Color in zirconia-base restorations

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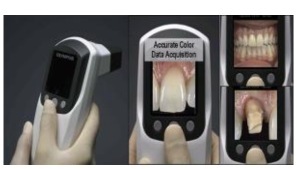
Introduction

Recently the use of zirconia crown due to the appropriate biocompatibility and high strength has been increased in restorative dentistry. Advanced CAD/CAM systems have been well established in prosthodontics in order to fabricate zirconia restorations. From esthetic point of view, zirconia crowns have advantages compared with metal ceramic crowns, which is caused by the metal margin and its show beyond the gingiva. However the requirement to achieve natural looking restorations is still challenging and the shade matching of the restorations with the natural dentition is difficult, due to the complex optical characteristics of natural teeth. Successful color selection depends on dentist perception of color, light source for color evaluation, surface characteristics of tooth and restorative material, and having knowledge of basic principles of color perception. Moreover, dentists should be able to clearly communicate instructions with dental technicians. The practical steps include: to select the best possible shade using a shade guide and/or an electronic shade taking device and to reproduce this shade with an appropriate dental material.

Shade selection in zirconia-base restorations seems to be unpredictable, because of the different factors which affect the target color of restoration. These factors include: dental core (background), cement, zirconia core, porcelain layers of dentin and enamel, glaze, and manufacturing processes. The color measurement, perceptional threshold, shade selection, measuring devices, and shade reproduction in zirconia-base restorations are demonstrated as follows.

Color measurement

First dental shade guide, which was introduced to dentistry, was the Vitapan Classical with 16 Tabs. Though this shade guide is easily used, it is not supported logically by the literature. The CIELab color system was defined to measure and calculate the color in industry and dentistry. The color attributes of L (value), a (red-green Chroma), and b (yellow-blue Chroma) were defined as a number. Based on this system the Vitapan 3D Master (29 Tabs) was developed. This shade guide is logical, however it is not easily used. To make the Vitapan 3D Master simpler, Linear guide 3D Master was introduced which is a new arrangement of Vitapan 3D Master. Shade guides have some disadvantages affecting shade selection. Type and quality of light, color blindness and perceptional defects, and dentist experience can affect the outcomes. In the last decade shade taking devices have been developed as a substitute for human eyes. Two main categories of them are colorimeters and spectrometers. Mostly a digital color image is analyzed and calculated by a software with a data set of several shade guides stored in the instrument. Some of them are listed: Shade Eye, Easyshade, Easy Shade Compact, Shade Scan, Shade Vision, Spectroshade Micro, Clear Match, Color Scanner, Crystal Eye, Shade X. Gerthke et al (1) and Yoshida et al (2) reported better control over the outcome and color match using shade taking devices compared with shade guides. Chu et al (3) recommended that both the devices and the guides should be used in clinic.

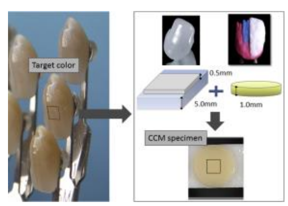


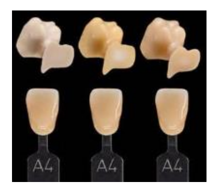
Perceptional threshold

Spectrophotometers are challenged by human eyes which means final color of the restoration is evaluated by human eyes. The reference value is ΔE. The ΔE is defined to calculate color difference in dentistry: $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$. Acceptable color match and perfect color match are achieved by $\Delta E<2.6$ and $\Delta E<1.4$, respectively.

Shade reproduction in zirconia-base restorations

Use of zirconia frameworks are gaining popularities due to good mechanical and physical properties of zirconia and its biocompatibility. Also CAD/CAM systems have been employed to fabricate zirconia substructures. From esthetical point of view, zirconia is white and optically acts as a semi translucent material (4). Translucency may be positive or negative effect in different cases. For example over a discoloured tooth or amalgam core, a highly masking material with opacity is needed and on a natural dentin core a translucent material is indicated. Veneering porcelain on zirconia core can reduce translucency (5). To compensate for the possible negative effect of the white color of zirconia on the target color, use of liner or dipping or pre-colored zirconia has been proposed (6). Target color of zirconia restoration depends on both core and veneer thicknesses (7). Zirconia core, dentin porcelain, glaze can influence value and Chroma (8). Color of opaque cements like zinc phosphate cannot be compensated perfectly by the veneering porcelain (9). Increasing zirconia core thickness from 0.4 mm to 0.8 mm affects the target color, but increasing from 0.8 mm to 1mm has no impact on the target color (10).Wang et al (11) suggested a computer color matching system for zirconia–base restorations which enables dentists to provide patients with restorations that match a target tooth color more reliably. Laboratory technicians and dentists will be able to measure tooth color and generate a formula that will allow them to reproduce a patient's tooth color. This system is similar to what is now used in textile industry. It seems that color in zirconia-base restorations needs specific shade guides and more investigations in future.





Conclusions

1. There is not sufficient data on the color of zirconia restorations in the literature.
2. For shade selection using traditional shade guides and shade taking devices are both necessary.
3. New shade guides for zirconia restorations should be developed.
4. Prosthodontics will be directed to create the target color for zirconia restorations with minimum error by precise and accurate formulations.

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