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Research Article

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The Development and Assessment of Different Shade Selection Protocols, A Novel Approach

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ABSTRACT

This study aimed to evaluate various shade selection protocols using corrective light for shade selection with different viewing backgrounds and to assess the shade matching the performance of students in King Abdulaziz University Faculty of Dentistry (KAUFD). One-Hundred participants were recruited from undergraduate levels with clinical experience. Six different techniques took place with each participant individually using either daylight or corrective light (Smile Lite), with or without a polarizing filter, and different backgrounds. Participants were asked to choose the most appropriate shade of three different shades of artificial teeth placed on an experimental model. A statistically significant difference was reported in correct shade selection between participants who are familiar with the gold standard compared to those who are not. Corrective light with a polarizing filter was the most preferred technique among all participants (62%). There was a significant difference between techniques where using the corrective light technique presented the highest number of correct shade selections (P-value= 0.008). The shade matching performance among dental undergraduates was better when corrective light with a filter was used and when they have previous knowledge of the gold standard protocol for shade selection.

Key words: *Shade Selection, Protocols, Corrective light, Smile lite, Polarization filter*

INTRODUCTION

Nowadays, patients are more aware of the smile's impact on their social as well as professional life. Therefore, dentists should respect patients' demands regarding their dental esthetic [1]. As concerns about appearance are increased, it is important to recognize the elements that may contribute to esthetically pleasant teeth. Teeth color, dimensions, and proportions to the midline and facial elements are other essential elements. Determining shade for both direct and indirect restorations is a crucial step and has been always a challenge for esthetic dentists [2]. Recent studies showed that the major aspect of patient satisfaction and judging the quality is mainly through color matching of the restoration or prosthesis [3].

Matching tooth shades may be achieved visually using dental shade guides or instrumentally. Visual shade matching remains the most commonly utilized method by dentists [2]. Although visual methods for shade selection is subjective and can be affected by many variables, such as experience and color deficiency, they should not be considered inferior [3]. Shade guide tabs used in the visual methods are arranged according to their concept of manufacturing either hue-based or value-based shade guides. However, It was found that shade guides which are value-based are more accurate in shade determination as the human eye is more sensitive to changes in chroma

and lightness or darkness [4].On the other hand, digital shade-taking devices are increasingly used nowadays in an attempt to achieve standardized, reliable, as well as accurate color measurements and shade matches as these methods are considered more objective than visual shade selection [5]. Instrumental shade selection includes the use of spectrophotometers, colorimeters, or image analysis techniques. However, these specialized devices being expensive and not always convenient to use decreased their regular use by dentists [6]. A combination of using visual and instrumental methods has been recommended, whenever it is possible, to reach a more certain esthetic outcome [7].

The illuminating conditions in the dental clinic vary greatly depending on the availability of daylight, the time of the day, and the light source or a combination of these sources. It has been found that these variations greatly affect the quality of shade determination [8]. Therefore, light correcting devices have been introduced and recommended to control the effect of different light sources and it is considered an affordable substitute for digital shade-taking devices [9]. The early version of the handled light-correcting device used a fluorescent tube which has a large dimension and was not user-friendly. Eventually, new generations of light-correcting devices have been introduced and reported more efficient color-matching results [9, 10]. Lately, polarizing filters have been added to light correcting devices to annihilate the reflected light and enhance the assessment of depth and transparency [11]. One of these devices with its polarizing filter has been investigated previously and the study found that using a light correcting device has improved the shade-matching ability, however, no improvement in shade matching was reported upon using filter [9]. Up till now, there is no studies were reported to investigate the effect of using these light correcting devices with different backgrounds compared to natural light source in standard settings.

The purpose of this study is to investigate participants with the same level of clinical experience in terms of their shade-matching performance using a new light correction device with multiple shade-taking techniques for different shades. The null hypothesis states that (1) the observer's knowledge of standard shade selection guidelines or (2) their gender did not influence the shade-matching results, and (3) there was no difference in the shade selection performance of dental students using different protocols.

Daylight corrected light source of 5500oc significantly improves shade-taking accuracy of dental personnel.

MATERIALS AND METHODS

Participants

A total of one hundred participants from King Abdulaziz University Dental Hospital were included in the present study. Higher levels of dental education were included to ensure suitable clinical experience (Internship year, and final undergraduate year students). This research was approved by Research Ethics Committee at King Abdulaziz University, according to guiding principles for investigational methods found in the Declaration of Helsinki of the World Medical Association (No. 144-11-19). Each participant received information regarding the study proposal and signed written consent for participation. Before participation, participants were asked to take Ishihara's test for color blindness, available on the website (Colormax.org) [12]. Only participants with normal color vision were included.

Experimental setup

VITA Classical shade guide (VC) with sixteen tabs assorted according to value, was used in this study. Three shades (A1, B2, and A3) were chosen from on VC as the tabs to be masked and matched. These shades were selected due to the frequency of their existence in natural teeth. A phantom head with its jaws (typodont) was used in a standard location with a large window and neutral color surroundings in the prosthodontic laboratory at KAUFD. A Grey placard was secured behind the phantom head and was easily replaced with a blue one when indicated. Each of the selected shade tabs was mounted, consequently for each participant, on a typodont replacing the upper right central incisor tooth. To ensure the blinding of participants, each shade tab ID was masked with a tape and assigned by a code throughout the study. At the start of each shade-taking session, the Smile Lite device was fully charged and the polarization filter attached to the device except for the shading technique which indicated otherwise.

Testing shade selection protocols

The test took place between 10:00 a.m. and 3:00 p.m. with appropriate illumination in the research setting. All participants were asked to select the shade of the mounted tooth with six different techniques; **T1;** Daylight with a grey background, **T2;** Daylight with a blue background, and **T3;** Corrective light (Smile Lite – Smile Line,

Z.I La Clef 5, 2610 St-Imier, Switzerland) with a blue background, **T4;** Corrective light (Smile Lite) with a grey background, **T5;** Corrective light (Smile Lite) with polarizing filter, and **T6;** Corrective light (Smile Lite) without polarizing filter **Figure 1**.

The masked tab was replaced with the following shade, 3 times. Each participant performed shade-matching using all six conditions while selecting the most preferred technique. There was no time limit allocated for each participant to experiment.

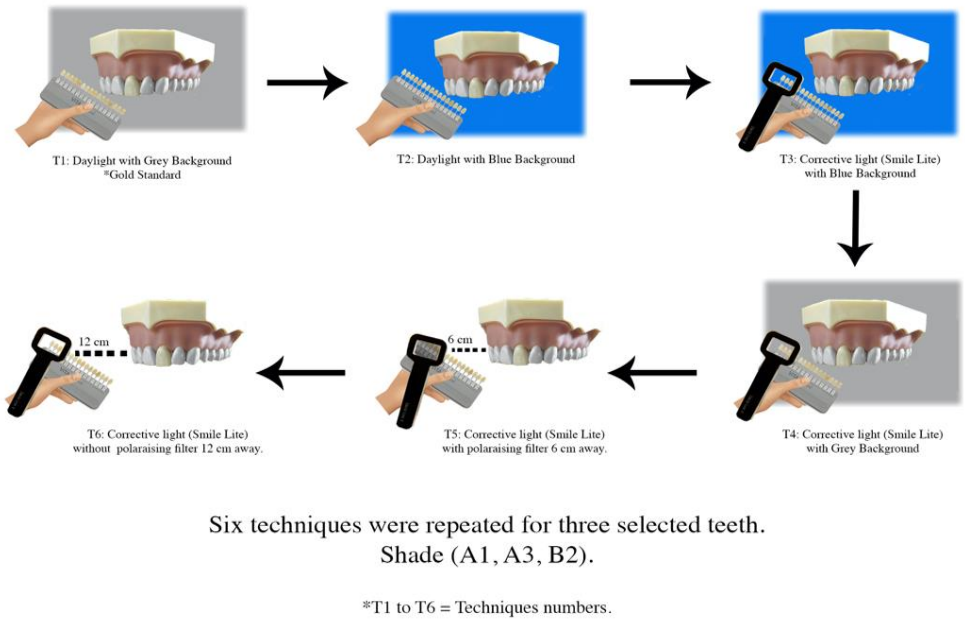

Figure 1. Schematic illustration of the shades, corrective light, and shade selection techniques

Shade -matching technique code and statistical analysis

Each technique code was recorded with the preferred one reported by each participant till all participants performed all techniques. Data were collected and explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests with non-parametric (non-normal) distribution resulting. The Kruskal Wallis test was applied to compare non-related samples between more than two groups and the Mann-Whitney test was used for comparing non-related samples between two groups. The Chi-square test was used for frequency comparison. The level of significance was set at $P \leq 0.05$. For Windows, statistical analysis was calculated using IBM® SPSS® Statistics Version 20.

RESULTS AND DISCUSSION

A total of 100 dental students (48 Females and 52 Males) with normal color vision participated in the present study. Of all participants, 80% were familiar with the standard guidelines for shade selection before participation in the study, and 20% were non-familiar (P=0.001). Moreover, the results indicate a significant difference in the correct selection of shade between those who are familiar with the standard guidelines (mean value 3.5) compared to those who are not, (mean value 5.7), (P= 0.01). On the other hand, gender didn't influence correct shade selection, the mean value was 5.35 in the (Males) group, while 5.13 in (Females) with no statistically significant as (P=0.640).

The light corrective device showed very promising results in the selection of the correct shade in the present study **Table 1**. The results showed that the techniques using the device with the polarization filter (T5) has the highest value of correct shade selection (124) correct answers out of 300 trials, followed by T6, a corrective light device without filter (93), and the least was T2, daylight with blue background (60), with a statistically significant difference among other techniques performed (P=0.001). Moreover, this protocol was significantly preferred by 62% of participants followed by T3,6. Corrective light devices with a grey background (T3) represent (3%) the lowest percentage of the total 100 participants with a statistically significant difference between frequencies of

different techniques where (*P*=0.001), **Table 2**.

Comparing visual and light corrective techniques regardless of the background (comparing with and without SmilLite- Grey background), it was found that there is a significant difference between T1 and T4 (*P*=0.054). Moreover, comparing T2, and T3 (with and without SmilLite Blue background) showed significant differences as (*P*= 0.03).

It was found that the background color used didn't affect the results with no- statistically significant difference recorded between the grey and blue colors used comparing T1&2 (daylight) as (*P*=0.11) and T3& 4 (corrective light devise) as (*P*=0.55). Similarly, using the polarization filter influenced the correct shade selection, as there was no significant difference in the mean of correct shade selection when comparing T5 &6 (*P*=0.06).

Table 1. Values of the correct shade selected with different techniques performed

Variable	Value	Percentage	SD	St error
T1	78	26	0.77	0.08
T2	60	20	0.68	0.07
T3	87	29	0.87	0.09
T4	78	26	0.76	0.08
T5	124	41	0.90	0.09
T6	93	31	0.82	0.08

Table 2. The frequencies of the preferred technique

Shade selection technique	Preferred technique % of participants
T 1	5%
T 2	4%
T 3	15%
T 4	3%
T 5	62% *****
T 6	11%
p-value	**<0.001***

Visual shade selection remains the most common technique used by dentists to select the shade of any new restorations. It depends largely on the color perception of the observer, thus it is highly subjective. Moreover, when matching the color of the same tooth, high disagreements have been found between dentists and also between different readings of the same individual dentist at different times [13]. This is mainly because the visual method can be affected by multiple variables which may be related or not related to the observer. Therefore, several researchers have looked at developing protocols and methodical approaches to shade taking to limit the effect of these variables. In this study, different protocols were proposed and have been compared by dental students at KAU who were tested for color blindness before participating in the study. Possibly, both color-deficient and non-color-deficient dental students could benefit from a commercially available light source, however, in this study only participants with normal color vision were included [7].

There are general guidelines while selecting the shade which is well known to young dentists and thoroughly covered in their undergraduate studies. The level of knowledge and the ability to follow these guidelines may help standardize the process and reduce the chances of shade mismatching [8]. In the present study, it was found that participants who are familiar with standard guidelines for shade selection performed significantly better than those who are not. Therefore, the first null hypothesis was rejected. This is in agreement with another study which found that the knowledge, as well as the practice on color science and shade selection, dramatically improved visual shade matching [14]. Moreover, when the performance of three groups of observers was compared, it was found that familiarization with the shade-matching processes is significant for the dentists to achieve accurate shade selection [15, 16].

On the other hand, this study found that gender did not have any effect on shade-matching results in any of the used protocols. Therefore, the second null hypothesis was accepted. A similar result was found in previous studies where no gender differences in shade-taking performance were found [10, 17]. However, gender influence on

shade selection has been a controversial subject as reported by Haddad *et al*. in 2009 [18] who claimed that female participants achieved significantly better shade matching results than male ones. However, Miranda 2012 found males to be better able to discriminate shades [19].

Regarding the tested protocols in the current study, different light sources were compared against two different colors of the background. Illumination is a critical variable in dental shade selection that must be considered. It has been found that poor lighting showed a negative effect on the performance of all observers regardless of experience [13]. To minimize this effect, daylight was suggested as being the most suitable type of lighting used for matching shades [8]. However, this is usual in the dental clinic as the shade may not be taken during the day, nor is a good quality of daylight can be available. Therefore, in such conditions, the use of correcting lamps has been recommended as it showed considerably superior results compared to artificial lighting [10]. In the current study, several techniques were tested against 3 main variables: (1) comparing both day-light and corrective light devices (Smile Lite, Smile Line), (2) using the corrective light with and without a polarization filter, and finally (3) using two different backgrounds.

The device used in this study (Smile Lite – Smile Line, Switzerland) is a daylight-corrected lamp that utilizes LED technology with a color temperature of 5500oK and provides a detachable colorless polarization filter. The device is handheld, user-friendly, and is believed to enhance the visualization of internal details of color, transparencies, and characteristics [11]. However, the benefits of using the polarizing filter in visual shade selection are still questionable. The results of the present study demonstrated that correct shade matching scores were significantly higher while using the Smile Lite device with a polarization filter (T5) which was also the preferred technique by most of the participants (62%) **(Figure 2, Table 2)**. Therefore, the first null hypothesis was partially rejected. Similar findings were found in previous studies, where the use of the corrective light device has significantly improved the shade selection results [19]. Some studies also tested the Smile Lite, however, they concluded that the polarisation filter did not provide additional benefits, but Smile Line, which produces the Smile Lite claim that the use of polarization improves shade taking [20]. The results of this study suggested that although using the polarizing filter was preferred by most of the participants, it did not increase the number of correct shade selections (comparing T5 &T6). Previous studies stated that the polarization filter reduces oblique reflections from glossy surfaces which in turn darkens and saturates the perceived color by removing all redundant reflections, which may explain why the observers preferred it but it did not improve their shade selection performance.9Another possible explanation for the favorable effect of T5 is that the field of view was focused through the small window of the corrective light device and the participants directly examined the area of interest for color matching. Therefore, any background distraction would be eliminated which may result in a more relaxed and focused shade selection process. However, since the extent to which the polarizing filter influences the outcomes of visual shade selection is still not clear, future research is recommended to include natural teeth to evaluate the actual influence of the device and the polarizing filter. This would allow to include the influence of different optical properties of enamel and dentine in the evaluation rather than the standard shade tabs used in this study.

On the other hand, the grey and blue color backgrounds in this study were selected based on several types of research which reported utilizing a grey background and others stated that blue background is recommended during shade selection, as both colors are believed to reduce eye fatigue [21, 22]. One of the limitations of the present study is that there was no time limit set for participants, they were only advised to rest their eyes on a neutral background of color whenever required if eye fatigue might have occurred during the tests. However, the results of this study suggest that different background colors did not have an impact on the results of the shade selection procedure, either with or without a light correcting device. Although blue background has been described as helpful in resting the observer's eyes [22], it was reported that it can result in an after-image and lead to choosing shades that are toward the orange range [21].

CONCLUSION

In conclusion and within the limitations of this study, the results revealed that participants, who were familiar with the gold standard performed significantly better than those who were not. Dental practitioners preferred to select the tooth shade using the light corrective device with the polarization filter which significantly improved the shade selection performance, however, the use of a polarization filter with the light did not further improve shade taking. No difference in the shade-taking performance was found when using different background colors.

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