81	.333
P[b]	<.001	<.001	<.001	
After aging				
ZZ	9.00 ±0.56	8.62 ±0.36	8.59 ±0.34	.018
IPS	15.54 ±1.51	14.48 ±1.62	14.64 ±1.14	.174
P[b]	<.001	<.001	<.001	

G, glazing; IPS, IPS e.max Press; IQR, interquartile range; P, rubber polishing system followed by polishing paste; R, rubber polishing system; TP, translucency parameter; ZZ, Zirkonzahn Prettau. Data shown as median ±IQR. [a]Comparisons among polishing systems within each material, Kruskal-Wallis test, according to Bonferroni correction, *P*<.012 considered as statistically significant. [b]Comparisons between materials within each polishing system, Mann-Whitney U test, according to Bonferroni correction, *P*<.008 considered as statistically significant.

Table 5. Change in TP values according to aging

Group (Material)	G	R	P	P[a]
ZZ	-0.39 ±0.57	-0.16 ±0.36	-0.02 ±0.65	.588
IPS	-0.16 ±0.26	-0.10 ±0.62	-0.20 ±0.34	.305
P[b]	.222	.666	.258	

G, glazing; IPS, IPS e.max Press; IQR, interquartile range; P, rubber polishing system followed by polishing paste; R, rubber polishing system; TP, translucency parameter; ZZ, Zirkonzahn Prettau. Data shown as median ±IQR. [a]Comparisons among polishing systems within each material, Kruskal-Wallis test, according to Bonferroni correction, *P*<.025 considered as statistically significant. [b]Comparisons between materials within each polishing system, Mann-Whitney U test, according to Bonferroni correction, *P*<.017 considered as statistically significant.

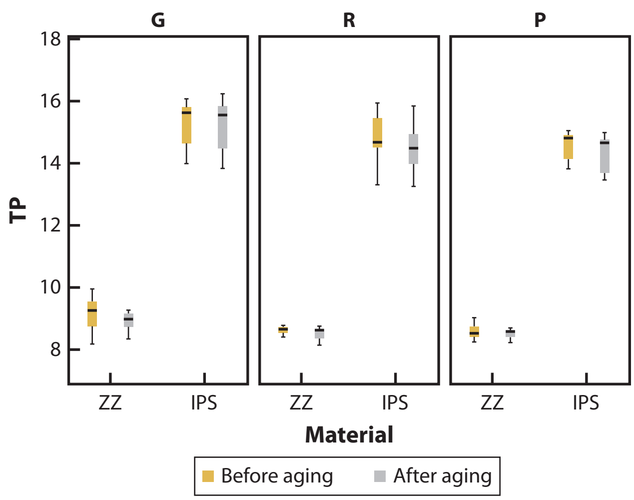

Figure 2. Translucency parameters of tested ceramic materials before and after aging. G, glazing; IPS, IPS e.max Press; R, rubber polishing system; P, rubber polishing system followed by polishing paste; TP, translucency parameter; ZZ, Zirkonzahn Prettau.

surfaces. Mechanical polishing without paste induced irregularities and voids on the ceramic surfaces. The outlines of these scratches seem to be less sharp after paste application. However, they were not completely removed, and remnants or residues of the polishing paste were observed (Fig. 3).

Subgroups G and P of the ZZ specimens had a similar uniform appearance; however, in the subgroup G, the glaze material was not homogeneously distributed in some regions. In subgroup R, grooves in the direction of the grinding strokes were observed. The SEM image of subgroup P showed that striation was considerably reduced after the polishing paste application, exhibiting the smoothest surface among the surface treatments used (Fig. 4).

DISCUSSION

Based on the results of the present study, the null hypothesis that accelerated aging would not affect the translucency and color stability of monolithic zirconia and lithium disilicate with different surface treatments was rejected. The aging process affected the color and translucency of the specimens, especially the zirconia specimens, which were found to be clinically unacceptable (ΔE=5.03). When the zirconia surface was in contact with water, water vapor, or body fluids at 37 °C, slow and spontaneous tetragonal to monoclinic phase transformation was observed on the zirconia surface; this is called low-temperature degradation (LTD).[43,53,54] This represents a 4% increase in volume of the particles under the surface. Stress formation around the monoclinic particles because of this volume increase leads to separation of the particles from the surface. This separation results in the increase of the roughness with the microcracks on the surface.[42,43,53-55]

Monolithic zirconia restorations are directly exposed to the intraoral environment because they are not veneered by a ceramic layer. This exposure triggers LTD in this material.[2,42] In addition, the alumina content of monolithic zirconia is reduced to enhance translucency when compared with conventional zirconia. However, the alumina is responsible for the resistance to LTD. Thus, monolithic zirconia may be more sensitive to LTD.[12] Fathy et al[42] reported that monolithic zirconia had a higher risk of LTD than the core type. This situation negatively affects the esthetics of zirconia restorations during long-term exposure to the oral environment.[43]

Volpato et al[43] reported that zirconia maintained its colorimetric properties after an aging protocol. However, these authors used an aging protocol in an autoclave without UV light exposure. Dikicier et al[13] found the mean color difference of the zirconia specimens was ΔE=1.29. This value was much lower than the ΔE value in the present study. This difference may result from using the veneered specimens produced from the colored presintered block, and thus, a separate coloring procedure before sintering was not applied by the investigators. Other studies reported that color change in ceramic materials due to aging may be associated with metal oxides. Metallic pigments are added for color shading of ceramic, and these oxides are easily dissolved under UV radiation.[13,35,39] Consequently, the significant color change in the zirconia material in this study may be attributed to the dissolution of metal oxides caused by the UV light applied during the aging process.

The porosity formed on the surface after aging causes an increase in the scattering of incident light that decreases translucency.[42,46] Furthermore, after aging, the presence of the monoclinic and tetragonal phases in the structure reduces the translucency because each phase has different refractive indices.[32,42] Fathy et al[42] reported that a significant decrease had occurred in the TP mean values of zirconia after hydrothermal aging. Similarly, in the present study, TP values decreased in the zirconia group, but this decrease was not statistically significant. This difference can be attributed to the variation in aging procedures. In their study, aging was performed using an autoclave under more aggressive conditions, 15 hours at 134 °C and 200 kPa pressure corresponding to 45 to 60 years in the patient's mouth. In the present study, the specimens were exposed to an artificial aging period equivalent to only 1 year of use and lower temperature values. Liu et al[31] stated that when the changes in the contrast ratio values are 0.07 or greater, they could be detected by the naked eye. Lee[51] calculated the TP value corresponding to this threshold value as 2. In the present study, the TP change was found far below the clinically perceptible level.

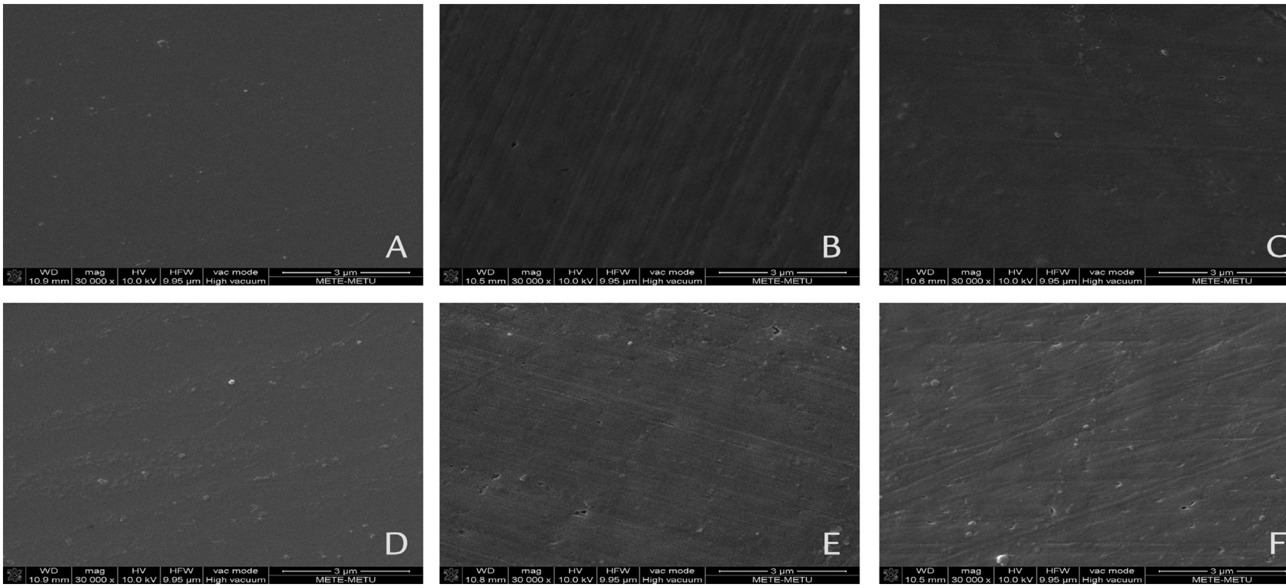

Figure 3. Scanning electron microscopy images of lithium disilicate ceramic subgroups. A, Before aging glaze. B, Before aging rubber polishing system. C, Before aging polishing paste. D, After aging glaze. E, After aging rubber polishing system. F, After aging polishing paste (original magnification ×30 000).

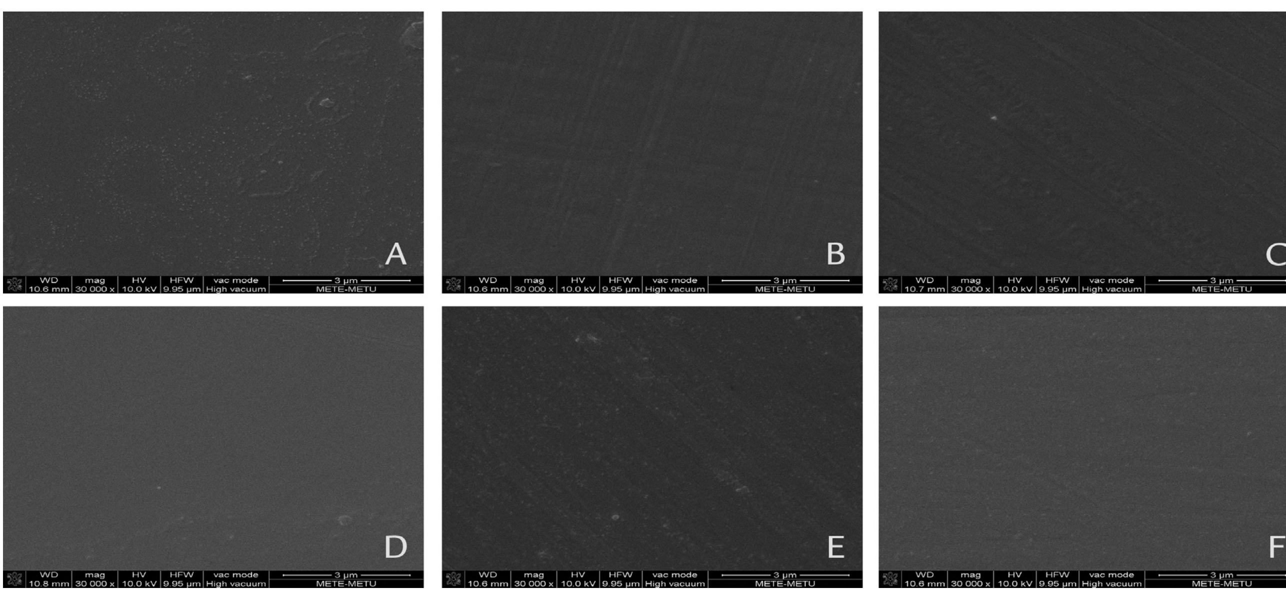

Figure 4. Scanning electron microscopy images of zirconia ceramic subgroups. A, Before aging glaze. B, Before aging rubber polishing system. C, Before aging polishing paste. D, After aging glaze. E, After aging rubber polishing system. F, After aging polishing paste (original magnification ×30 000).

The interaction of surface treatments with aging also affects the color stability of ceramic systems. Atay et al[38] reported that the color change was higher in the polished group followed by the glaze group after aging. In the present study, the ΔE value of the polishing paste applied zirconia specimens was found to be higher than that of the other surface treatments. However, the ΔE value was not affected by the surface treatment in the lithium disilicate material. It is then suggested that a material in the polishing paste interacted with the aging conditions and caused more variation in the color of the zirconia specimens.

In the present study, lithium disilicate specimens exhibited significantly higher translucency than zirconia specimens, which is consistent with the findings of the previous studies.[12,33,34,49] The translucency of monolithic zirconia had increased relative to conventional zirconia because of the modifications made during the production phase. However, translucency of the monolithic zirconia is still not comparable with even conventional lithium disilicate at the same material thickness.[8,29,33] In the present study, no statistical differences in TP values were found among the surface treatments. This indicated that the surface properties of the subgroups were similar in terms of roughness, suggesting that the polishing procedure used in this study was comparable to the glazing. These results were consistent with those of previous studies which indicated that a surface similar to glazed surfaces can be achieved using various polishing methods.[6,24,56] The appearance of ceramic materials is also affected by other surface factors such as luster (dull or glossy).[6,12] As the present study was limited to only 1 brand of zirconia, further studies are needed to evaluate other surface-related factors and recently introduced zirconia materials. Another limitation of this study was the restricted time of the aging process to simulate the clinical life of the prosthesis. The aging process was carried out only in water vapor and at standard temperatures. Further research should be conducted over longer periods of time in the presence of saliva, colored drinks, cigarettes, and various enzymes to better reflect clinical conditions.

CONCLUSIONS

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

1. Lithium disilicate ceramic was found to be more successful than monolithic zirconia ceramic in terms of color stability and translucency.
2. The effects of surface treatments and aging on translucency were not found to be significant.
3. Color change after aging was higher in the zirconia specimens treated with polishing paste than other surface treatments. However, in the lithium disilicate material, no significant difference in color change was found among the groups with different surface treatments.

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