

Chromatic Study of All-ceramic Restorations

— Influence of the Color of the Abutment Tooth and Cement on the Color Tone of Copings —

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All-ceramic restorations have been advocated for superior esthetics. The ability to blend an all-ceramic crown with its natural counterpart involves the size, shape, surface texture, translucency, and color. IPS Empress, IPS Empress 2 (IVOCLAR VIVADENT), and Procera AllCeram (Nobel Biocare) remain popular and had continued widespread use.

*The purpose of this study was to examine the influence of the color of the abutments and resin cements (Variolink II VOCLAR VIVADENT) on the final color of copings for three kinds of all-ceramic core materials: Empress, Empress 2, and Procera AllCeram. Variolink II Try-In pastes (5 shades: transparent, A1 · white, A3 · yellow, A4 · brown, opaque white) were applied in a thin layer on to three kinds of all-ceramic copings. Copings were inserted in to each abutment (six kinds of die materials from the Empress system, gold-silver-palladium alloy, gold alloy) and the final color of the central part of the buccal surface was measured using a spectrophotometer. The L*a*b* colour space was used to obtain the color values.*

Empress had the greatest effect on the influence of abutment tooth color and cement color on the color of coping. Regardless of the color shades of the abutments and cements, the lightness values rose in the order of Empress, Procera, and Empress 2. Regardless of the copings and abutments, when opaque white cement was applied to the coping, the lightness value.

Key words: all-ceramic crown, IPS Empress, Procera AllCeram, resin cement, L*a*b* color system

INTRODUCTION

Recently, the use of all-ceramic crowns has spread widely in clinical applications to meet the demand for both functional and esthetically-pleasing restorations^{1~5)}. In making all-ceramic crowns, it is necessary to reproduce as close as possible the shape and the color of the natural teeth; however, the color shades of abutments might influence the color of the copings which are made of highly transparent material.

When an all-ceramic restoration is chosen, the amount of force that the restoration must withstand should be evaluated, not just the esthetic qualities alone.

Empress, Empress 2 (IVOCLAR VIVADENT)^{1,3,5~12)}, and Procera AllCeram (Nobel Biocare)^{4,13~17)} remain popular and in widespread use. Empress crowns are superior to alumina cores in terms of producing the desired aesthetic appearance¹⁸⁾. For moderately translucent teeth, Empress, Procera, and Empress 2 are feasible restorative materials¹⁹⁾.

We previously reported the influence of abutment tooth color on the color tone of the coping²⁰⁾. Regardless of the

color shade of the abutment, the chroma values of the copings rose in the order of Empress, Empress 2, and Procera, and the values of lightness rose in the order of Empress, Procera, and Empress 2. When the final colors of each coping measured under wet and dry conditions were compared, the difference in chroma was significant. In clinical and dental laboratory operations, it is hoped to observe and measure the color of copings and restorations under wet conditions.

The purpose of this study was to examine the influence of the color shade of the abutment and colored resin cement (Variolink II IVOCLAR VIVADENT) on the final color of copings for three kinds of all-ceramic core materials: Empress, Empress 2, and Procera AllCeram.

MATERIALS AND METHODS

Preparation design

A 360-degree rounded deep chamfer preparation for the all-ceramic crown was made using a maxillary right central incisor dentoform tooth as the dental mode (study model OK T14, KAVO, Germany).

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The silicone index was produced before the tooth preparation. The amount of tooth preparation was decided using the silicone core as a guide.

The width of the circular chamfer was approximately 1mm and reducing the incisal areas by approximately 2mm, the reduction in the labial and palatal areas was approximately 1.5mm.

Coping construction

Impressions of the prepared tooth were made with polyvinylsiloxane impression material, filled with dental stone, a working model was manufactured, and the following copings were fabricated on the abutment tooth. Copings of 0.5 mm thickness were fabricated using Empress (Staining technique), Empress 2 (Layering technique), and Procera AllCeram core materials for the abutment tooth (Fig. 1, Table 1).

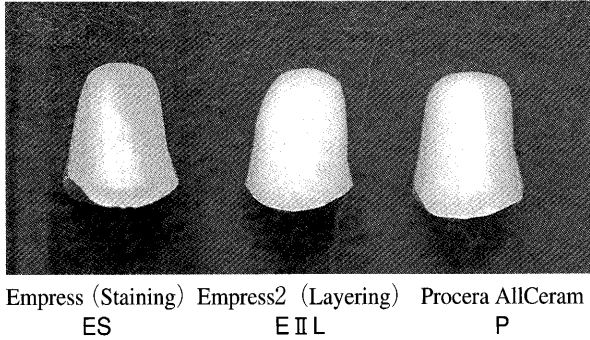


Fig. 1 Types of all-ceramic coping

The coping chromatic used most frequently in the clinical setting was selected. TC1 was chosen from nine Empress colors, for Empress 2, 100 was chosen from six colors, and for Procera AllCeram, white was chosen from two colors.

Abutment construction

Abutments were made using six kinds of die materials in the Empress system (ST1, ST2, ST3, ST5, ST8, ST9), gold-silver-palladium alloy (Super cast, Heraeus Kulzer, Germany), and gold alloy (Maingold DP, Heraeus Kulzer, Germany).

The gold-silver-palladium alloy and the gold alloy were ground with the silicone point (Fig. 2, Table 2).

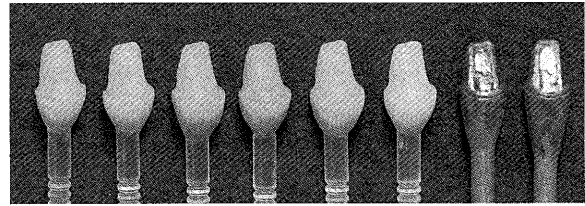


Fig. 2 Types of abutment tooth

Table 2 Materials used in this study and abbreviations (abutment tooth)

Types of abutment tooth (die)	Abbreviated
ST1 of Empress system die material	ST1
ST2 of Empress system die material	ST2
ST3 of Empress system die material	ST3
ST5 of Empress system die material	ST5
ST8 of Empress system die material	ST8
ST9 of Empress system die material	ST9
gold-silver-palladium alloy	Pd
gold alloy	Au

Cement

Variolink II Try-In pastes (IVOCLAR VIVADENT) are water-soluble glycerin pastes. The ideal luting composite shade is determined with the help of the Try-In pastes.

Variolink II Try-In pastes (5 shades: transparent, A1 · white, A3 · yellow, A4 · brown, opaque white) were applied in a thin layer on the three kinds of all-ceramic copings. The coping was then seated onto the preparation with sustained finger pressure and excess paste was wiped away (Table 3).

Table 3 Materials used in this study and abbreviations (resin cement)

Conditions	Abbreviated
With try-in pastes	
Variolink II Transparent	Trans
Variolink II White · A1	A1W
Variolink II Yellow · A3	A3Y
Variolink II Brown · A4	A4B
Variolink II Opaque white	OW

Table 1 Materials used in this study and abbreviations (all-ceramic coping)

Types for all-ceramics coping	Manufacturer	Strengthening component	Particle size and volume	Abbreviated
Empress (Staining technique)	IVOCLAR VIVADENT	Leucite	1-5 μ m, 40% volume	ES
Empress 2 (Layering technique)	IVOCLAR VIVADENT	Lithium disilicate	0.5-4.0 μ m, 60% volume	E II L
Procera AllCeram	Nobel Biocare	Alumina	4.0 μ m, 99.5% volume	P

Colour space

Spectrophotometric measurements were made using a contact-type spectrophotometer CMS-35FS (Murakami color Technical Research Laboratory) with D65 standard CIE illuminant.

The CMS-35FS is a pen-type hand piece. It is easy to hold the instrument steadily for measurements: the measuring time is 3 seconds.

The final color of the central part of the buccal surface was measured and the L*a*b* colour space was used to obtain the color values.

RESULTS

C* values of Empress (Staining technique) tended to be greater when gold alloy abutment and transparent, white (A1), yellow (A2), brown (A4) try-in pastes were used rather than opaque white (Fig. 3). C* values tended to be less when a gold alloy abutment was used.

ΔL^* and ΔC^* values of Empress 2 (Layering technique) tended to be less when Empress (Staining technique) was used rather than Empress 2 (Fig. 4).

ΔL^* values of Procera AllCeram tended to be less when Procera coping was used rather than the others (Fig. 5).

Regardless of the color shades of the abutments and Try-

in pastes, the lightness values rose in the order of Empress, Procera, and Empress 2.

The influence of the color shades of the abutments and cements on the final color of the three kinds of copings was greater when Empress coping was used.

Regardless of the color shades of the abutments, L* values tended to be greater when opaque white cement was used.

When Empress specimens (abutment ST1) were compared, the brightness values rose in the order of Transparent, A1 White, A3 Yellow, A4 Brown, and Opaque White.

Abutment ST1 Empress specimens showed more difference in cement brightness than the others (Fig. 6).

Regardless of the coping, the ST5 abutment in Opaque White was lighter than the others (Transparent, A1 White, A3 Yellow, and A4 Brown) (Fig. 7).

The gold-silver-palladium alloy abutment with coping were Empress, Opaque White cement as lighter, with more difference in brightness and chroma values than the other cements.

Empress 2 specimens with gold-silver-palladium alloy abutment had lower chroma values than the other abutments, whereas Procera specimens with a gold-silver-palladium alloy abutment had higher chroma values than

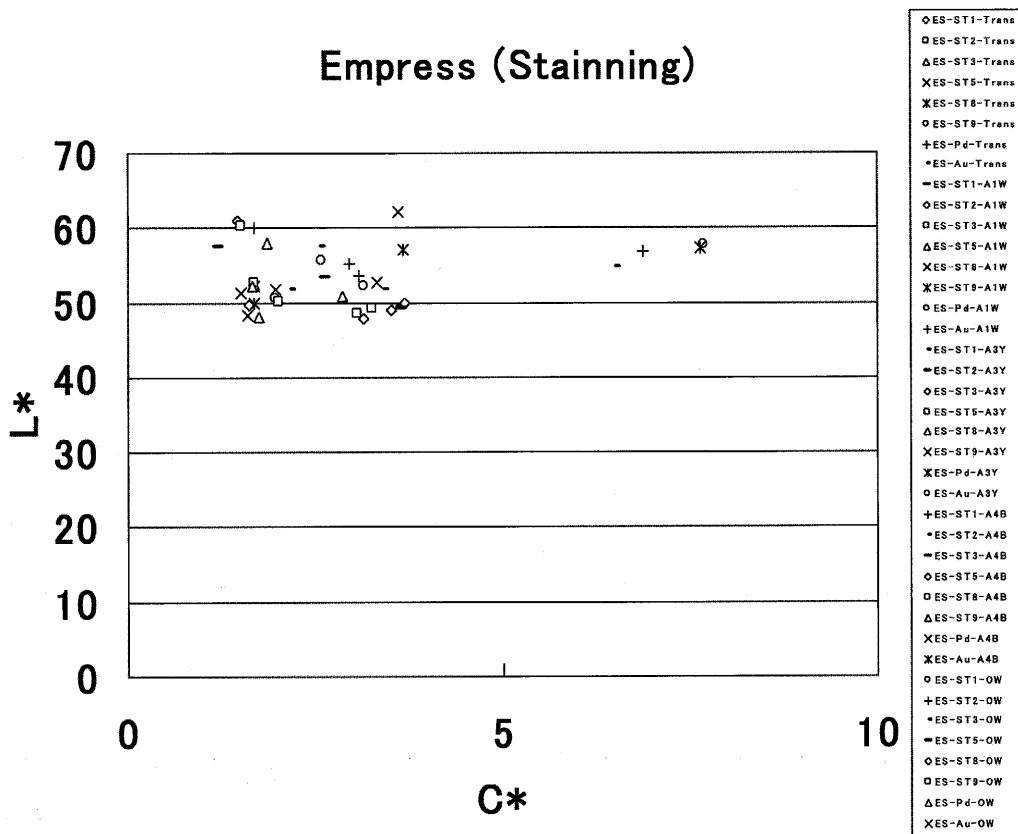
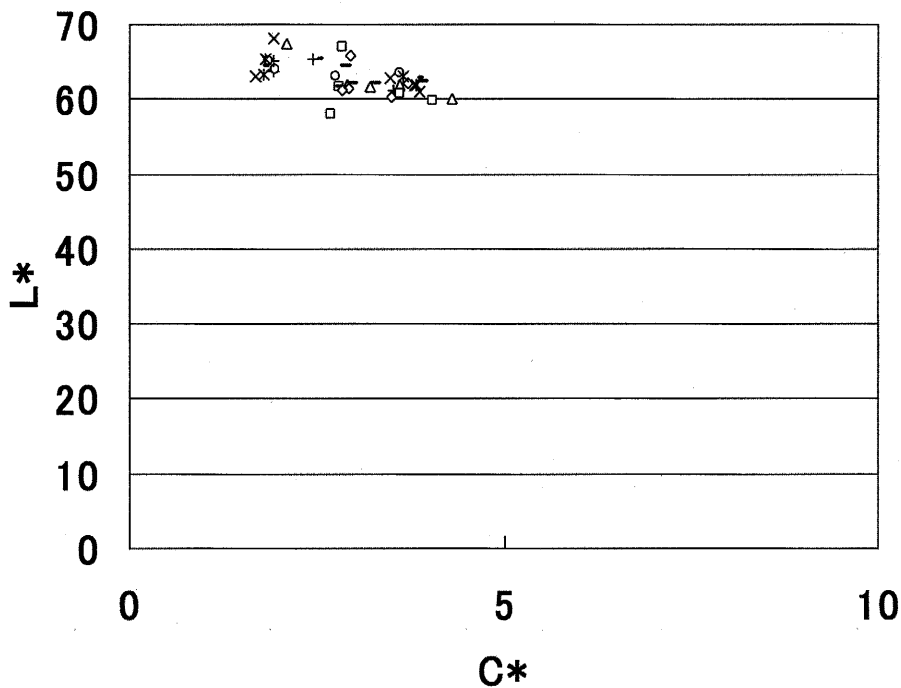


Fig. 3 C*L* (Empress)

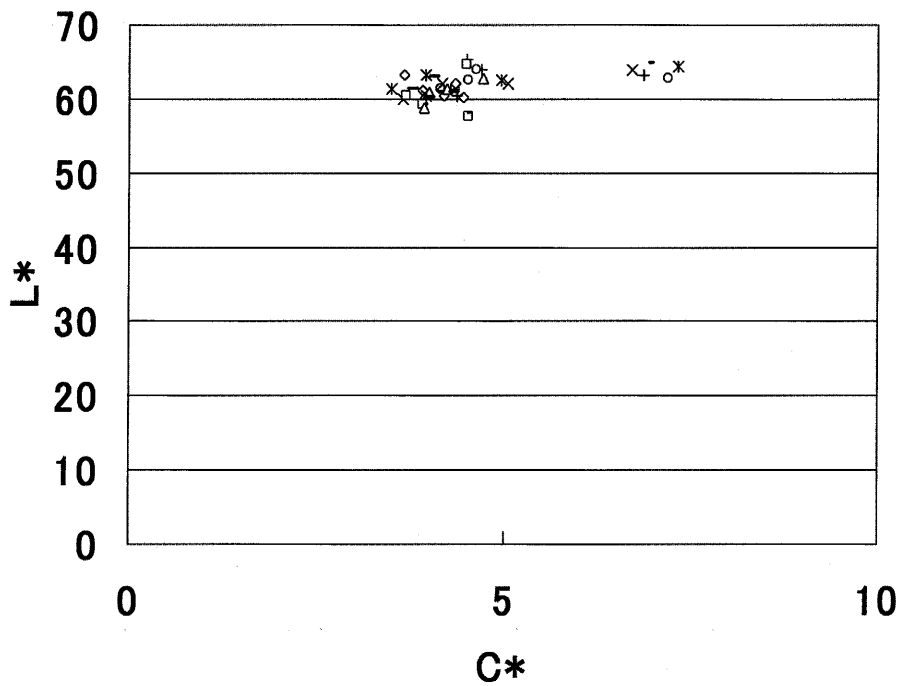
Empress 2 (Layering)



- EE-ST1-Trans
- EE-ST2-Trans
- △EE-ST3-Trans
- ×EE-ST5-Trans
- ×EE-ST8-Trans
- EE-ST9-Trans
- +EE-Pd-Trans
- *EE-Au-Trans
- EE-ST1-A1W
- EE-ST2-A1W
- EE-ST3-A1W
- △EE-ST5-A1W
- ×EE-ST8-A1W
- ×EE-ST9-A1W
- EE-Pd-A1W
- +EE-Au-A1W
- *EE-ST1-A3Y
- EE-ST2-A3Y
- EE-ST3-A3Y
- EE-ST5-A3Y
- △EE-ST8-A3Y
- ×EE-ST9-A3Y
- ×EE-Pd-A3Y
- EE-Au-A3Y
- +EE-ST1-A4B
- *EE-ST2-A4B
- EE-ST3-A4B
- EE-ST5-A4B
- EE-ST8-A4B
- △EE-ST9-A4B
- ×EE-Pd-A4B
- ×EE-Au-A4B
- EE-ST1-OW
- +EE-ST2-OW
- EE-ST3-OW
- EE-ST5-OW
- EE-ST8-OW
- EE-ST9-OW
- △EE-Pd-OW
- ×EE-Au-OW

Fig. 4 C*L* (Empress 2)

Procera AllCeram



- P-ST1-Trans
- P-ST2-Trans
- △P-ST3-Trans
- ×P-ST5-Trans
- ×P-ST8-Trans
- P-ST9-Trans
- +P-Pd-Trans
- *P-Au-Trans
- P-ST1-A1W
- P-ST2-A1W
- P-ST3-A1W
- △P-ST5-A1W
- ×P-ST8-A1W
- ×P-ST9-A1W
- P-Pd-A1W
- +P-Au-A1W
- *P-ST1-A3Y
- P-ST2-A3Y
- P-ST3-A3Y
- P-ST5-A3Y
- △P-ST8-A3Y
- ×P-ST9-A3Y
- ×P-Pd-A3Y
- P-Au-A3Y
- +P-ST1-A4B
- *P-ST2-A4B
- P-ST3-A4B
- P-ST5-A4B
- P-ST8-A4B
- △P-ST9-A4B
- ×P-Pd-A4B
- ×P-Au-A4B
- P-ST1-OW
- +P-ST2-OW
- *P-ST3-OW
- P-ST5-OW
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- P-ST9-OW
- △P-Pd-OW
- ×P-Au-OW

Fig. 5 C*L* (Procera)

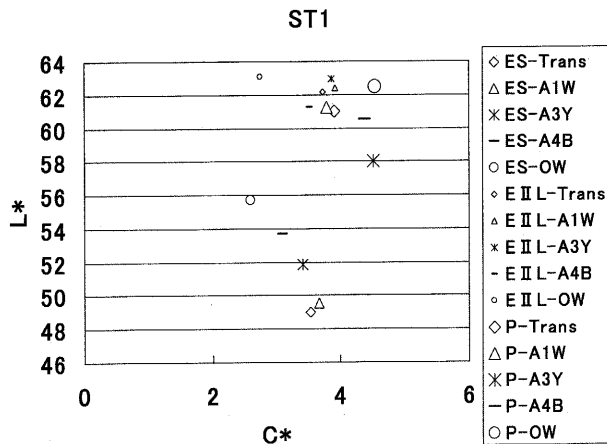


Fig. 6 C*L* (ST 1)

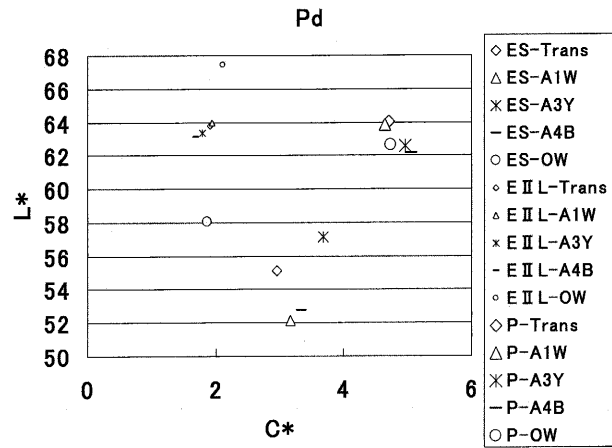


Fig. 8 C*L* (Pd)

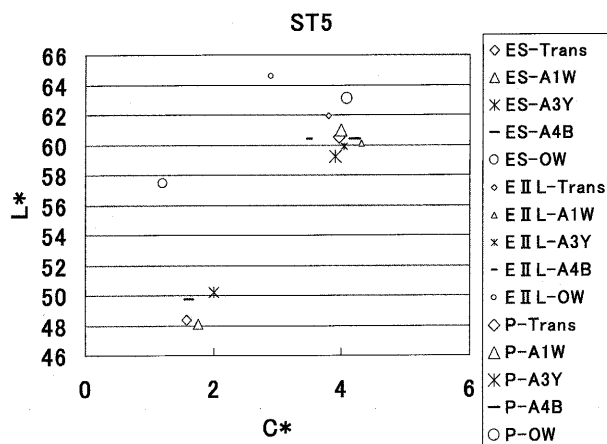


Fig. 7 C*L* (ST 5)

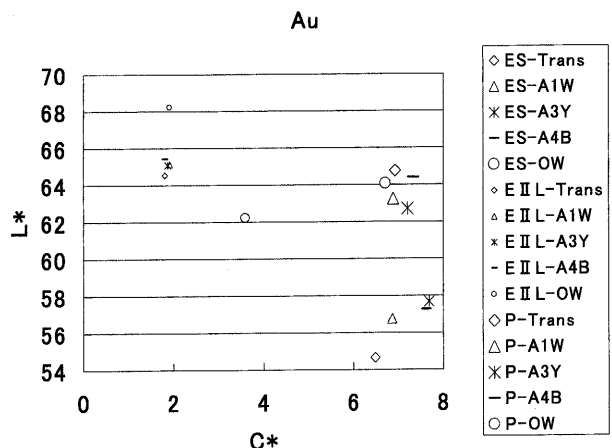


Fig. 9 C*L* (Au)

the other abutments (Fig. 8).

Empress 2 specimens with a gold alloy abutment had lower chroma values than the other abutments: however, when Empress and Procera specimens used a gold alloy abutment, they had higher chroma values than the other abutments (Fig. 9).

DISCUSSION

The popularity of metal-ceramic restorations is due largely to their predictable strength achieved with reasonable esthetics; however, Cornell²¹ reported that patients with porcelain fused to metal restorations often exhibit a grey-purple hue in otherwise perfectly healthy tissue. The dark or discolored areas around the margins of the crowns are attributable to the shadowing of the tooth structure and tissue by the metal coping.

Kelly et al.²² identified core translucency as one of the primary factors in controlling esthetics and a critical consideration in the selection of materials.

Three ceramics were selected for study: IPS Empress

((1) Empress, (2) Empress 2) that have high translucency and excel in reproducing the color of natural teeth, and (3) Procera AllCeram that has both good esthetics and strength.

The IPS Empress glass-ceramic material is made of a glass phase and a leucite-type crystal phase. Empress, Empress 2 has a lower crystal content within the matrix than Procera, which has excellent strength but poor aesthetic qualities

According to Oden et al.¹⁵, the L*a*b* values of the Procera AllCeram core material measured on block graphite and white plaster exhibited no statistically significant differences when the wall thickness was increased.

Leucite (used to strengthen Empress) and lithium disilicate (used to strengthen Empress 2) have refractive indices of 1.51²³ and 1.55, respectively-close to that of the porcelain matrix of 1.50²⁴. In contrast, alumina (Procera) has a refractive index of 1.76²⁵.

Empress is superior to alumina cores in terms of producing the desired aesthetic appearance: however, in actual

clinical application, it is necessary to take into consideration the effect of the abutment colour.

According to Vichi et al.²⁶⁾, the final esthetic result of the all-ceramic IPS-Empress glass-ceramic restorations was not affected by the presence of different substrates with different colors when the thickness was more than 2.0mm. When the ceramic thickness decreases to 1.5mm, it is advised to take the substrate aspects into consideration. If the ceramic thickness is less than 1.0mm, the use of a full ceramic crown is contraindicated.

According to Nakamura et al.,¹⁸⁾ the following conclusions were drawn concerning the use of Empress crowns for restorations: when making a cast post using a gold alloy, the dentin ceramic must be more than 1.6mm thick; in cases where this thickness cannot be attained, it is effective to make a post using tooth-coloured material, such as a porcelain-veneered cast post.

The effect of color blocking was significantly improved when using an opaque color cementation insertion.

This result is similar to that reported by Kon et al.²⁷⁾ Ito,²⁸⁾ and Kawahara.²⁹⁾

CONCLUSIONS

1. Using Empress, the color of the abutment tooth and cement had the greatest influence on the color tone of the coping.
2. Regardless of the color shades of the abutments and cements, lightness values rose in the order of Empress, Procera, and Empress 2.
3. Regardless of the copings and abutments, when opaque white cement was used on the coping, the lightness values rose.
4. Regardless of the copings, the ST5 abutment was unaffected by the cement color except for opaque white cement.

From the above findings, the following conclusions were drawn concerning the use of Empress, Empress 2 and Procera: in actual clinical application, it is necessary to take into consideration the effect of the abutment colour and cement.

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オールセラミックレストレーションの色調に関する研究 —支台歯色とカラーセメントがコーピングの色調に及ぼす影響—

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人々の審美性に対する要求が高まり、オールセラミックレストレーションは、普及してきている。天然歯を模倣したオールセラミックレストレーションにおいて、大きさ、形態、表面性状、光透過性および色調が重要である。なかでも、IPS Empress, IPS Empress 2 (IVOCLAR VIVADENT), Procera AllCeram (Novel Biocare) は広く普及し、長期にわたり使用されている。

本研究では、3種類のオールセラミックコーピング (Empress, Empress 2, Procera) の色調は、支台歯色およびカラーレジンセメントの色調により、どのような影響を受けるかについて検討を行った。

3種類のオールセラミックのコーピングと各種ダイの間に、Variolink II の Try-In pastes (5 shades: transparent, A1・white, A3・yellow, A4・brown, opaque white) を介在させ装着した歯冠側中央部を高速分光光度計により測色した。表色は、L*a*b*表色系を用いた。

Empress は、支台歯色およびカラーセメントの影響を最も受けやすかった。全体的な傾向として、明度の高い方から Empress 2, Procera, Empress であった。すべてのコーピングにおいて、opaque white のセメントは特徴的であり、どの支台歯のときも介在させることにより明度が高くなった。

キーワード：オールセラミッククラウン, IPS Empress, Procera AllCeram, レジンセメント, L*a*b*表色系

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