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RESEARCH AND EDUCATION

Effects of number of firings and veneer thickness on the color and translucency of 2 different zirconia-based ceramic systems

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ABSTRACT

Statement of problem. Color matching between a zirconia-based ceramic restoration and a natural tooth is a common clinical challenge.

Purpose. The purpose of this in vitro study was to investigate the effects of the number of firings, veneer thickness, and zirconia core translucency on the final color and translucency of zirconia-based ceramic restorations.

Material and methods. Sixty disk-shaped zirconia specimens (10×1 mm) were prepared in high and low translucencies (n=30 per translucency group). Each zirconia group was subdivided into 3 subgroups (n=10) veneered with ceramic layers of 0.5-, 1-, and 1.5-mm thicknesses. The specimens were then subjected to 1, 3, 5, and 7 firing times. Color and translucency parameters were measured by using a spectrophotometer. Data were analyzed by using multifactorial repeated measures ANOVA and subgroup analysis (α=.05).

Results. The number of firings affected the L*, a*, and b* values and translucency parameter in both zirconia-based systems with different veneer thicknesses (*P*<.05). Increasing the veneer thickness decreased the translucency parameter and increased the L*, a*, and b* values in both zirconia-based systems (*P*<.05). The color difference values (ΔE) were the highest between 1 and 3, 1 and 5, and 1 and 7 firings, and the lowest between 5 and 7 firings in both zirconia systems.

Conclusions. Repeated firings and porcelain veneer thickness affected the final color and translucency of both zirconia systems and, consequently, adversely influenced the esthetic outcomes. Thus, these factors should be considered in the tooth preparation and laboratory phase. (J Prosthet Dent 2019;122:565.e1-e7)

Using a ceramic instead of a metal core allows more light transmission within a crown and therefore creates restorations with improved color and translucency.[1] Layering a strong ceramic core, such as yttria-stabilized tetragonal zirconia polycrystal (Y-TZP) with a highly esthetic veneering porcelain, can provide a restoration with excellent esthetics.[2] The excellent mechanical properties of Y-TZP is derived from the transformation toughening mechanism.[3]

Matching the color of ceramic restorations to natural teeth is influenced by the surface texture, translucency, fluorescence, opalescence, porcelain brand and batch, number of porcelain firings, porcelain thickness, and condensation technique.[4,5] A ceramic restoration will look more translucent if most of the light is diffusely transmitted and only part of it is scattered.[6-8] Kelly et al[9] reported the core translucency as a pivotal factor in the esthetic outcome and a crucial consideration in material selection.

Increasing the crystalline content of the core material improves strength but generally raises the opacity.[3,10] The translucency parameter is measured from the color difference of specimens on black and white backgrounds.[5,7] Some studies have reported that firing causes clinically significant color changes as the pigment breakdown occurs at porcelain firing temperatures.[11,12] However, other investigations have reported that porcelain color remains stable despite repeated firings.[2-4]

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Clinical Implications

The esthetics of zirconia-based ceramic restorations can be improved by choosing an appropriate thickness for the porcelain veneer, a proper number of firings, and a zirconia core of appropriate translucency.

The core and veneer thicknesses influence the appearance of layered ceramics.[13-16] Even if the veneering ceramic is sufficiently thick, shade matching is complex because of the wide spectrum of available translucencies of the core materials of ceramic systems at clinically relevant core thickness.[4] Antonson and Anusavice[17] reported that the thickness of layered core-veneering ceramic affects their translucency. Lee et al[18] observed that the color of different ceramic restorations depended on the type of ceramic core material.

Instrumental color analysis, such as with a spectrophotometer, has been reported to be better than visual color determination because this method offers rapid, quantifiable, objective results.[19] The Commission Internationale de l'Eclairage (CIE)[3,20] recommended calculating the color difference (ΔE) based on CIE L*a*b* color parameters.[20] The intensity of the color difference depends on the perception of color by the human eye. According to previous studies, if the color difference of a material is ΔE=0 after the test requirements have been met, the color is defined as stable. A color difference of $0.5 \leq \Delta E \leq 1$ is not clinically perceived; color difference of $1 \leq \Delta E \leq 2$ is perceptible by 50% of observers. ΔE=1 is defined as the perceptibility threshold of color difference. Since $\Delta E \geq 3.7$ is perceived by 100% of observers, ΔE=3.7 has been defined as the clinically acceptable threshold.[21,22]

The present in vitro study was designed to investigate the effect of the number of firings, veneer thickness, and zirconia core translucency on the final color and translucency of zirconia-based ceramic restorations. The null hypothesis was that the number of firings, veneer thickness, and zirconia core translucency would not affect the final color and translucency of zirconia-based ceramic restorations.

MATERIAL AND METHODS

Sixty disk-shaped zirconia cores (ZircoStar; Kerox Dental Ltd) in A2 shade (10×1 mm) were fabricated by using computer-aided design and computer-aided manufacturing (CAD-CAM) technology (CORiTEC 340i; imes-icore GmbH). The zirconia specimens were divided into 2 equal groups of high-translucent (High Translucent ZircoStar; Kerox Dental Ltd) and low-translucent zirconia (High Strength ZircoStar; Kerox Dental Ltd). The thickness of each group of specimens was measured by using digital calipers with 0.02-mm accuracy (Dial caliper D; Aura Dental GmbH). All the specimens were set to 1 mm thickness and 10 mm in diameter. Zirconia core groups were subdivided into 3 subgroups (n=10) to be veneered with dentin ceramics of 0.5-, 1-, and 1.5-mm thicknesses. Based on the VITA Classic shade guide, the cores were veneered with A2 dentin ceramic (IPS e.max; Ivoclar Vivadent AG).

Dentin ceramics of standard thickness were prepared with 3 custom-made metal molds of 10-mm diameter and heights of 0.5, 1, and 1.5 mm, as previously described.[4,17] To veneer the copings with the layering technique, liner (IPS e.max Zirliner; Ivoclar Vivadent AG) was applied on the zirconia copings and fired at 960 °C in a compatible ceramic furnace (Programat P700; Ivoclar Vivadent AG). Then, a nanofluoroapatite glass-ceramic dentin layer was applied and processed at 750 °C. All the fabrication procedures were performed by a single technician. The thickness of dentin ceramic in each subgroup of specimens was measured by using digital calipers and corrected to 0.5, 1, or 1.5 mm with a diamond rotary cutting tool (ISO 173/016; Mani Inc). The ceramic surfaces were then steam-cleaned (Triton SLA steam cleaner; Bego GmbH & Co KG) under 0.3 MPa pressure to remove debris.

The CIELab values were measured by using a spectrophotometer (VITA Easyshade; VITA Zahnfabrik), which was calibrated before each measurement according to the manufacturer's instructions. The spectrophotometer's CIELab output was based on D65 illuminant and a 2-degree standard observer. The Vita Easyshade spectrophotometer has been reported to provide excellent repeatability under standardized conditions, although its validity is below that of some other devices.[23-25] The 3-mm measuring tip of the spectrophotometer was positioned at the center of the 10-mm specimens by using a polytetratfluoroethylene (PTFE) mold. Three measurements were made for each specimen, and the mean value was calculated. The color and translucency measurements were performed at the same time of day by 1 researcher (R.G.). The color measurements were done against a neutral gray background, and the translucency measurements were made against black (b) and white (w) backgrounds. The translucency parameter was calculated based on L_b, a_b, b_b and L_w, a_w, b_w values with the following formula:

$$\text{Translucency parameter} = ([L_b - L_w]^2 + [a_b - a_w]^2 + [b_b - b_w]^2)^{1/2}.$$

The color and translucency measurements were repeated after 1, 3, 5, and 7 firing cycles. Then, the total color difference was calculated from the following formula:

$\Delta E = ([\Delta L^*]^2 + [\Delta a^*]^2 + [\Delta b^*]^2)^{1/2}$, where L* is a measure of lightness-darkness of the specimen, a* is a measure of

Table 1. Results of three-factor repeated-measures ANOVA for changes in color coordinates after repeated firings of ceramic

Parameter	Effect	Pillai Value	F	Numerator df	Denominator df	*P*
L*	Number of firings	0.788	213.593[b]	3	172	<.001
	Number of firings×zirconia core translucency	0.067	4.136[b]	3	172	.007
	Number of firings×veneer thickness	0.699	30.986	6	346	<.001
	Number of firings×zirconia core translucency×veneer thickness	0.099	2.998	6	346	.007
a*	Number of firings	0.300	24.622[b]	3	172	<.001
	Number of firings×zirconia core translucency	0.121	7.909[b]	3	172	<.001
	Number of firings×veneer thickness	0.309	10.519	6	346	<.001
	Number of firings×zirconia core translucency×veneer thickness	0.287	9.646	6	346	<.001
b*	Number of firings	0.213	15.475[b]	3	172	<.001
	Number of firings×zirconia core translucency	0.101	6.445[b]	3	172	<.001
	Number of firings×veneer thickness	0.138	4.290	6	346	<.001
	Number of firings×zirconia core translucency×veneer thickness	0.112	3.428	6	346	.003
TP	Number of firings	0.574	23.366[a]	3	52	<.001
	Number of firings×zirconia core translucency	0.480	16.023[a]	3	52	<.001
	Number of firings×veneer thickness	0.152	1.452	6	106	.202
	Number of firings×zirconia core translucency×veneer thickness	0.417	4.658	6	106	<.001
ΔE	Number of firings	0.843	53.697[b]	5	50	<.001
	Number of firings×zirconia core translucency	0.256	3.443[b]	5	50	.009
	Number of firings×veneer thickness	0.887	8.133	10	102	<.001
	Number of firings×zirconia core translucency×veneer thickness	0.548	3.848	10	102	<.001

P<.05 indicates significant difference.

chroma along the red-green axis, and b* is a measure of chroma along the yellow-blue axis. ΔL*, Δa*, and Δb* are differences in the CIE color-space parameters of the 2 colors.

The data were analyzed by using a statistical software program (IBM SPSS Statistics for Windows, v24.0; IBM Corp). Repeated-measures ANOVA was performed considering the number of firings as the repeated measures and the veneer thickness and zirconia core translucency as intergroup factors. Given the significant interaction effects among all factors, a 1-sample repeated measures ANOVA and the Sidak pairwise comparison test were used to separately compare the mean values of the L*, a*, and b* color parameters, the translucency parameter, and the ΔE of the different number of firings in each veneer thickness and zirconia core translucency. Additionally, in each number of firing cycles and zirconia core translucency, the mean values of different veneer thicknesses were compared by using 1-way ANOVA and the Tukey HSD post hoc test. The independent *t* test was used to compare the mean values between the 2 translucency types of zirconia core in each veneer thickness and the number of firings separately (α=.05).

RESULTS

Table 1 displays the results of multivariate ANOVA of the L*, a*, and b* color parameters, translucency parameter, and ΔE for the 3 veneer thicknesses of the 2 zirconia core systems after repeated firings. Tables 2 and 3 show the mean values and results of multiple comparison test for L*, a*, b*, the translucency parameter, and the ΔE. All color parameters (L*, a*, b*), the translucency parameter, and the ΔE were significantly affected by the number of firings (*P*<.001), the interaction of the number of firings, and the zirconia core translucency (*P*=.007 for L*, *P*<.001 for a*, b* and translucency parameter, *P*=.009 for ΔE) and the interaction of the number of firings, the zirconia core translucency, and the veneer thickness (*P*=.007 for L*, *P*=.003 for b*, and *P*<.001 for a*, translucency parameter, and ΔE). Moreover, the interaction of the number of firings and veneer thickness was significantly different for L*, a*, b* and ΔE (*P*<.001) but not significantly different for the translucency parameter (*P*=.202) (Table 1).

Increasing the number of firing cycles to 5 and 7 significantly increased the L* value in all the 3 veneer thicknesses for both zirconia systems. This value was also significantly increased in both high- and low-translucent zirconia cores after increasing the veneer thickness to 1.5 mm (*P*<.05) (Fig. 1). Additionally, increasing the number of firing cycles from 1 to 3 led to a significant decrease in the a* value of low-translucent zirconia core in all veneer thicknesses. In the high-translucent zirconia core, the 1-mm veneer thickness subjected to 5 and 7 firing cycles, and in the low-translucent zirconia core, the 1.5-mm veneer thickness for all numbers of firings showed significantly higher a* values than those of the other thicknesses (*P*<.05), so they appeared more reddish (Fig. 2). Additionally, the b* parameter significantly increased after increasing the number of firing cycles in the high-translucent zirconia core with veneer

Table 2. Mean values and multiple comparison of L*, a*, b* and translucency parameter for different number of firings, zirconia core translucency, and veneer thicknesses

Property	Zirconia Core Translucency	Veneer Thickness (mm)	Number of Firings 1	3	5	7
L*	High	0.5	70.35^{Bb}	70.69^{Bc}	74.73^{Ac}	74.95^{Ac}
		1	72.50^{Bb}	75.69^{Ab}	76.45^{Abc}	76.81^{Abc}
		1.5	76.98^{Ba}	82.65^{Aa}	83.45^{Aa}	83.60^{Aa}
	Low	0.5	71.77^{Bb}	71.75^{Bc}	74.05^{Ac}	74.96^{Ac}
		1	76.27^{Ba}	77.93^{ABb}	78.55^{Ab}	78.94^{Ab}
		1.5	71.58^{Bb}	79.18^{Aab}	79.37^{Ab}	79.73^{Ab}
a*	High	0.5	0.88^{Acd}	1.13^{Aab}	1.06^{Aab}	0.93^{Abc}
		1	1.19^{Abc}	1.11^{Aab}	1.25^{Aa}	1.28^{Aab}
		1.5	1.53^{Aab}	0.78^{Bab}	1.07^{Bab}	1.02^{Babc}
	Low	0.5	0.55^{Ad}	-0.05^{Bc}	0.68^{Ab}	0.78^{Abc}
		1	0.99^{Acd}	0.67^{Bb}	0.73^{ABb}	0.72^{ABc}
		1.5	1.90^{Aa}	1.20^{Ba}	1.43^{Ba}	1.46^{Ba}
b*	High	0.5	26.67^{ABb}	24.72^{Bc}	28.65^{Ab}	28.72^{Aab}
		1	29.92^{Aab}	30.45^{Aab}	31.32^{Aab}	31.59^{Aab}
		1.5	30.36^{Ba}	33.35^{Aa}	31.41^{ABab}	31.26^{ABab}
	Low	0.5	21.72^{ABc}	20.04^{Bd}	22.27^{ABc}	23.49^{Ac}
		1	29.50^{Aab}	27.54^{Abc}	28.64^{Ab}	28.67^{Ab}
		1.5	31.51^{Aa}	30.18^{Aab}	32.20^{Aa}	32.21^{Aa}
TP	High	0.5	3.54^{Aa}	2.27^{Bab}	2.86^{ABa}	2.95^{ABa}
		1	2.33^{Abc}	1.58^{Abc}	1.50^{Ab}	1.90^{Ab}
		1.5	2.06^{Abc}	1.43^{Abc}	1.87^{Ab}	1.71^{Ab}
	Low	0.5	2.46^{Bb}	2.68^{Ba}	2.22^{Bab}	3.60^{Aa}
		1	1.51^{Ac}	1.44^{Abc}	2.14^{Aab}	2.04^{Ab}
		1.5	1.49^{Ac}	1.21^{Ac}	1.36^{Ab}	1.49^{Ab}

Mean values with same letter not significantly different from each other. Uppercase letters indicate significant differences among number of firings ($P<.05$); lowercase letters indicate differences between zirconia core translucency and veneer thicknesses ($P<.05$).

Table 3. Mean values and multiple comparison of ΔE between different number of firings in different zirconia core translucencies and veneer thicknesses

Property	Core Translucency	Veneer Thickness (mm)	Number of Firings 1-3	1-5	1-7	3-5	3-7	5-7
ΔE	High	0.5	3.43^{BCcd}	5.65^{Aa}	5.35^{ABbc}	5.51^{ABa}	5.17^{ABa}	2.00^{Ca}
		1	5.20^{Abc}	6.03^{Aa}	6.15^{Aab}	1.47^{Bb}	1.92^{Bb}	1.15^{Ba}
		1.5	6.26^{Aab}	7.18^{Aa}	6.14^{Aab}	1.89^{Bb}	1.79^{Bb}	1.18^{Ba}
	Low	0.5	2.60^{Ad}	2.54^{Ab}	3.28^{Acd}	3.22^{Ab}	3.55^{Aab}	2.02^{Aa}
		1	3.61^{Acd}	3.00^{ABb}	2.83^{ABd}	1.80^{ABb}	1.42^{Bb}	1.07^{Ba}
		1.5	7.64^{Aa}	7.54^{Aa}	7.76^{Aa}	2.20^{Bb}	2.34^{Bb}	0.67^{Ba}

Mean values with same letter not significantly different from each other. Uppercase letters indicate significant differences among number of firings ($P<.05$); lowercase letters indicate differences between zirconia core translucency and veneer thicknesses ($P<.05$).

thicknesses of 0.5 and 1.5 mm and in the low-translucent zirconia core with a veneer thickness of 0.5 mm ($P<.05$). This parameter also significantly increased after increasing the veneer thickness for both zirconia cores, so the thicker specimens appeared more yellow (Fig. 3).

Regarding the translucency parameter, for the high-translucent zirconia core with a 0.5-mm thick veneer, the translucency value decreased significantly after increasing the number of firing cycles from 1 to 3 ($P=.001$) and significantly increased as the number of firings was increased from 3 to 5 ($P=.012$). Likewise, in the low-translucent zirconia core with a 0.5-mm veneer thickness, increasing the number of firings from 5 to 7 significantly increased the translucency ($P=.001$). However, when the veneer thickness was 1 and 1.5 mm in both zirconia systems, the translucency values were not significantly different among the different numbers of firing cycles. The highest translucency was observed in the 0.5-mm veneer thickness ($P<.05$) in both zirconia systems and any number of firing cycles (Fig. 4).

Significantly higher ΔE values were observed between 1 and 3, 1 and 5, and 1 and 7 firing cycles than between 3 and 5, 3 and 7, and 5 and 7 cycles. The ΔE values between 5 and 7 firings were significantly lower

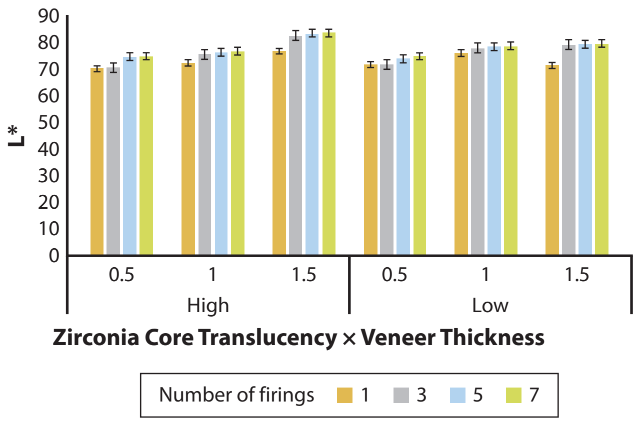

Figure 1. Means (±SE) of L* parameter in different zirconia core translucencies, number of firings, and veneer thicknesses. SE, standard error.

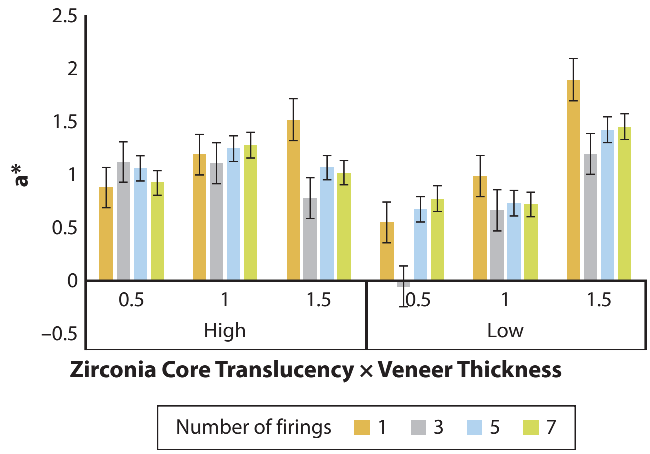

Figure 2. Means (±SE) of a* parameter in different zirconia core translucencies, number of firings, and veneer thicknesses. SE, standard error.

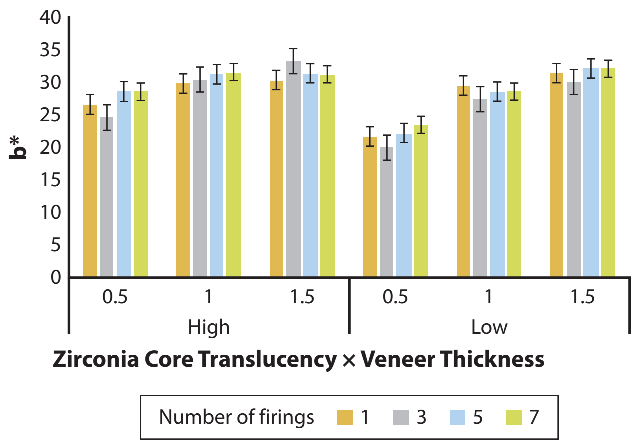

Figure 3. Means (±SE) of b* parameter in different zirconia core translucencies, number of firings, and veneer thicknesses. SE, standard error.

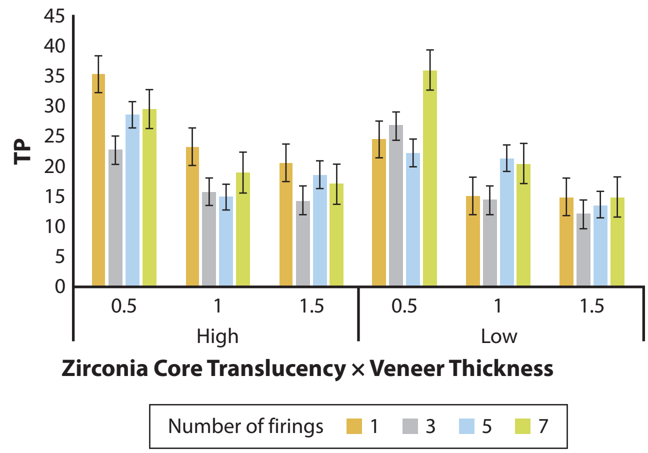

Figure 4. Means (±SE) of translucency parameter in different zirconia core translucencies, number of firings, and veneer thicknesses. SE, standard error; TP, translucency parameter.

than those of the other number of firings for both zirconia cores and all veneer thicknesses. The ΔE values between 3 and 5, 3 and 7, and 5 and 7 firings for both zirconia cores and in all veneer thicknesses were below the clinically acceptable threshold (ΔE=3.7), except for the veneer thickness of 0.5 mm in the high-translucent zirconia core between 3 and 5 and 3 and 7 firings, which showed ΔE above the clinically acceptable threshold (Fig. 5).

DISCUSSION

The null hypothesis was rejected because different veneering porcelain thicknesses and number of firing cycles affected the final color and translucency of zirconia-based ceramic restorations. The accuracy of translucency measurements can be affected by the edge loss phenomenon,[8] which is, in turn, affected by the specimen size; small specimens are more vulnerable to edge loss.[6] It was prevented in the present study by using a 3-mm spectrophotometer for a 10-mm specimen.

The current results showed that increasing the number of firings significantly increased the L* and b* parameters, which made the specimens lighter and yellower in both zirconia core systems. The a* parameter remained constant in the high-translucent zirconia core and decreased significantly between 1 and 3 firing cycles in the low-translucent zirconia core with any of the studied veneering thicknesses.

Bachhav and Aras[4] detected that in 0.5-mm-thick specimens, higher numbers of firing significantly increased the L* and b* but decreased the a* value. Likewise, Ozturk et al[3] noted that in DC-Zirkon core specimens, a higher number of firings increased the L* and b* values and decreased the a* value. Moreover, Celik et al[19] found that repeated firings

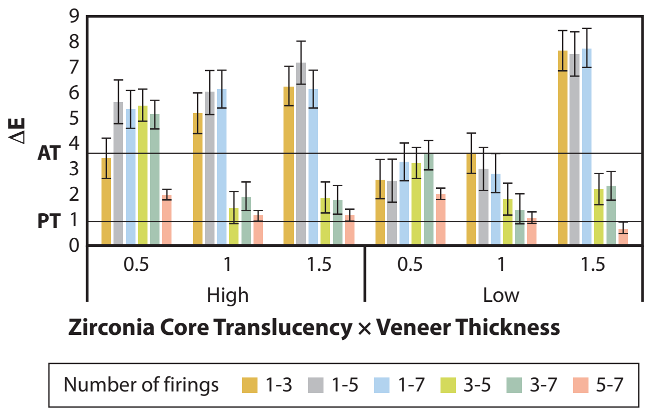

Figure 5. Mean (±SE) of ΔE in different zirconia core translucencies, number of firings, and veneer thicknesses. AT, clinical acceptability threshold; PT, clinical perceptibility threshold; SE, standard error.

yielded lighter, greener, and yellower specimens. The findings of the present study are consistent with those of these studies.

Uludag et al,[12] however, observed that a higher number of firings reduced the L* value and increased the a* and b* color values of In-Ceram and IPS Empress. Sahin et al[2] obtained fewer reddish and yellowish specimens after repeated firings. These studies are inconsistent with the present one probably because of the optical properties of the core materials tested, as the color change caused by repeated firings might be due to the color instability of metal oxides.[3]

The present study also found that in both zirconia core systems, increasing the veneer thickness significantly increased the L*, a*, and b* values. Increasing the material thickness alters its behavior in light; that is, more light is absorbed and dispersed and less is reflected and passed through the material.[14,16] The results of the present study are consistent with those of Montero et al[13] that thicker ceramic disks had higher L*, a*, and b* values than thinner specimens.

In the studies performed by Son et al,[15] Ozturk et al,[3] Bachhav and Aras,[4] and Bayinder and Ozbayram,[11] the a* and b* values increased as the porcelain thickness increased, so the specimens became more red and yellow. The present findings were consistent with those of these studies.

In the present study, the translucency parameter was higher in the 0.5-mm veneer thickness than in the 1- and 1.5-mm thicknesses. This was consistent with the findings of Kursoglu et al,[7] who observed lower translucency in the higher veneer thickness and total thickness of ceramic specimens. Likewise, Jeong et al[26] noted an increase in transmittance value when decreasing the veneer thickness. Applying thicker veneer layer accumulates more of the crystal content of the veneering ceramics. The subsequent reflection occurring within the range of the framework and veneering, interlayer porosity, and the firing processes may explain the decrease in the translucency parameter by increasing the veneer thickness.[27]

The present study also showed that in the 0.5-mm-thick veneer, translucency decreased when the number of firings increased from 1 to 3, but the translucency then increased when the firing cycles reached 5 and 7. However, translucency did not change for 1-and 1.5-mm veneer thicknesses. Apparently, increasing the veneer thickness to 1 and 1.5 mm diminished the effect of multiple firings on the translucency.

Li et al[28] reported that the translucency parameter was directly related to the number of firing cycles. Likewise, Bayinder and Ozbayram[11] reported that the translucency values increased under a higher number of firings. The increase in translucency parameter can be attributed to the changes of the pore volume caused by repetitive firings.[28]

In the present study, the ΔE between 1 and 3, 1 and 5, and 1 and 7 firings was significantly higher than that between 3 and 5, 3 and 7, and 5 and 7 firings. The ΔE between 5 and 7 firings was the least in both zirconia core systems. These findings were in agreement with those of Bayinder and Ozbayram,[11] who detected the highest ΔE between 1 and 5 firings. Uludag et al[12] reported that the color change diminished with repetitive firings, especially after the fifth firing, because of the color stability of metal oxide after multiple firings. Consistent with the present findings, Celik et al[19] observed the minimum ΔE in A3 veneering porcelain shade fired 7 to 9 times.

Technicians typically use a minimum of 3 firing cycles when fabricating esthetic restorations. The results of the present study revealed that for both zirconia core systems in veneer thicknesses of 1 and 1.5 mm and the color change (ΔE) between 3 and 5, 3 and 7, and 5 and 7 firing cycles were below the clinically acceptable threshold. Therefore, clinically, there is little concern about the color change with thicker veneers after repeated firings. However, with thin veneers (0.5 mm), the color changes between 3 and 5 and 3 and 7 firing cycles were above the clinically acceptable threshold for the high-translucent zirconia core.

Limitations of this study include the in vitro use of a spectrophotometer to evaluate the shade differences and using disk-shaped specimens rather than tooth-shaped ones. Another limitation was the use of the VITA Easyshade spectrophotometer, whose validity was not comparable with that of some similar devices.[25] The use other types of spectrophotometer and zirconia systems is recommended in future studies to evaluate the color and translucency changes of zirconia-based ceramic restorations with different core thicknesses after repeated firings.

CONCLUSIONS

Based on the findings of this in vitro study, the following conclusions were drawn:

1. L* and b* parameters increased with an increased number of firings for both high- and low-translucent zirconia cores, consequently yielding lighter and yellower specimens. Moreover, increasing the number of firings from 1 to 3 decreased the a* parameter values in the low-translucent zirconia core, resulting in less reddish specimens.
2. The CIELab values increased with increased veneer thickness in both zirconia core systems, the specimens becoming lighter, more yellow, and more red.
3. Translucency of 0.5-mm-thick specimens decreased when the number of firings increased from 1 to 3, but this parameter increased when the firing cycles raised to 5 and 7. However, the translucency of 1- and 1.5-mm-thick specimens remained stable with an increase in the number of firing cycles. Increasing the veneer thickness for both zirconia systems decreased the translucency of specimens.
4. The mean color difference (ΔE) values were the highest between 1 and 3, 1 and 5, and 1 and 7 firing cycles and the least between 5 and 7 firings in both zirconia core systems. The color changes of both zirconia systems with veneer thicknesses of 1 and 1.5 mm between 3 and 5, 3 and 7, and 5 and 7 firing cycles (routine clinical situations) were below the clinically acceptable threshold. However, the color change of the high-translucent zirconia core with a 0.5-mm veneer thickness between 3 and 5 and 3 and 7 firing cycles was above the clinically acceptable threshold.

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