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Case Report / Приказ болесника

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Photocolorimetry for full crown central incisor shade matching

Фотоколориметријско одређивање боје централних секутића

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SUMMARY
Introduction The objective of this case series report is color matching of the central incisors all-ceramic crowns and determine the color difference between those crowns and contralateral or neighboring intact natural incisor using the ΔE_{ab} value from CIELab formula.
Case report The subject of this color assessment was all-ceramic crowns for central incisors for three young female patients. The intact natural incisors were used as the target shade for the all-ceramic crown.
After tooth preparation and IO scan everything has been done at once, regarding the design of restoration and model. For these cases Ivoclar ZirCAD PRIME multi A1 block has been used. For proper shade mapping polarized picture with grey card for digital calibration is necessary as well as one standard picture for mapping the color effects. For tooth color mapping has been used the eLAB app. Highest ΔE_{ab} value for all three cases was 2.7 or less, which indicates that the color is clinically acceptable, considering acceptability threshold value of less than 2.7 (three-year follow-up confirmed acceptable color appearance.
Conclusion Following recommended protocol based on the eLAB software, clinically acceptable color of the all-ceramic crown were obtained.
Keywords: dentistry; color; color matching; all-ceramic crown

САЖЕТАК
Увод Циљ овог извештаја о серији случајева је избор боје централних секутића керамичких круна и утврђивање разлике у боји између керамичких круница и контралатералног или суседног интактног природног секутића користећи *ΔE_{ab}* вредност из формуле *CIELab*.
Приказ болесника Предмет овог избора боје биле су керамичке крунице за централне секутиће за три пацијенткиње (32–43 год). Интактни природни секутићи коришћени су као циљна нијанса боје за керамичке крунице. Након припреме зуба и интраоралног скенирања у лабораторији је израђен виртуелни модел и дизајниране су крунице. За све случајеве је коришћен *Ivoclar ZirCAD PRIME multi A1* блок. За правилно мапирање нијанси коришћена је поларизована слика са сивом картицом за дигиталну калибрацију, као и једна стандардна слика за мапирање ефеката боја. За мапирање боја зуба коришћен је *eLAB* софтвер. Највиша *ΔE_{ab}* вредност за сва три случаја била је 2,7 што указује да је боја клинички прихватљива, с обзиром да је вредност прага прихватљивости мањи од 2,7 (трогодишње праћење је потврдило прихватљив изглед боје).
Закључак Применом протокола заснованом на *eLAB* софтверу добијене су клинички прихватљиве боје керамичких круница код сва три пацијента.
Кључне речи: стоматологија; боја; избор боје; керамичке крунице

INTRODUCTION

The delivery of natural looking restoration is one of the most challenging tasks in oral rehabilitation. The shape, texture and color are factors that contributes to a natural appearance. The color matching of the anterior artificial crown to adjacent natural teeth is especially critique for the patient's satisfaction. In the daily dental practice, visual shade matching with a dental shade guide is still one of the most common methods for color determination. Visual shade matching is subjective, tooth is polychromatic and dental materials present limited shade tab. [1] Instrumental methods using electronic devices such as dental spectrophotometers (e.g Easy

Shade, VITA) and digital photography have shown higher precision for shade matching [2] and can be used to convey information to the dental technician.

The visible color is a mix of three primary colors: red, green, and blue (determine Hue). The addition of some color pigment in the mixture gives a darker effect (determine Value), and addition of another pigment will produce more color intensity (determine Chroma). [1-4]

For color matching of ceramic crowns the CIELab system (CIE - International Commission on Illumination) is the most commonly used. The colors in this system are represented in a spherical color space through three coordinate values, Figure 1. The vertical dimension "L" indicates lightness (on the upper pole is the pure white, and on the lower pole is the pure black). Chromatic color characteristics are followed along two horizontal axes: "a" expresses the red-green axis, and "b" the blue-yellow axis [1,5,6].

The CIELab system is particularly applicable in dental laboratories for determining and reducing color differences, while producing restorations. The degree of diversity, ΔE_{ab} (E - Euclidean distance) is color space with differences in lightness, chroma and hue, and it is determined in this system by the formula:

$$\Delta E_{ab} = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}$$

The difference between compared colors is represented by the relative value ΔE_{ab}, which is considered as a standard for measuring color differences. It is considered that the threshold of human sensitivity to distinguish shades is at the value of $\Delta E_{ab} = 1$. Color differences lower than this ΔE_{ab} are not perceptible for 50% of the observers, while $\Delta E_{ab} \leq 2.7$ is considered clinically acceptable. [1,7–11]

This case series reports the color matching of all-ceramic central incisors using a photocolorimetry protocol for CIELAB color differences calculation. The procedure for tooth color matching is shown schematically in Figure 2.

CASE REPORTS

Case № 1: The subject of this color assessment was a maxillary central incisor prepared for a full-ceramic crown at 37-year-old female patient. The contralateral intact natural incisor was used as the target shade for the all-ceramic crown, Figure 3.

After tooth preparation and IO (intraoral) scan everything has been done at once, regarding design of the restoration and model, Figure 4. For this case Ivoclar ZirCAD PRIME multi A1 block was used. For proper shade mapping polarized picture with grey card for digital calibration is necessary as well as one standard picture for mapping the color effects, Figure 5.

For tooth color mapping the eLAB app has been used. Values of this grey card are: L:79 lightness, a:00 red, b:00 yellow. These values were used for matching in the next steps. In that manner it was easy to superimpose picture of tooth shot on the model with the polar filter picture in mouth and digital try-in. The finalization with the layered ceramic has been made by a special recipe combining knowledge and measurements, Figure 6 and Figure 7.

Highest ΔE_{ab} value was 2.7 which indicates that the color is clinically acceptable, considering acceptability threshold value of less than 2.7 (3-years follow-up confirmed acceptable color appearance), Figure 8.

Case № 2: As we have shown, the highest challenge was to determ the color and match it with the remaining natural teeth of one upper central incisor. It is demanding, but with a lesser extent, to determ color of the two upper central incisors and match it with the remaining teeth.

In this case color assessment were all-ceramic crowns for both maxillary central incisor with 34-year-old female patient. The intact natural second incisors were used as the target shade, Figure 9. The procedure for tooth color matching and interpretation was the same as in the previous case, Figure 10 and Figure 11.

Case Nº 3: Color determination of the lower central incisor and matching it with the remaining natural teeth is also very demanding and creative. However, due to slightly less visibility while speaking and smiling and the vertical overbite of the teeth, determining teeth color is somewhat less demanding compared to maxillary incisors.

In this case color assessment was an all-ceramic crown for mandibular central incisor with 30-year-old female patient. The contralateral intact natural incisor has been used as the target shade for the all-ceramic crown, Figure 12. The procedure for tooth color matching and interpretation was the same as in the previous cases. In this case also, we used the CIELab formula and calculated ΔE_{ab} value. ΔE_{ab} value was less than 2.7 which indicates that the color is clinically acceptable. In this, as in previous cases, patients were extremely satisfied with the tooth color, Figure 13.

Ethical standards: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Written consent to publish all shown material was obtained from the patients.

DISCUSSION

Digital photocolorimetry has shown to improve the communication between the dental professional and technician [3,12,13] by delivering a set of protocol-based information besides data obtained with the conventional visual method. The reliability of this protocol depends on the type of camera, its settings, ambient light, flashlight, and size of the captured image. [3]

The calculation of ΔE_{ab} color difference through image editing software (eLab) or data from spectrophotometers (Vita Easyshade) is of a great help for both, dental technicians, and dental professionals. Although recent studies have established better correlation of color differences calculated with CIEDE 2000 formula, [1,14-17] dental technicians are used to

interpret L, a, b and consequently ΔE_{ab} color differences values. The value for $\Delta E_{ab} = 2.7$ was taken arbitrarily.

The CIELab formula that we used coincides in 75% of cases with the examiner's visual perception, while a new color-difference equation CIEDE2000 matches in 90% of the cases with the examiner's visual perception [15].

In daily dental practice, use of color difference formula for determining teeth color gives results that both the patient and the entire dental team are satisfied with. A multitude of variables involved (salivary reflections, translucency of dental ceramics, illuminant metamerism between natural teeth and ceramic restorations) are necessary for more serious research.

Color matching is a crucial step in the process of fabricating an aesthetically satisfying restoration. In all our presented cases highest ΔE_{ab} value was ≤ 2.7 which indicates that the color is clinically acceptable, considering acceptability threshold value of less than 2.7. 3-years follow-up confirmed acceptable color appearance.

Conflict of interest: None declared.

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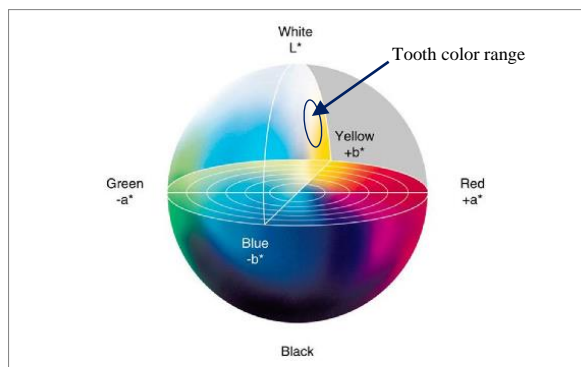
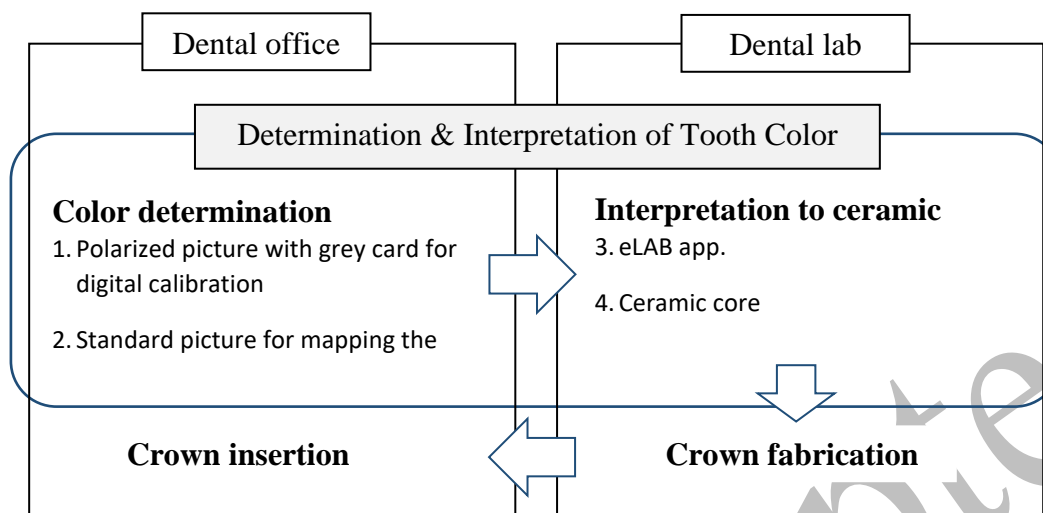**Figure 1.** Tooth color range in CIELab color system

Figure 2. The scheme of communication between dental office and dental technician for tooth color determination, interpretation and crown fabrication

Figure 3. Pre-operative view of the right maxillary central incisor

Figure 4. Digital modeling of all-ceramic crown
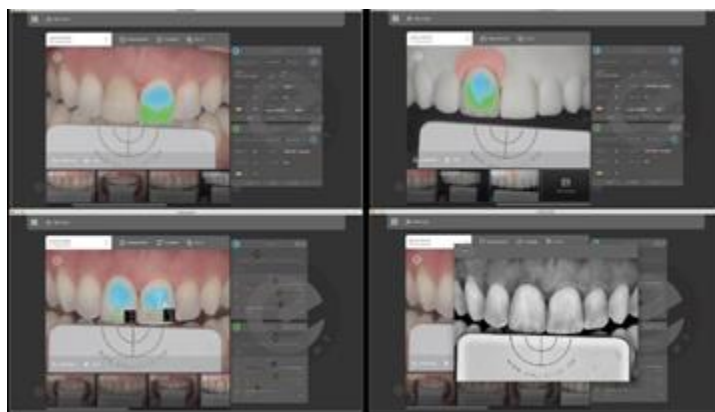
Figure 5. Shade mapping and check

Figure 6. For this case Ivoclar ZirCAD PRIME multi A1 block has been used

Figure 7. Highest ΔE_{ab} value was 2,7 which indicates that the color is clinically acceptable

Figure 8. Three-year follow-up confirmed acceptable color appearance

Figure 9. Pre-operative view of both maxillary central incisors

Figure 10. Shade mapping of all-ceramic crown for both maxillary central incisors

Figure 11. Post-operative view of both maxillary central incisors

Figure 12. Pre-operative view of the left mandibular central incisor

Figure 13. Post-operative view of the left mandibular central incisor all-ceramic crown