Evaluation of Color Duplication in Metal-Ceramic Complexes Using Visual and Instrumental Shade-Matching Systems

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This study was designed to evaluate color differences (ΔE) between intended and fabricated shades of various metal-ceramic complexes using visual and instrumental shade determination. Forty-two master disks were made to represent every tab in two shade guides. The shades of the master disks were determined visually and instrumentally. Accordingly, 84 experimental disks were fabricated. Color measurements of the master and fabricated disks were performed using a spectrophotometer. Visual shade determination showed a significantly lower ΔE value than the instrumental shade determination. However, all groups showed ΔE values exceeding 2.75, which could be considered perceivable and therefore clinically unacceptable. A reliable shade duplication of an existing metal-ceramic restoration cannot be ensured, regardless of the method of shade assessment. *Int J Prosthodont 2010;23:149–151.*

The color replication process in dentistry comprises a shade determination phase followed by shade duplication.[1] Visual color determination, using shade guides, is the most frequently followed method of shade selection. Nevertheless, visual color determination has been reported to yield unreliable and inconsistent results.[2] Consequently, instrumental colorimetric techniques have been introduced. However, intraoral colorimeters suffer from edge loss and the inability to assume a repeatable position on the same tooth.[3] Furthermore, the instrumental color assessment of teeth is not error proof.[3] Accordingly, the fabrication of a restoration that matches the target shade is extremely challenging.

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This study was designed to evaluate color differences between intended and fabricated shades of metal-ceramic complexes after using visual and instrumental shade determination systems.

Materials and Methods

Specimens used in this investigation were in the form of disks that were 15 mm in diameter and 3-mm thick (Fig 1). Each disk had a 2-mm-thick metal base (Wiron 99, Bego), over which a 1-mm-thick layer of porcelain was applied. Casting and porcelain application procedures were performed following manufacturer's recommendations. Forty-two master disks were fabricated to represent every tab of the two shade guides used (16 for the Vita Classical and 26 for the Vita 3D-Master, VITA Zahnfabrik). Shade determination for these master disks was performed visually using the two shade guides with their respective ceramic versions, and instrumentally using VITA Easyshade (VITA Zahnfabrik) with both ceramic versions (Table 1). Accordingly, 32 Classical (16 visual + 16 instrumental) and 52 3D-Master (26 visual + 26 instrumental) disks were fabricated, yielding a total of 84 experimental disks.

Fig 1 Finished specimens.

Table 1 Codes of the Experimental Disks

Shade determination system		No. of experimental disks	Code
Visual (V)	Vita Classical shade guide and Omega 900/Classical porcelain (CL)	16	VCL
Instrumental (I)	Easyshade and Omega 900/ Classical porcelain (CL)	16	ICL
Visual (V)	Vita 3D-Master shade guide and Omega 900/3D-Master porcelain (3D)	26	V3D
Instrumental (I)	Easyshade and Omega 900/ 3D-Master porcelain (3D)	26	I3D
Total		84	

Table 2 Descriptive Statistics and Tukey Studentized Range Test for Mean ΔE Values

Group	Variable	N	Mean*	SD	Minimum	Maximum
I3D	ΔE	26	6.29[a]	1.78	3.04	9.64
ICL	ΔE	16	5.20[a]	3.66	1.51	15.53
V3D	ΔE	26	3.80[b]	1.80	0.68	7.08
VCL	ΔE	16	3.17[b]	1.55	0.67	6.37

*Similar letters indicate no significant differences.

Table 3 One-Way ANOVA of Within-Subjects Effects for Mean ΔE Values

Source	*df*	Sum of squares	Mean square	F	*P*
Model	3	128.4401302	42.8133767	8.62	$<.0001$
Error	80	397.3727647	4.9671596		
Corrected total	83	525.8128949			

Visual shade determination was performed under controlled lighting conditions following the guidelines recommended by Hammad[3] in 2003. Five women of a similar age (25 to 35 years) and educational background (senior prosthodontic residents) were chosen to perform the visual shade determinations after passing the Ishihara color blindness test.

Color measurements of the 42 master and 84 fabricated specimens were then performed using a spectrophotometer (Color-Eye 7000A, GretagMacbeth) and evaluated via the Commission Internationale d'Eclairage (CIE) L*a*b* colorimetric system. Color change (ΔE) values were then determined using the following equation:

$$\Delta E = [\Delta L^* \ (L^*_f - L^*_m)^2 + \Delta a^* \ (a^*_f - a^*_m)^2 + \Delta b^* \ (b^*_f - b^*_m)^2]^{1/2}$$

where m and f are descriptors representing master and fabricated disks, respectively.

Results

Data were analyzed statistically with one-way analysis of variance (ANOVA) and the Tukey studentized range test for multiple comparisons ($\alpha = .05$) using the SAS statistical program (Version 9.1.3, SAS Institute). Descriptive statistics for ΔE of all groups are presented in Table 2. One-way ANOVA showed a significant interaction between shade determination methods and ΔE ($P < .0001$, Table 3). The Tukey test revealed that visual shade determination using Vita Classical and 3D-Master shade guides showed significantly lower ΔE than the instrumental shade determination (Table 2).

Discussion

ΔE values obtained in this study were relatively lower than those previously reported.[1] This could be attributed to the use of each shade guide with its matching porcelain brand to fabricate the master disks and their corresponding fabricated disks. To maximize coverage of the tooth color space, master disks represented all shades in the shade guides used. Furthermore, to simulate metal-ceramic restorations and enhance clinical relevance in this study, a metal substructure was used.

The lowest ΔE perceivable by human observers is reported to be 1,[4] and a ΔE greater than 2.75 is considered to be clinically unacceptable.[5] Although visual shade determination produced lower ΔE values than instrumental, the fabricated specimens of all groups showed ΔE values exceeding 2.75 when compared to the master specimens. The present study therefore indicates that ΔE values of all groups are within the clinically unacceptable range. Consequently, a revised paradigm for enhancing color replication merits further investigation.

Conclusions

Within the limitations of this study, visual shade determination produced lower ΔE values than instrumental. Fabricated specimens of all groups showed ΔE values exceeding 2.75. Such color differences are perceivable and could be considered clinically unacceptable. This indicates that reliable shade duplication of an existing metal-ceramic restoration cannot be ensured, regardless of the shade assessment method used (visual or instrumental).

References

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Literature Abstract

A prospective multicenter 5-year radiographic evaluation of crestal bone levels over time in 596 dental implants placed in 192 patients

Dental implants are commonly used to replace missing teeth to restore both function and esthetics. An additional long-term goal is the maintenance of bone around the implant. One method of evaluating the bone level is to use radiographs to measure the marginal bone levels on the mesial and distal aspects of the implant over time. The purpose of this study was to evaluate crestal bone changes radiographically between the time of implant placement and 5 years after final prosthesis placement in a prospective multicenter clinical trial involving five international sites, 192 patients, and 596 implants. The implants were nonsubmerged single-stage implants with a titanium plasma-sprayed coating; solid screw and hollow-cylinder implants were used. Radiographs were taken at the time of implant placement, at the time of final prosthesis placement, 6 months after prosthesis placement, and annually thereafter. All radiographs were digitized and the linear dimensions of the digitized images were calibrated to take into account the magnification and distortion of the films. The reference point was taken to be the apical border of the 45-degree inclined shoulder of the implant, which was also the restorative margin after prosthesis placement. The distance from the reference point to the most coronal crestal bone level on the mesial and distal aspect of each implant was measured. The largest mean marginal bone loss (2.44 ± 1.20 mm) occurred between the time of surgery and final prosthesis placement. After that, the mean changes in bone levels were not significant; 0.22 ± 0.42 mm of bone loss occurred between prosthesis placement and 1 year postloading and 0.19 ± 0.88 mm of bone loss was observed between 1 and 5 years after prosthesis placement. Between implant placement and 5 years postloading, mean bone loss was 2.84 ± 1.63 mm, of which 86% was accounted for at the time of prosthesis delivery. The same trends were seen regardless of implant design, type of restoration, or the length of the implant. This study indicates that in general, significant bone remodeling occurs between the time of implant placement and final prosthesis placement for single-stage nonsubmerged implants. After that, bone loss is insignificant up to 5 years postloading.

Cochran DL, Nummikoski PV, Schoolfield JD, Jones AA, Oates TW. *J Periodontol* 2009;80:725–733. **References:** 34. **Reprints:** Dr David L. Cochran, Department of Periodontics, MSC7894, University of texas Health Science Center at San Antonio, 7703 Floyd Curl Dr, San Antonio, TX 78229-3900. Email: cochran@uthscsa.edu—*Clarisse Ng, Singapore*