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착색와 두께가 투명 지르코니아의 색상과 반투명도에 미치는 영향

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Effect of coloring and thickness on the color and translucency parameter of translucent zirconia

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심미성에 대한 요구에 부응하여 투명도가 향상된 투명 지르코니아가 개발되었다. 최근에 개발된 투명 지르코니아는 자연치의 색상을 재현하기 위해 착색을 적용하지만 이에 대한 정보는 부족하다. 본 연구의 목적은 착색과 두께가 투명 지르코니아의 색상과 반투명도에 미치는 영향을 평가하는 것이다. 투명 지르코니아를 1 mm와 1.5 mm 두께로 절삭하여 A2, B2, C2, D2로 착색하여 각 군당 7개씩 총 56개 시편을 제작하였으며, 착색하지 않은 시편을 1 mm와 1.5 mm 두께로 14개를 제작하였다. 제조사에서 지시한 소성 스케줄에 따라 소결한 투명 지르코니아 시편은 색차계를 사용하여 CIE Lab 값을 측정하고 색차와 반투명도를 산출하였다. 통계 분석을 위해 일원배치 분산분석(one-way ANOVA)과 독립표본 t-test를 시행하였고 사후검정으로 Tukey's test를 시행하였다. 투명 지르코니아 시편에 착색 시, CIE L*과 a* 값은 모든 색상군에서 유의하게 감소하였고 CIE b* 값은 유의하게 증가하였다($p<0.001$). 동일한 색상으로 착색된 투명 지르코니아의 두께가 증가할 시 색차는 임상적으로 인식할 수 있는 색차($\Delta E=3.7$)보다 낮은 값을 보였다. 착색과 두께의 증가는 모든 시편군의 투명도를 통계적으로 유의하게 감소시켰다($p<0.001$). 투명 지르코니아를 착색하면 밝기가 감소하고 녹색과 노란색 경향을 부여한다. 착색된 투명 지르코니아의 두께의 증가로 인한 색차는 인식할 수 있는 범위($\Delta E=3.7$)보다 작다. 착색과 두께는 투명 지르코니아의 투명도에 영향을 미친다.

색인단어 : 투명 지르코니아, 착색, 색상

Introduction

With the improvement of living standards, interest in dental prosthesis has expanded not only in terms of functionality but also in terms of esthetics. The emergence of dental zirconia, which is attracting attention owing to its excellent mechanical properties, has evolved to meet the expectations of patients.

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First-generation white zirconia was used as a coping and framework, which is a substructure of zirconia-based restoration owing to its excellent mechanical properties (though with opaque and white characteristics), and was applied with veneer ceramics (1). Second-generation zirconia has evolved into monolithic zirconia, which can be used to produce restorations with staining and glazing without the application of veneer ceramics (2, 3). However, a second-generation monolithic zirconia restoration has low translucency and poor color reproducibility, such as for natural teeth. Therefore, it is limited to posterior crowns and fixed dental prostheses (4-8). Third-generation zirconia has been developed to complement the disadvantages of second-generation zirconia and to improve translucency. It has been used for the restoration of anterior crowns as well as posterior crowns (9).

The recently developed translucent monolithic zirconia has been introduced to the market owing to improve translucency and esthetic aspects (9-11). Translucent zirconia is either manufactured by decreasing the grain size to less than 100 nm, eliminating light scattering alumina sintering aids, or by incorporating zirconia crystals in the cubic phase (12, 13). As the content of Y_2O_3, which has excellent light translucency, increases, zirconia is increased in tetragonal phase to cubic phase, and the translucency increases (14, 15). Manufacturers fabricate translucent zirconia blocks by varying the mixing ratio of the powder, sintering temperature, and/or molding method (11).

The optical properties of tooth and dental materials include color (hue, value, and chroma), translucency, opalescence, fluorescence, and iridescence (9). The translucency plays an important role in the selection of materials and is one of the main factors affecting esthetics (11, 16). Light has the property of being absorbed by, passing through, and reflected from an object, depending on the structure of the ceramic.

As more light passes through the object, the translucency of the material increases (17). When the color of a restoration is combined with proper translucency, the restoration can closely match the surrounding tooth structure (18). Therefore, it is necessary to reproduce the restoration with natural color and translucency in order to meet the demand of esthetic restorations (18).

Recently, studies have been conducted on the translucency and strength of translucent zirconia (10-14, 19-21). The translucency increases with the decrease in the thickness of translucent zirconia (11, 13, 19). The translucency of translucent zirconia is higher than those of conventional white zirconia and monolithic zirconia (10, 19), but lower than that of lithium disilicate ceramic (14). The translucency increases by glazing; however, low-temperature degradation does not show any effect (20).

The flexural strength of translucent zirconia is lower than those of conventional white zirconia and monolithic zirconia (10, 21) but higher than that of lithium disilicate ceramic (14). The introduction of 0.2 mol% La_2O_3 was found to increase the translucency of translucent zirconia without reducing its strength (13).

In the fabrication of translucent zirconia restorations, coloring is applied to translucent zirconia to reproduce the color of natural teeth. While interest in translucent zirconia is increasing, little research has been done on the effects of coloring and thickness on the color and translucency of translucent zirconia. Hence, the purpose of this study was to compare and analyze the effects of coloring and thickness on the color and translucency of translucent zirconia. The null hypothesis was that the coloring and thickness do not affect the color and translucency of translucent zirconia.

Materials and Methods

In this study, specimens were fabricated from a translucent zirconia block (Prettau Anterior, Zirkonzahn GmbH, Gais, Italy) (Table 1).

The presintered zirconia block was cut into dimensions of 12.5 mm×12.5 mm×1.3 mm and 12.5 mm×12.5 mm ×1.9 mm using a Zirkonzahn M5 milling unit (Zirkonzahn GmbH, Gais, Italy). The specimens were polished with 1000-grit silicon carbide paper to produce a uniform surface profile. Experimental groups of 56 specimens were divided into 8 groups of 7 specimens, as listed in Table 2.

Color Liquid Prettau® Anterior Aquarell (Zirkonzahn GmbH, Gais, Italy), which is a special coloring agent for Prettau Anterior zirconia blocks, was used. The specimens were immersed in A2, B2, C2, and D2 colorants for 3 seconds. Non-shaded zirconia specimens were used as the control group. The specimens were dried in an oven at 130℃ for 30 minutes and then sintered in a sintering furnace (LHT 02/17LB, Nabertherm, Lilienthal, Germany) according to the manufacturer's specifications. First, the temperature of the sintering furnace was increased to 1500℃ for 3 hours at room temperature, maintained at 1500℃ for 2 hours, and cooled gradually for 3 hours. After sintering, the final specimen dimensions were adjusted to 10 mm×10 mm×1 mm and 10 mm ×10 mm×1.5 mm using 1000-grit silicon carbide paper.

The Commission Internationale de l'Eclairage (CIE) Lab

Table 1. Composition of the material used

Material	Composition	Manufacturer
Prettau Anterior	$<$12% Y_2O_3, 1% Al_2O_3, max. 0.02% SiO_2, max. 0.01% Fe_2O_3, max. 0.04% Na_2O	Zirkonzahn GmbH, Gais, Italy

Table 2. Specimens groups according to thickness and color treatment (n=7)

Material	Thickness (mm)	Coloring Liquid	Shade	Group Code
Prettau Anterior	1.0	—	—	Z10
		Colour Liquid Prettau® Anterior Aquarell	A2	A10
			B2	B10
			C2	C10
			D2	D10
	1.5	—	—	Z15
		Colour Liquid Prettau® Anterior Aquarell	A2	A15
			B2	B15
			C2	C15
			D2	D15

Z10 and Z15: Non-shaded zirconia (control); A10: A2 coloring liquid application, 1.0 mm thickness; B10: B2 coloring liquid application, 1.0 mm thickness; C10: C2 coloring liquid application, 1.0 mm thickness; D10: D2 coloring liquid application, 1.0 mm thickness; A15: A2 coloring liquid application, 1.5 mm thickness; B15: B2 coloring liquid application, 1.5 mm thickness; C15: C2 coloring liquid application, 1.5 mm thickness; D15: D2 coloring liquid application, 1.5 mm thickness.

parameters of the final sintered zirconia specimens were measured using a spectrophotometer (CM-3600A, Konica Minolta, Tokyo, Japan). The light source employed was D65 (6503 K), which is standard lighting as per the CIE. The CIE L*, a*, and b* values of the specimens were measured on a white background (L: 96.56, a: −0.10, b: −0.15) and a black background (L: 0.05, a: −0.05, b: 0.00) in the reflection mode using the specular component excluded (SCE) method. The CIE Lab system is a three-dimensional coordinate system, where the L value represents the brightness of the object on the y axis, the a value represents the red (+) or green (−) chromaticity on the x axis, and the b value represents the yellow (+) or blue (−) chromaticity on the z axis (22). The translucency parameter (TP) was calculated using the following equation.

$$TP^* = [(LB^* - LW^*)^2 + (aB^* - aW^*)^2 + (bB^* - bW^*)^2]^{\frac{1}{2}}$$

Here, the subscripts B and W represent the color coordinates on the black background, and white backgrounds, respectively. A TP value of 0 corresponds to a completely opaque material and the higher the TP value, the higher the actual translucency of the material (23).

To determine the color difference (ΔE), the average CIE values against a black background were used. ΔE was calculated using the following CIE Lab color-difference formulae (24).

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{\frac{1}{2}}$$

$$(\Delta L^* = L^*_2 - L^*_1,\ \Delta a^* = a^*_2 - a^*_1,\ \Delta b^* = b^*_2 - b^*_1)$$

Here, ΔL*, Δa*, and Δb* denote the difference on the lightness, red/green axis, and yellow/blue axis, respectively.

The data were analyzed using statistical software (SPSS v.24.0, SPSS Inc., Chicago, IL, USA). 1-way ANOVA and independent sample t-test were performed for color and TP analyses. Tukey's test was performed with post-test to detect any statistically significant differences (α=0.05).

Results

Tables 3 and 4 list the CIE L*, a*, and b* values of the specimen group measured in the reflection mode on the black plate. The CIE L* and a* values of all the colored specimen groups were significantly lower than those of the non-shaded zirconia specimen groups ($p<0.001$). The CIE b* values of the colored groups were significantly higher than those of the non-shaded zirconia specimen groups ($p<0.001$). The CIE L* and a* values of the non-shaded Z10 specimen group were the highest, and the CIE L* and a* values of the C15 specimen group were the lowest among all the groups ($p<0.001$). The CIE b* value of the C10 specimen group was the highest, and the CIE b* value of the non-shaded Z15 specimen group was the lowest among all the groups ($p<0.001$). With the increase in the thickness, the CIE L* values decreased in a statistically significant manner when colored with A2 and B2 ($p<0.001$, $p<0.01$); the CIE L* and b* values decreased in a statistically significant manner when colored with C2 ($p<0.001$, $p<0.01$); and the CIE a* and b* values decreased significantly when colored with D2 ($p<0.01$).

Table 5 lists the color difference (ΔE) results. The ΔE value between the same shade specimen groups with different thicknesses (Z, A, B, C, and D group: 1.3, 1.2, 1.6, 1.4, and 1.0) was lower than the clinically recognizable color difference (ΔE: 3.7) (25). For a thickness of 1 mm, the ΔE value between all the colored specimen groups was lower than the clinically recognizable ΔE value (3.7) except for the ΔE value (4.0) between B10 and C10 groups. For a thickness of 1.5 mm, the ΔE value between all the colored specimen groups was lower than the

Table 3. CIE L*, a*, b* value of the zirconia specimens depending on the application of coloring liquid (SD)

Group	L*	a*	b*
Z10	67.92 (0.40)^{a}	-0.79 (0.09)^{a}	-3.99 (0.38)^{g}
A10	63.48 (0.36)^{c}	-1.42 (0.11)^{c}	7.88 (0.55)^{bc}
B10	64.84 (0.77)^{b}	-1.62 (0.09)^{d}	7.26 (0.71)^{de}
C10	61.26 (0.45)^{e}	-2.12 (0.04)^{e}	8.79 (0.13)^{a}
D10	63.75 (0.33)^{c}	-2.93 (0.04)^{f}	7.27 (0.32)^{de}
Z15	67.22 (0.97)^{a}	-1.00 (0.02)^{b}	-4.54 (0.16)^{h}
A15	62.51 (0.28)^{d}	-1.37 (0.05)^{c}	7.53 (0.19)^{cd}
B15	63.39 (0.48)^{c}	-1.61 (0.08)^{d}	6.86 (0.15)^{ef}
C15	59.99 (0.44)^{f}	-2.12 (0.15)^{e}	8.21 (0.45)^{b}
D15	63.25 (0.62)^{cd}	-3.02 (0.06)^{f}	6.63 (0.21)^{f}
p	〈 0.001	〈 0.001	〈 0.001

Z10 and Z15: Non-shaded zirconia (control); A10: A2 coloring liquid application, 1.0 mm thickness; B10: B2 coloring liquid application, 1.0 mm thickness; C10: C2 coloring liquid application, 1.0 mm thickness; D10: D2 coloring liquid application, 1.0 mm thickness; A15: A2 coloring liquid application, 1.5 mm thickness; B15: B2 coloring liquid application, 1.5 mm thickness; C15: C2 coloring liquid application, 1.5 mm thickness; D15: D2 coloring liquid application, 1.5 mm thickness.

Table 4. Means and standard deviations of CIE L*, a*, b* values of zirconia specimens as analyzed by t-test

	Shae of coloring liquid	Mean (SD) of CIE L*, a*, b* values		p value
		1.0 mm thickness	1.5 mm thickness	
L*	—	67.92 (0.40)	67.22 (0.97)	=0.103
	A2	63.48 (0.36)	62.51 (0.28)	〈0.001
	B2	64.84 (0.77)	63.39 (0.48)	〈0.01
	C2	61.26 (0.45)	59.99 (0.44)	〈0.001
	D2	63.75 (0.33)	63.25 (0.62)	=0.082
a*	—	-0.79 (0.09)	-1.00 (0.02)	〈0.001
	A2	-1.42 (0.11)	-1.37 (0.05)	=0.339
	B2	-1.62 (0.09)	-1.61 (0.08)	=0.803
	C2	-2.12 (0.04)	-2.12 (0.15)	=0.962
	D2	-2.93 (0.04)	-3.02 (0.06)	〈0.01
b*	—	-3.99 (0.38)	-4.54 (0.16)	〈0.01
	A2	7.88 (0.55)	7.53 (0.19)	=0.128
	B2	7.26 (0.71)	6.86 (0.15)	=0.171
	C2	8.79 (0.13)	8.21 (0.45)	〈0.01
	D2	7.27 (0.32)	6.63 (0.21)	〈0.01

Table 5. ΔE value among zirconia specimen groups

Group	Z10	A10	B10	C10	D10	Z15	A15	B15	C15	D15
Z10	—	12.7	11.7	14.5	12.2	1.3	12.7	11.8	14.6	11.8
A10	12.7	—	1.7	2.6	1.8	13.0	1.2	1.2	3.6	2.2
B10	11.7	1.7	—	4.0	1.9	12.1	2.5	1.6	5.1	2.4
C10	14.5	2.6	4.0	—	3.1	14.7	1.9	2.9	1.4	3.0
D10	12.2	1.8	1.9	3.1	—	12.5	2.0	1.6	4.0	1.0
Z15	1.3	13.0	12.1	14.7	12.5	—	13.0	12.1	14.7	12.1
A15	12.7	1.2	2.5	1.9	2.0	13.0	—	1.2	2.8	2.1
B15	11.8	1.2	1.6	2.9	1.6	12.1	1.2	—	3.6	3.7
C15	14.6	3.6	5.1	1.4	4.0	14.7	2.8	3.6	—	3.8
D15	11.8	2.2	2.4	3.0	3.0	12.1	2.1	3.7	3.8	—

Z10 and Z15: Non-shaded zirconia (control); A10: A2 coloring liquid application, 1.0 mm thickness; B10: B2 coloring liquid application, 1.0 mm thickness; C10: C2 coloring liquid application, 1.0 mm thickness; D10: D2 coloring liquid application, 1.0 mm thickness; A15: A2 coloring liquid application, 1.5 mm thickness; B15: B2 coloring liquid application, 1.5 mm thickness; C15: C2 coloring liquid application, 1.5 mm thickness; D15: D2 coloring liquid application, 1.5 mm thickness.

Table 6. Means and standard deviations of translucency parameter of zirconia specimens

Group	Mean (SD)
Z10	11.69 (0.71)[a]
A10	10.17 (0.21)[b]
B10	10.03 (0.16)[b]
C10	7.87 (0.45)[d]
D10	9.23 (0.43)[c]
Z15	9.13 (0.53)[c]
A15	6.90 (0.25)[ef]
B15	7.54 (0.37)[de]
C15	4.52 (0.77)[g]
D15	6.53 (0.35)[f]

Superscript letters for each column and row indicate mean values that are significantly different between groups ($p<0.001$).

clinically recognizable ΔE value (3.7), except for the ΔE value (3.8) between C15 and D15 groups. The color difference between non-shaded and colored translucent zirconia for all thickness values was higher than the clinically recognizable color difference.

Tables 6 and 7 list the TP values of each specimen. The colored groups exhibited significantly lower TP values than the non-shaded groups ($p<0.001$). In the colored

Table 7. Means and standard deviations of translucency parameter of zirconia specimens as analyzed by t-test

Shade of coloring liquid	Mean (SD) of translucency parameter values		p value
	1.0 mm thickness	1.5 mm thickness	
—	11.69 (0.71)	9.13 (0.53)	<0.001
A2	10.17 (0.21)	6.90 (0.25)	<0.001
B2	10.03 (0.16)	7.54 (0.37)	<0.001
C2	7.87 (0.45)	4.52 (0.77)	<0.001
D2	9.23 (0.43)	6.53 (0.35)	<0.001

zirconia specimen group with a thickness of 1 mm, the TP value was the highest in shade A2 group, followed by B2, D2, and C2 groups. In the colored zirconia specimen group with a thickness of 1.5 mm, the TP value was the highest in the shade B2 group, followed by A2, D2, and C2 groups. The TP value decreased in a statistically significant manner in all the colored groups with the increase in the thickness of the specimen ($p<0.001$).

Discussion

The null hypothesis that the colorant and thickness do not affect the color of translucent zirconia was partially employed. After coloring the translucent zirconia, the CIE L* and a* values decreased, and the CIE b* value increased. The color difference between non-shaded and colored translucent zirconia for all thickness values was higher than the clinically recognizable color difference (ΔE: 3.7). The CIE a* and b* values of non-shaded transparent zirconia decreased with the increase in the thickness. With the increase in the thickness, the CIE L* values decreased in the shade A2 and B2 colorant groups; the CIE L* and b* values decreased in the shade D2 colorant groups; and the CIE a* and b* values decreased in the shade C2 colorant groups. These comparative data indicate that the effect of the thickness on the CIE L*, a* and b* values of translucent zirconia varies depending on the shade of the colorant.

However, the color difference ΔE between the zirconia specimens with different thicknesses in the same shade groups was lower than the clinically recognizable color difference. For the specimens with the same thickness, the color difference ΔE between the translucent zirconia groups colored with different colorants was lower than the clinically recognizable value in all the groups except between B10 and C10 (ΔE: 4.0), and C15 and D15 (ΔE: 3.8) groups.

The color of extracted human teeth has CIE L*, a*, and b* values in the ranges of 72.6 – 71.4, 1.5 – 0.9, and 18.4 – 12.8, respectively (26). In the present study, the CIE L*, a*, and b* values of non-shaded translucent zirconia ranged from 67.9 – 67.2, 0.8 – −1.0, and −4.5 – −4.0, respectively. This shows that The CIE L* and a* values are similar to those of natural teeth, with a blue hue compared to natural teeth. The CIE L* and b* values of translucent zirconia (CIE L*, a*, and b*: 67.2, −1.0, −4.5) were lower than the CIE Lab values of conventional white zirconia (94.1, −0.9, and 5.9) (27). It could be seen that translucent zirconia has lower brightness and higher yellow hue compared with white zirconia. Coloring translucent zirconia with shades A2, B2, C2, and D2 (CIE

L*, a*, and b*: 59.99 – 64.84, −3.02 – 1.37, 6.63 – 8.79) reduced the color difference ΔE between translucent zirconia and natural teeth because of the increase in the CIE b* value, i.e., increase in yellow hue. Nam *et al* (20) studied the optical properties of translucent zirconia colored with shade A3, and the ranges of CIE L*, a*, and b* values obtained were 71.34 – 74.42, −1.21 – 1.60, and 8.40 – 10.67, respectively. The CIE a* and b* values obtained in this study are similar to those obtained by Nam *et al* (20).

The null hypothesis that the colorant and thickness do not affect the translucency of translucent zirconia was rejected. Coloring translucent zirconia reduced the translucency in all the color groups. With the increase in the thickness of the colored translucent zirconia, the translucency decreased in all the color groups (TP: 7.87 – 10.17 (for a thickness of 1 mm) and 4.52 – 6.90 (for a thickness of 1.5 mm). The translucency of the shade A2 group was the highest in the 1 mm thickness group, whereas the translucency of the shade B2 group was the highest in the 1.5 mm thickness group. The translucency of translucent zirconia colored with shade C2 was the lowest in all the thickness groups. In the study conducted by Nam *et al* (20), the TP value of 1.2 mm-thick translucent zirconia colored with A3 was 9.36. This is similar to the TP value (10.17) of translucent zirconia colored with shade A2 in this study.

In this study, the TP values of non-shaded translucent zirconia with thicknesses of 1 and 1.5 mm were found to be 11.69 and 9.13, respectively, which decreased with the increase in the thickness. This is consistent with other studies on the translucency and thickness of translucent zirconia (11, 12, 19). Church *et al* evaluated the TP and flexural strength of four translucent monolithic zirconia (BruxZir Shaded 16 and BruxZir HT, Glidewell; Lava Plus, 3M ESPE; inCoris TZI C, Sirona) (11). The translucency of translucent zirconia decreased significantly with the increase in the thickness. The flexural strengths of translucent zirconia were similar and higher than that of IPS e.max CAD HT. The TP value range of transparent zirconia with a thickness range of 0.5 – 2.0 mm was 6.3 – 26.31, and the translucency was lower than that of IPS e.max CAD HT (13.3 – 34.2). Zang reported that the in-line transmission of a dense, high-purity zirconia increases with the decrease in the grain size and thickness (12). For thicknesses of 1.3, 1.5, and 2 mm, the mean grain size of a translucent 3Y-TZP should be 82, 77, and 70 nm, respectively. The introduction of 0.2 mol% La_2O_3 in conventional 0.1 – 0.25 wt.% Al_2O_3-doped 3Y-TZP resulted in an excellent combination of high translucency and superior hydrothermal stability, while retaining the mechanical properties (13). Wang *et al* compared the translucency of dental ceramics with different thicknesses (19). The TP value range of glass ceramic with a thickness range of 0.6 – 2.0 mm was 2.2 – 25.3, and the TP value range of zirconia ceramic with a thickness range of 0.4 – 1.0 mm was 5.5 – 15.1. The translucency of translucent zirconia (Lava Plus high translucency) increased with the decrease in thickness and was higher than those of conventional white zirconia and monolithic zirconia (Cercon Base, Zenotec Zr Bridge, Lava Standard, and Lava Standard FS3).

Nassary Zadeh *et al* compared the translucency and flexural strength of cubic/tetragonal zirconia materials (14). The TP value range of 0.5 mm-thick cubic/tetragonal zirconia was found to be 33.1 – 38.3, which is lower than that of IPS e.max CAD LT (40.4). The flexural strength of cubic/tetragonal zirconia materials is in the range of 490 – 557 MPa and is higher than that of IPS e.max CAD LT (296 MPa). Carrabba *et al* compared zirconia with different yttria contents (10). Aadva NT zirconia with a yttria content of 5.5 mol% showed higher translucency and lower flexural strength than zirconia with a yttria content of 3 mol%. Muñoz *et al* studied the effects of flexural strength on the mechanical and hydrothermal aging of conventional zirconia, monolithic zirconia, and translucent zirconia (ICE Zirkon, Prettau, Prettau Anterior) (21). Translucent zirconia (Prettau Anterior) showed the largest mean size and the lowest BFS value and was affected when mechanical cycling was involved.

In this study, only one colorant and one type of translucent zirconia were employed. Therefore, it is necessary to evaluate the changes in the color and translucency due to coloring using various translucent zirconia and coloring agents. As various types of zirconia are commercially available, it is necessary to provide information on the optical characteristics, such as the color difference between them and natural teeth, and translucency, and provide a basis for clinical use. Moreover, it is necessary to analyze the variation in the strength of transparent zirconia due to coloration of specimens of various thicknesses.

Conclusion

The results of this study were as follows. Coloring translucent zirconia diminished the brightness and gave a green/yellow hue. The color difference due to the increase in the thickness of the colored translucent zirconia was lower than the clinically recognizable range (ΔE: 3.7). The coloring and thickness affected the translucency parameter of translucent zirconia.

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Original Article

Effect of coloring and thickness on the color and translucency parameter of translucent zirconia

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The purpose of this study was to evaluate the effects of coloring and thickness on the color and translucency parameter (TP) of translucent zirconia. Experimental groups of translucent zirconia with thicknesses of 1 and 1.5 mm were prepared and colored with A2, B2, C2 and D2 colorants. Non-shaded zirconia specimens were used as the control group. The color coordinates (CIE Lab) of the translucent zirconia specimens, sintered according to the manufacturer's sintering specification (n=7), were measured using a spectrophotometer (CM-3600A, Konica Minolta, Tokyo, Japan), and the color difference (ΔE^*) and TP were calculated. One-way ANOVA and independent sample t-test were used for statistical analysis, and Tukey's test was used for post-test. The CIE L* and a* values were significantly decreased, and the CIE b* values were significantly increased after coloring the translucent zirconia specimens ($p<0.001$). With the increase in the thickness of the translucent zirconia colored with the same color, the color difference was found to be lower than the clinically recognizable color difference ($\Delta E=3.7$). As the coloring and thickness were increased, the TP values were reduced in all the specimen groups in a statistically significant manner ($p<0.001$). Coloring the translucent zirconia diminished the brightness and resulted in a green/yellow hue. In conclusion, the coloring and thickness affected the translucency parameter of translucent zirconia.

Key Words : Translucent zirconia, Coloring, Color