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Color discrimination of dental professionals and color deficient laypersons☆

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ARTICLE INFO

Article history:
Received 21 July 2011
Received in revised form
2 September 2011
Accepted 21 September 2011

Keywords:
Color discrimination
Color deficient persons
Dental professionals

ABSTRACT

Objectives: The aim of the present study was to compare results of non-dental (conventional) and dental color discrimination tests (customized, shade guide test), to evaluate influence of profession, gender and age of color normal dentists and laboratory technicians on color discrimination results and to evaluate results of color deficient laypersons.

Methods: A total of 36 color normal dental professionals, all volunteers were divided into two groups consisting of 18 participants each: dentists (DDS) and laboratory technicians (CDT). In addition, a group 15 color deficient males also volunteered (CDP).

Color discrimination was examined using Farnsworth–Munsell 100 Hue Test and total error scores (TES) were calculated. Participants performed a dentistry related color discrimination test by matching 26 pairs of shade tabs. Shade guide scores (3DS) were calculated. These tests were performed under the controlled conditions of a viewing booth. Mean values and standard deviations were determined. ANOVA, Mann–Whitney test, *t*-test and Pearson's correlation coefficient (*r*) were used for result analysis.

Results: TES and 3DS were correlated for color normal observers, $r = 0.47$ ($p < 0.01$). No statistically significant differences in TES and 3DS by profession, gender and age were recorded. TES of 159 (83) and 3DS of 6.7 (2.7) were recorded for color deficient laypersons. Based on TES, 33% of color deficient laypersons had average discrimination, whilst 67% had low discrimination.

Conclusions: Within the limitation of this study, it was concluded that results of non-dental and dental color discrimination tests were correlated, and that profession (DDS/CDT), gender and age gender did not influence color discrimination of color normal participants.

Clinical significance: Although color and appearance of dental restorations are of paramount importance for the aesthetic outcome, color vision of dental professionals is not routinely tested. This paper validates and recommends the usage of dental shade guides for a simple, affordable and understandable testing of color vision, either as a sole test or complementing conventional (professional) tests.

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☆ Presented in part at the 86th General Session & Exhibition of the IADR, Miami, FL, 2009.

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doi:10.1016/j.jdent.2011.09.008

1. Introduction

Aesthetics is one of the most important factors contributing to the increase of patients' satisfaction in dentistry.[1–4] Numerous factors influence dental aesthetics, including color and shape of the teeth and shape of the dental arch. These factors are affected by individual preferences, cultural factors and socio-demographic factors. Several studies pointed out that the tooth color was a major factor with regards to dental aesthetics.[5–7]

Tooth color is a complex optical phenomenon that presents an interaction amongst polychromatic, multi-layered hard and soft dental tissues.[8,9] In addition, perception of color is also a complex process which depends upon a number of factors.[8–17] Therefore, successful selection and reproduction of shade are important clinical steps in restorative dental procedures.

Two methods have been utilized for analysis of color of an object: visual and instrumental.[18–20] Visual color matching is based on visual comparison of the object with tooth color standards – shade guides. This method is most frequently utilized in dentistry. Color measuring instruments are based on the analysis of the light reflected by the tooth.

Although the tools for shade matching and color reproduction are constantly improving,[9–17,20] lack of color education and training including inappropriate usage of tools may diminish the aesthetics of dental restorations. In addition, the inconsistencies in visual color matching amongst individuals, and for the same individuals regardless of gender, have been reported.[21] Color deficiency of dental professionals has also been reported.[22–25] The dental literature is equivocal on whether experience improves the shade matching ability, and whether profession, gender and age play a role in tooth color matching. Several studies offered evidence on non-significance of differences in shade matching quality between color normal females and males.[10,16,17,26,27] In addition, it was reported that age and clinical experience did not play an important role in shade matching.[16] Several papers also reported the influence of light source and other conditions on shade matching results.[10,16–18,28–32]

Color vision of is frequently evaluated using conventional tests, such as Ishihara test or Farnsworth–Munsell 100 Hue Test. The later test is designed to determine color discrimination and anomalies in color vision,[33] and has been performed on general population,[34] individuals with different medical conditions,[35] and for some non-medical and medical professions.[36–38] In addition to conventional tests of color vision that were administered in numerous dental studies, customized tests utilising shade guides or other tooth colored materials have been performed in or recommended for dentistry.[39,40,25,41]

The aim of the present study was to compare results of non-dental (conventional) and dental (customized, shade guide test) color discrimination tests. The null hypotheses were that: (1) results of non-dental and dental color discrimination tests were correlated; (2) profession (DDS/CDT), gender and age did not influence color discrimination results (the first two hypotheses were related to color normal dental professionals); and (3) color deficient laypersons had low color discrimination.

2. Materials and methods

2.1. Participants

Upon the approval of the Ethics in Research Committee, a total of 36 color normal dental professionals, 25 females (F) and 11 males (M), were recruited. All individuals participated on voluntary basis and gave written consent. They had previous experience in tooth shade matching and were divided into two groups consisting of 18 participants each: dentists (DDS) and laboratory technicians (CDT). There were 13 females and 5 males in the DDS group, and 12 females and 6 males in the CDT group. The mean (s.d.) age of the participants in the DDS group was 44 (13), with 20 (13) years in practice, whilst corresponding values for CDT group were 39 (13) and 19 (13), respectively. In addition, a group 15 color-deficient males were created (CDP). Their deficiencies were professionally diagnosed and verified by optometrists and they had no affiliation with dentistry.

2.2. Study protocol

Color discrimination was examined using Farnsworth–Munsell 100 Hue Test (X-Rite, Grand Rapids, MI, Fig. 1) and total error scores (TES) were calculated using the corresponding scoring software. In accordance with the manufacturer's instructions, if total error scores (TES) of color normal observers were 0–16, 20–100 and >100, it was classified as superior, average and low color discrimination, respectively. In addition, participants were asked to perform a dentistry related color discrimination test by matching 26 pairs of tabs (groups 1 through 5) of two Vita 3D-Master shade guides (Vita Zahnfabrik, Bad Säckingen, Germany). One set of tabs had original shade markings and the other was labelled with custom marks. Shade guide scores (3DS) were calculated as the number of correctly matched pairs. Both tests were performed under the controlled conditions (D65 light source, distance of 25–33 cm, and 0°/45° optical geometry) of PDV-2e/M viewing booth (GTI Graphic Technology, Newburgh, NY). All participants completed the tests individually, without any time limitations.

2.3. Statistical analysis

Mean values and standard deviations were determined. ANOVA, *t*-test and Mann–Whitney test were used for comparisons amongst scores related to profession, gender, age, and color vision classification for TES and 3DS, respectively. Pearson's correlation coefficient (*r*) was used to measure the strength of the association between the two tests (TES and 3DS).

3. Results

3.1. Color normal observers (dentists and laboratory technicians)

TES and 3DS were correlated, $r = 0.47$ ($p < 0.01$). The total error scores (TES) and 3D scores (3DS) results by gender, age,

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