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Original article

Influence of different post core materials on the color of Empress 2 full ceramic crowns

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Keywords: color difference; ceramic crown; post core; try-in paste

Background For esthetic consideration, dentin color post core materials were normally used for all-ceramic crown restorations. However, in some cases, clinicians have to consider combining a full ceramic crown with a metal post core. Therefore, this experiment was conducted to test the esthetical possibility of applying cast metal post core in a full ceramic crown restoration.

Methods The color of full ceramic crowns on gold and Nickel-Chrome post cores was compared with the color of the same crowns on tooth colored post cores. Different try-in pastes were used to imitate the influence of a composite cementation on the color of different restorative combinations. The majority of patients could not detect any color difference less than △E 1.8 between the two ceramic samples. So, △E 1.8 was taken as the objective evaluative criterion for the evaluation of color matching and patients' satisfaction.

Results When the Empress 2 crown was combined with the gold alloy post core, the color of the resulting material was similar to that of a glass fiber reinforced resin post core (△E = 0.3). The gold alloy post core and the try-in paste did not show a perceptible color change in the full ceramic crowns, which indicated that the color of the crowns might not be susceptible to change between lab and clinic as well as during the process of composite cementation. Without an opaque covering the Ni-Cr post core would cause an unacceptable color effect on the crown (△E = 2.0), but with opaque covering, the color effect became more clinically satisfactory (△E = 1.8).

Conclusions It may be possible to apply a gold alloy post core in the Empress 2 full ceramic crown restoration when necessary. If a non-extractible Ni-Cr post core exists in the root canal, it might be possible to restore the tooth with an Empress 2 crown after covering the labial surface of the core with one layer of opaque resin cement.

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Normally, if full ceramic crown restorations are chosen for endodontically treated teeth, clinicians use tooth colored material like ceramic or glass fiber with a reinforced composite to build up post cores. However, in some cases, such as when metal post cores are already cemented in root canals, a risk of root fracture is present for removal, or the axis of the crowns needs to be significantly shifted in order to realign the teeth. In addition, tooth colored post cores may be difficult to handle or too brittle or flexible.[1] Consequently, a question comes: what if combining full ceramic crowns with metal post cores results in such cases? Will full ceramic crowns lose their optical advantage in such combinations? This experiment was conducted to test the clinical esthetic possibility of combining cast metal post cores with full ceramic crowns.

METHODS

Samples fabrication

Four similar ceramic crowns with an average facial middle third thickness[2-5] of (1.53±0.11) mm were fabricated with Empress 2 ingot No. 100 and Empress 2 veneer ceramic powder No.140 (Ivoclar AG, Liechtenstein). Four identically shaped post cores were made with different materials; the materials of the four post cores were Ni-Cr alloy (Heraenium S., Germany) covered with opaque composite (opaque white resin cement, variolink II,

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Ivoclar AG, Liechtenstein),[6,7] gold alloy (Jelenko, Heraens-Kulzer Inc, USA), Ni-Cr alloy (Heraenium S., Germany), and glass fiber (GF) (post: Parepost Fiber White, Coltene/Whaledent Inc., USA) reinforced resin (core: Luxacore, DMG Hamburg, Germany). The GF post core was used as a sample of tooth colored post core.

Measurement of color values

The Shade Eye colorimeter (Shofu, Japan) was used to measure the color values (CIEL*, a*, b*) of the full ceramic crowns on identical abutment models (3K resin, Dreve-Dentamid GmbH, Germany) without post core and post cores composed of four different materials. The color values of the crowns with transparent or opaque try-in paste (variolink II Ivoclar AG, Liechtenstein) were also measured when tried on the abutments with different post cores. In order to unify the measuring area, the abutment model was fixed in a silicon fixture when the crown was being measured. Fig. 1 shows the shape and size of the abutment model with the post core. Fig. 2 shows the measuring area on the facial surface of the crown. The measurements for each combination were continually conducted three times.

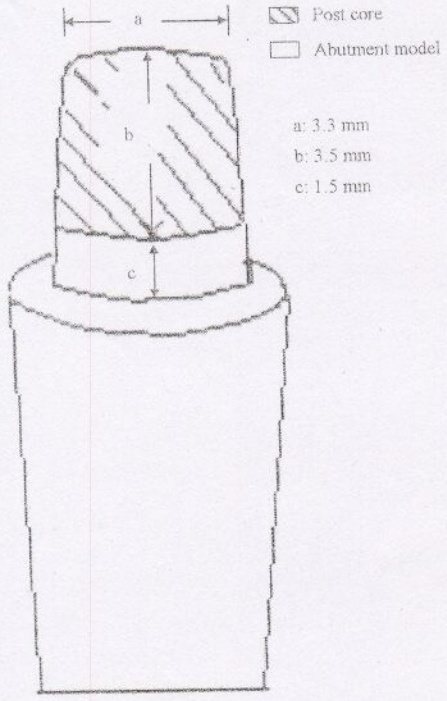

Fig. 1. The abutment model with post core.

Calculation of color deference

The average CIEL*, a*, b* values of original crowns (on the abutment without any post core), crowns on different post cores without try-in paste, crowns on different post cores with transparent try-in paste, crowns on different post cores with opaque try-in paste were calculated. From these values, we then calculated the average color difference (△ E) between the following combinations: (1) original crowns and crowns on different post cores (without try-in paste), (2) crowns on the same post cores with and without transparent try-in paste and those with and without opaque try-in paste, (3) original crowns and crowns on different post cores with transparent or opaque try-in paste, and (4) crowns on the GF post core with transparent try-in paste and crowns on three metal post cores with transparent try-in paste. The color value differences (△L*,△a*,△b*) and the color difference (△ E) between the following combinations were also calculated: (5) crowns on the same post core with transparent try-in paste and opaque try-in paste, and (6) original crowns and the corresponding shade tab.

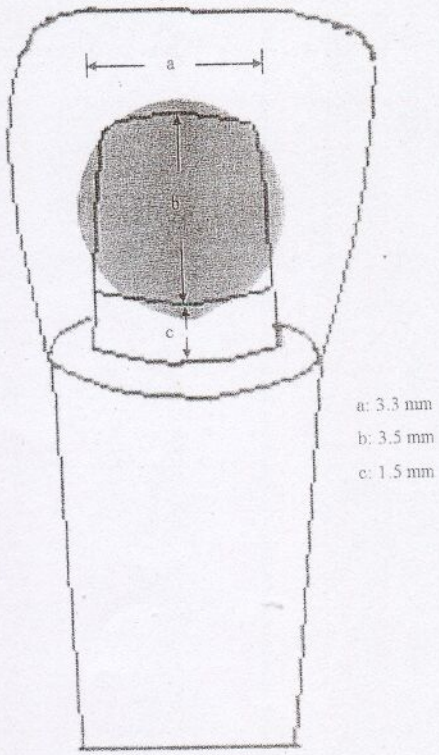

Fig. 2. Measuring area-shadow part.

The color difference, recorded in △E units, wa calculated with the following formula (CIE1976 L* a* b colorimetric system):[8]

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

△L*= The difference in the L* coordinate betwee the compared combinations

△a*= The difference in the a* coordinate between the compared combinations
△b*= The difference in the b* coordinate between the compared combinations

Evaluation and analysis

In our previous study, we concluded that the patients' average perception level of ceramic color difference, △E, was about 1.8.[9] The majority of patients could not detect any color difference when △E was less than 1.8 between the ceramic samples.[10-12] Therefore, the data were analyzed with △E 1.8 as the objective evaluative criterion for evaluating color matching and patients' satisfaction.

RESULTS

The color differences between the original crowns and crowns on different post cores

The color difference between the original crowns and crowns with the Ni-Cr post core was 1.6, which is very close to the average perception level of patients. For the other post cores, the color change was much smaller than the patients' average perception level, 1.8 (Fig. 3).

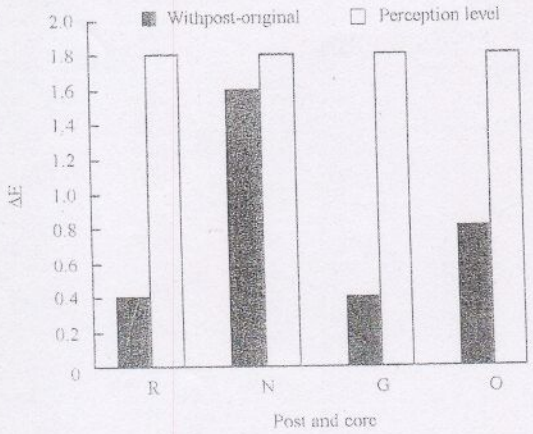

Fig. 3. The color differences between the original crowns and crowns on the different post cores. R: glass fiber post and resin; N: Ni-Cr post; G: gold post; O: opaque resin covered Ni-Cr post.

The color differences between crowns without any paste and those crowns on the same post cores with transparent or opaque try-in paste

Concerning the influence of try-in paste, the color of crowns on the same post core did not change perceptibly from those with to without transparent try-in paste. With opaque try-in paste, however, the color of crowns on the Ni-Cr post core and on the opaque composite covered Ni-Cr post core changed perceptibly from those without try-in paste (Fig. 4).

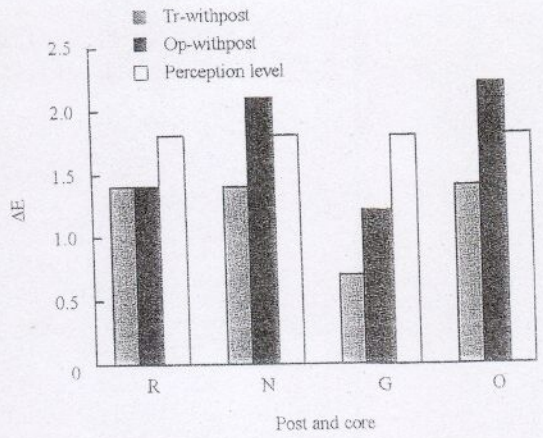

Fig. 4. The color differences between crowns on the same post cores with transparent or opaque try-in paste and these without any paste. R: glass fiber post and resin; N: Ni-Cr post; G: gold post; O: opaque resin covered Ni-Cr post.

The color differences between original crowns and crowns on the different post cores with transparent or opaque try-in paste

When combining the influence of post cores and try-in pastes, the full ceramic crowns were fitted on different post cores with opaque or transparent try-in paste. More frequently, the color of the variables did not change perceptibly from the color of original crowns; only when the Ni-Cr post core with transparent paste was applied to the crowns did the color change exceed the patients' perception level

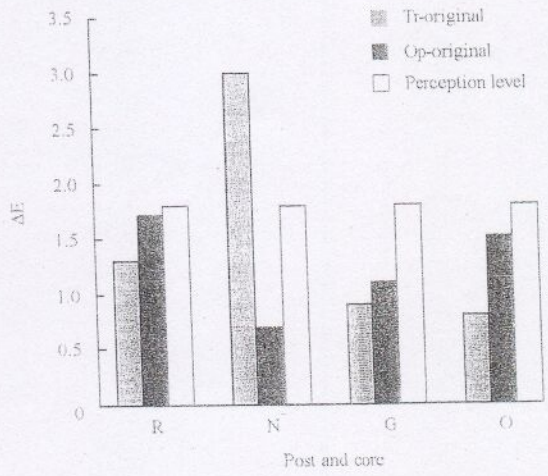

Fig. 5. The color differences between original crowns and crowns on the different post cores with transparent or opaque try-in paste. R: glass fiber post and resin; N: Ni-Cr post; G: gold post; O: opaque resin covered Ni-Cr post.

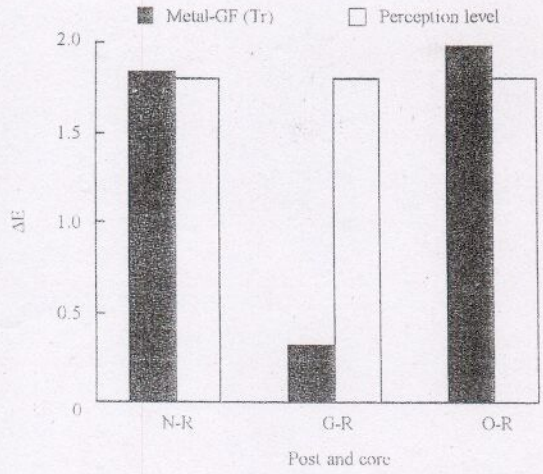

Fig. 6. The color differences between the crowns on GF post core with transparent try-in paste and the crowns on three metal post cores with transparent try-in paste. R: glass fiber post and resin; N: Ni-Cr post; G: gold post; O: opaque resin covered Ni-Cr post.

(Only when the Ni-Cr post core with transparent paste was applied to the crowns were the patients able to perceive a significant color change) (Fig. 5).

The color differences between the crowns on GF post core with transparent try-in paste and the crowns on three metal post cores with transparent try-in paste

In clinical practice, GF post cores are normally chosen for Empress 2 full ceramic crowns, and transparent composite for cementation. Based on this, crowns on the GF post core with transparent paste were used as the control group. With the transparent paste, the crowns on the gold alloy post core had a color appearance analogous to that of the GF post core, but when the crowns were tried on the Ni-Cr post core or the opaque resin covered Ni-Cr post core, their color appeared perceptibly different when compared to that of the GF post core (Fig. 6).

The color value differences and the color difference between the crowns with transparent paste and with opaque paste on the same post cores

Compared to the color appearance of the crown tried-in with transparent paste, the color of the crowns on the GF, Ni-Cr alloy and gold alloy post cores changed perceptibly when tried-in with opaque paste on the same post core. The color became brighter and yellowish with higher L* and b* values (Table).

Table. The color value differences and the color difference between the crowns with transparent paste and with opaque paste on the same post cores

Op−Tr	△L*	△a*	△b*	△E
R	2.25	−0.05	1.68	2.81
N	2.38	0.13	2.43	3.40
G	1.60	−0.15	1.00	1.89
O	0.70	−0.18	0.35	0.80

R: glass fiber post and resin; N: Ni-Cr post; G: gold post; O: opaque resin covered Ni-Cr post.

The color difference between original crowns and the corresponding shade tab

When comparing the color of original crowns to the corresponding shade tab (140), the color difference (△E 3.55) was much higher than the patients' average perception level. The crowns had augmented in brightness (△L*=1.33) and abated in yellowness (△b*=−3.30).

DISCUSSION

Both Vichi[13] and Nakamura[14] found that different substructure materials such as gold alloy and ceramic brought a detectable color difference to the Empress ceramic discs with a thickness less than 1.5 mm. In order to unify the experimental conditions they took the ceramic discs as samples in their studies. However, the fact that light behaves differently in flat disc ceramic samples than in solid ceramic crowns should be considered. Carossa[15] reported that ceramic crowns with ceramic post cores had higher transmission rates than those with gold post cores, but dentists were not able to detect the color differences between them in the clinic. Normally, we observe a tooth through reflected light and seldomly through transmitted light. Thus, in order to imitate a clinical condition in our study, we measured the color values of ceramic crowns under reflected light. In addition, since resin cements also influence the manner of light interaction and different post cores influence the light interaction in different ways, we brought try-in pastes into our study to imitate the effect of resin cements.

In clinical practice, GF post cores are normally combined with Empress 2 full ceramic crowns. Thus we took the GF post core as a sample representing a tooth colored post core system as well as a control group. When the full ceramic crowns were cast on the gold alloy post core, these crowns appeared to have a similar color as those on the GF post core

had. In addition, the gold alloy post core, regardless of try-in paste, did not bring the crowns a perceptible color change from their original crown color. This implied that the color of Empress 2 full ceramic crowns with gold post cores was predictable and easy to adjust. Further more, the lights entering the crown are mostly scattered by the ground, rough golden surface. The color appears natural in brightness and transparency. Conclusively, applying gold post cores with full ceramic crowns in practice may be possible when necessary.

The Ni-Cr post core, without any opaque covering, made the crowns conspicuously darker. With one layer of opaque resin covering, the color result was close to acceptability and easy to predict and control because the color of the opaque resin covered core did not influence the color of the crown perceptibly. However, when the opaque resin was too thick, the color of the crown became unnaturally bright and yellowish due to the high reflectivity of the thick opaque resin layer. Douglas' report resulted in the same conclusion.[16] As a result, if a non-extractable Ni-Cr post-core exists in the root canal and the patient demands a full ceramic restoration, covering the labial surface of the post core with opaque resin in proper thickness could be a liable solution. Previously, researchers had combined full ceramic crowns with opaque ceramic covered metal post cores in clinical cases;[6,17] some of them reported that the opaque ceramic covering gave a better color effect than did the opaque resin covering. However, it is not practical to use opaque ceramic covering in cases of non-extractible metal post cores.

The color difference between the original crowns and crowns on the Ni-Cr post core was very close to the patients' perception level. This suggested that the color of the post core did influence the color appearance of the crown restoration in some situations. If clinicians were to record the color of the prepared dentin or core in a clinic and transfer it to technicians, then the technicians can make resin abutment models according to the color information and fabricate the full ceramic crown on the models; a better color result and less inconsistency when transferring data between the clinic and the lab would assured.

Because opaque try-in paste has a higher light reflectivity, the color of the crown became perceptibly brighter and yellowish when tried-in on most of the abutments with opaque paste than transparent paste. This suggested that try-in pastes or resin cements did influence the final color of the crown. Opaque resin cement may cause the crown to appear brighter and yellowier. Thus, trying in the crown with try-in paste before the final cementation is a good way to anticipate the color change after the cementation. On the other hand, this property can also be used to adjust a minor color discrepancy or to get a fine, desired color result by mixing up different resin cements in different proportions.

The thickness of the manufactured shade tab is about 4 mm, much thicker than the crown's labial wall. Thus, the shade tab may absorb more light and reflect less light than the crown does. Light absorption causes higher color saturation; likewise, light reflection causes higher brightness. This explains why the crowns looked brighter and whiter than the shade tab. Thus, a customized shade tab, the shade tab composed of the same material as and structured with the similar thickness of restorations, should be used in practice.

Heat-pressed cast ceramic material like the Empress 2 is more translucent than other full ceramic materials such as inceram, procera, wolceram, and zirconia.[15,18-20] These ceramic materials are less translucent when considering optical esthetics but more tolerance when combining with metal post cores than the Empress 2. Thus, the proper material and reasonable design should be chosen based on the knowledge of different materials and a comprehensive consideration of clinical conditions, oral functions and facial esthetics.

Unfortunately, we have not researched the long term color stability of the resin cement on a metal surface at this point. In our research, only the short term color appearance was studied. For now, we are not certain if the interaction between the resin and metal will cause a color change in the long run. Further studies are recommended to be conducted.

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