

The Influence of Dental Shade Guides and Experience on the Accuracy of Shade Matching

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ABSTRACT

Aim: There is limited and inconsistent information on some factors affecting visual shade selection. The aim of this study was to evaluate the influence of shade guide type and professional experience on shade-matching results.

Materials and methods: Thirty Dental students (DS), 30 General dentists (GDs) and 30 Dental specialists (S) participated in this study. The participants were asked to match six target tabs using two dental shade guides: Vitapan Classical (VC) and Vitapan 3D-Master (3D). An intraoral spectrophotometer was used for color measurement of target tabs and selected tabs. The color difference (ΔE) values between the target tab and selected tab were calculated. Data were analyzed using analysis of variance (ANOVA) and paired *t*-test ($\alpha=0.05$). Results of the first five best matches for each target tab were expressed as ΔE_1 to ΔE_5 . Differences in the mean values of ΔE_1 to ΔE_5 between VC and 3D were compared using descriptive statistics.

Results: There were no significant differences among the three participating groups in ΔE values when the 3D was used ($p=0.389$). However, significant differences were found with VC ($p<0.001$). The ΔE values achieved from the 3D were significantly lower than those from VC for DS and S ($p=0.001$ and $p<0.001$, respectively). For each of the first five best matches, the mean ΔE values from the 3D were smaller than the corresponding values of VC.

Conclusion: The type of dental shade guide affected the shade-matching results. The level of experience was not found to be

an influential factor in shade matching when 3D-Master shade guide was used.

Clinical significance: Compared with Vitapan Classical shade guide, use of the Vitapan 3D-Master shade guide improves shade-matching results.

Keywords: Color, Experience, Gender, Selection, Shade, Visual.

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INTRODUCTION

Dental shade matching and the subsequent communication with the dental laboratory is one of the most critical procedures in esthetic dentistry. Many factors, such as light source, receivers, tooth texture and contour, and background, contribute to the quality of shade matching.¹⁻⁴ Tooth color is determined using either instrumental or visual methods. Instrumental shade determinations (spectrophotometer, colorimeter and spectroradiometer) are objective, therefore recommended as an invaluable complementary method along with a visual approach.⁵⁻⁷ Visual shade selection is the most common method used by clinicians, performed using a commercially available shade guide. However, most shade guides cover a limited number of tooth colors and do not show adequate distribution in the color range of the teeth.⁸⁻¹¹ In addition, lack of an exact color match between the tooth and the shade tab due to the limited number of shade guide colors results in an increase in the color difference between the tooth and the restoration.¹¹

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Despite these deficiencies, Vitapan Classical (VC) (Vita Zahnfabrik, Bad Sackingen, Germany), the most popular shade guide, has been widely used for decades and continues to be used. It contains 16 tabs arranged into four groups based on hue. In each group, tabs are arranged according to increasing chroma (a so-called A–D arrangement). In order to reduce the constraints described above, a Vitapan 3D-Master (3D) shade guide (Vita Zahnfabrik, Bad Sackingen, Germany) was introduced in the late 1990s. The manufacturer claims that this shade guide offers a wider color range, and that the tabs have a uniform color range. Compared with VC, which is designed empirically, 3D can facilitate greater shade selection because of closer utilization of the accepted color perception concepts of hue, value and chroma. This system contains 29 tabs that are divided into six groups according to value. Within the groups, shade tabs are systematically arranged according to the hue (horizontally) and chroma (vertically). Despite the advantages of the 3D over VC, less experienced dental practitioners find a shade guide with 29 tabs confusing and difficult to use.⁸

Experience is also discussed as a factor affecting shade selection quality. While it is traditionally believed that clinical experience plays an important role in shade matching, there are inconsistent findings. Some studies offer evidence of significant differences in shade-matching results between experienced and novice observers.^{1,12-15} However, other studies have found that the level of experience is not a significant factor.^{2,16,17}

The aim of this study was to evaluate the effect of shade guide type and professional experience on shade-matching ability under clinical light conditions. The null hypothesis was that the type of shade guide and the level of experience would have no effect on shade-matching results.

MATERIALS AND METHODS

The design of this study was approved by the Ethics Committee of the Vice Chancellor for Research at the Mashhad University of Medical Sciences. Thirty Dental students (DS), 30 General dentists (GDs) and 30 Dental specialists (S) participated in this study. Among them, there were 55 males and 35 females. All individuals were invited to participate in a voluntary shade-matching exercise. At least 5 years clinical experience and being aged less than 60 years were inclusion criteria for GD and S. Prior to the shade-taking procedure, DS and GD were trained in the correct shade-matching approach using VC and 3D. Prior to the experiment, all participants were tested using the Ishihara chart to determine color vision deficiency, based on 38 plates. Each volunteer was first asked to read 21 plates from the Ishihara test, and the examiner compared it with the checklist in the booklet.

More than four errors for an individual with normal color vision excluded the participant from the study. In this investigation, all participants passed the Ishihara test and no color vision deficiency was detected.

Six shade tabs, including A4, B1, B2, B4, D2, D3, were randomly selected from the Noritake shade guide (Kuraray Noritake Dental Inc, Kurashiki, Japan) and their identification code on the tab handle was concealed. The participants were asked to match the six target tabs using two shade guides: VC and 3D. The experiment was carried out in a spacious room with multiple windows in late spring between the hours of 10 am and 2 pm. The light condition was a compound of cool white fluorescent light and natural sunlight.

An intraoral spectrophotometer (Vita Easyshade, Vita Zahnfabrik, Bad Sackingen, Germany) was used for color measurement of target tabs and selected shade guide tabs from VC and 3D. A custom-positioning mold was made using heavy putty to provide accurate repositioning of the instrumental probe tip on the middle third of the labial tab surface. Cylindrical wax patterns (5 mm diameter × 5 mm height) were attached to the labial surface of the shade tabs in the area to be measured. The impression material was formed around the wax cylinder and over and around the labial surface of the tab. Upon setting, the wax cylinder was separated and a tunnel for placement of the spectrophotometer probe was created. The $L^*a^*b^*$ parameters were recorded and the color difference (ΔE) between the target tab and selected tab was calculated using following equation:

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

Based on ΔE values, the selected shade tabs for each target tab were arranged from lowest to highest. The five lowest ΔE values for each target shade tab were then chosen. The smallest color difference (ΔE) corresponded to the 1st best match. The second smallest ΔE corresponded to 2nd best match, and so on, up to the 5th best match that corresponded to 5th best match. In each of the two shade guides (VC and 3D), the mean ΔE values of the 1st match for all six target tabs were then calculated; this pattern was followed to 5th match. Differences in the mean values of ΔE for the 1st best matches between VC and 3D were compared using descriptive statistics; this pattern was followed to 5th best matches. Differences in shade-matching results between the two shade guides were analyzed using a paired t-test. A one-way analysis of variance was used for comparison of the three participating groups in each of the two shade guides. A *posthoc* Tukey test was applied when there was a significant difference. A significance level of $p < 0.05$ was used for all comparisons.

RESULTS

The mean and standard deviation (SD) of color difference (ΔE) values between target shade tabs and selected shade tabs from the two shade guides are presented in Table 1. A one-way ANOVA showed that there were no significant differences among the three participating groups in ΔE values when the 3D shade guide was used ($p=0.389$). However, significant differences were found among three participating groups with VC ($p<0.001$). Tukey's HSD test revealed that the ΔE values of DS and S were significantly smaller than those of GD ($p=0.001$ and $p=0.012$, respectively). Based on the results of the paired t -test, the ΔE values achieved from the 3D were significantly lower than those from VC for DS and S ($p=0.001$ and $p<0.001$, respectively). Independent t -test revealed no differences between ΔE values of male and female from both shade guides (Table 2). Descriptive data revealed that for each of the first five best matches, the mean ΔE values from the 3D were smaller than the corresponding values of VC (Graph 1).

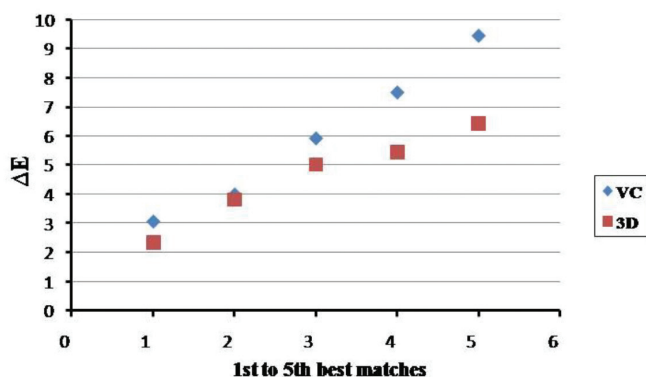
Table 1: Mean \pm SD of color differences (ΔE) values between target shade tabs and selected shade tabs from two shade guides for three participated groups

Participated groups	Dental shade guide	
	Vitapan Classical	Vita 3D-Master
DS	5.37 \pm 0.85 ^A	4.54 \pm 1 ^B
GD	4.44 \pm 0.81 ^C	4.47 \pm 0.94 ^C
S	4.2 \pm 0.79 ^D	5.15 \pm 1.09 ^E

Different lowercase letters in the column mean that the values are significantly different ($p<0.05$); Different uppercase letters in the row mean that the values are significantly different ($p<0.05$); DS: Dental student; GD: General dentist; S: Specialist

Table 2: Mean \pm SD of color differences (ΔE) values between target shade tabs and selected shade tabs from two shade guides for gender groups

Dental shade guides	Gender		p
	Female (N=35)	Male (N=55)	
Vitapan Classical	5.22 \pm 0.96	4.48 \pm 1	0.078
Vita 3D-Master	4.27 \pm 1.02	4.51 \pm 0.83	0.228



Graph 1: Mean color differences (ΔE) values of the first five best matches from 3D and VC

DISCUSSION

This study showed that the type of shade guide affected the shade-matching results of DS and S. However, the shade-selection results of GD were not influenced by shade guide type. Students with no clinical experience in shade matching achieved the same results as GD and S DP when the 3D shade guide was used. This result may be attributed to fact that the 3D shade guide provides a systematic approach in three steps. Thus, students with no experience in tooth shade matching can achieve a desirable result more easily. This is in agreement with the findings of Hassel et al,¹⁸ who asked dental students to match the shade of patient teeth using two shade guides, either the VC or the 3D. It was found that all tooth restorations whose shade had been determined using the 3D could be placed without any modification, whereas 17% of restorations that had been shade matched using the VC required color correction.

Surprisingly, GD exhibited better shade-matching results than S when VC was used. It should be noted that most GDs routinely use VC alone, while specialists, who use both VC and 3D shade guides, may experience hesitation or even erroneous selection when using the VC.

In this study, the three groups as organized by level of experience did not differ in shade-matching results when the 3D shade guide was used. This finding is consistent with studies that reported no effect of experience on shade matching.^{2,16,19} In contrast, Dagg et al¹³ reported that under ideal light conditions, the level of experience influences shade matching. Experienced practitioners including dentists and technicians obtained more accurate results than novice observers, including 3rd-year dental students. However, under a compound of natural and fluorescent light, there was no difference between experienced and novice observers. The discrepancy between the study by Dagg et al¹³ and the results reported here might be attributed to the fact that Dagg et al¹³ considered the number of correct and incorrect matches as a scale for shade-taking ability, whereas in our study, the color difference between the target tab and selected tab was a criterion.

In another study, Curd et al³ evaluated the shade selection ability of dental students based on the years in school. Third-year students were grouped as inexperienced practitioners, while fourth-year students were classified as experienced. Students used the VC shade guide and the shade-matching procedure was carried out under different light sources. Although it was found that the level of experience had no effect on shade matching, it should be noted that the level of experience investigated in this particular study cannot be considered as professional

experience, as dental students achieved no noticeable clinical experience during their education period.

In the current study, the first five best matches of each target tab were arranged according to ΔE , from lowest to highest. The mean ΔE values for the first five matches in six target tabs were calculated. The results indicate that for each of the first five matches, the mean ΔE values for the 3D were lower than that of the VC. Similar results were reported by Paravina.⁸ The first five matches for 3D exhibited smaller ΔE s than those for VC. This means that chances to select the shade with smaller color differences were higher with 3D, which is consistent with findings of coverage errors of these two shade guides.^{20,21} Nevertheless, the 1st-to-3rd best match for both VC and the 3D showed a color difference lower than 1 unit, as both shade guides nearly coincide with each other in ΔE 2 (Graph 1).

It was previously reported that the least perceptible color difference (ΔE) was 1 unit for 50% of human observers.²² Furthermore, under uncontrolled clinical conditions, such small differences in color would be unnoticeable, as average color differences below 3.7 are rated a 'match' in clinical conditions.²³ Considering the fact that in the present study, the mean ΔE values for the first best matches in both the shade guides were lower than 3.7, it can be concluded that both shade guides are clinically acceptable in the first best match. In support of this, Öngül et al revealed that ceramic crowns that had been shade matched with the 3D shade guide resulted in a closer color match to natural teeth ($\Delta E=0.84$) than those matched using the VC ($\Delta E=1.95$). However, the crowns created with both shade guides were within the clinically acceptable range ($\Delta E < 3.7$).²⁴

This study is in agreement with findings that gender is not an important factor in shade matching ability.^{1,2,4,5,25,26} It should be noted, however, that Haddad et al¹⁶ reported that females achieved better shade-matching results than males, while Milagres et al found that men were more successful in discriminating shades.¹⁵

In some studies,^{2-4,13,17} the number of correct choices was considered with respect to shade-matching results. In such studies, selections that are labeled as an incorrect choice may in fact be very close to the target tab. Thus, the degree of color difference (ΔE) between the selected tab and the target tab is considered in the present study.

As found in many studies, more accurate shade-matching results may have been obtained if this study could have been conducted under a corrected light source. However, the applied light condition used is closer to the clinical situation because no special area is allocated for shade selection in most dental clinics.

In some studies, the shade guide type which is used for shade matching and the target shade tabs are the same which may cause bias toward certain shade tab. Employing the Noritake shade guide, which is different to the other two shade guides, as the target shade tabs provided a closer situation to the clinical condition.^{1,3,4,8,17} It should be noted that in clinical situations, the tooth color of the patient does not necessarily fully match a shade tab from the shade guide, yet the closest color from the shade guide is selected. However, using vital natural teeth as a target provided our study with a situation closer to the clinical color selection.

CONCLUSION

Within the limitations of this study, the following conclusions can be drawn:

- The type of dental shade guide influenced the shade-matching results.
- The level of experience was not found to be influential factor in shade matching when 3D-Master shade guide was used.
- Chances to select the shade with smaller color difference were higher with 3D-Master than with VC.
- Gender was not a significant factor in matching.

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