

COMPARISON OF TOOTH SHADE MATCHING USING VISUAL AND DIGITAL CAMERA METHODS

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ABSTRACT

Accurate recording of the shade of the tooth, its communication to the dental laboratory and its reproduction plays a fundamental role in the restorative and prosthetic procedures. Visual shade selection with a reference shade guide is the most common method for shade matching employed in routine clinical practice but it is associated with a high degree of subjectivity. Recently digital devices like colorimeters and spectrometers have been developed to objectively measure the colour. These devices can read the colour data in terms of luminance (L), chroma (C), and hue (h). Researchers have also used high end digital cameras in combination with graphical softwares to measure the tooth colour. A photograph with a digital camera can replicate the true colours and presents this information in terms of numerical data. The aim of this study is to compare the tooth shade matching using simple visual method and digital camera assisted method.

In vitro experimental study conducted at the prosthetic laboratory of Aga Khan University Hospital, Pakistan

All shade tabs from a vita classic shade guide were photographed using a compact digital camera to acquire three images of each tab at a pre-set object-camera distance generating 144 reference images. Same was done with six masked tabs to acquire a set of 18 test images. Colour values were obtained for an area over body of each image and the closest match between test and reference tabs was determined for digital method. For visual method, participants were asked to match the tooth shade. The outcome was correct match versus incorrect match.

Data was analyzed using SPSS 19.0. Chi square test was applied to compare the visual and digital methods and to compare colour matching skills of the dentists and their assistants. P value of <0.05 was taken as significant.

With the visual and digital method, correct shade was selected in 39.4% and 66% cases respectively. The digital method yielded better shade matching that was statistically significant

Digital colour matching was found to be superior to the visual method. Significantly better shade selection can be done by using compact digital cameras as compared to the visual method alone. Males and dental assistants exhibited better colour matching skills than females and the dentists.

Key Words: Dental esthetics, Shade selection, Color matching, Teeth shade

INTRODUCTION

Accurate determination of the tooth shade is a crucial factor in restorative and prosthetic procedures¹. It is the key factor that influences the esthetic outcome of

anterior crown or bridge restoration. Accurate recording of shade of the tooth, its communication to the dental laboratory and its reproduction in the final restoration plays a fundamental role in these procedures.

Visual shade selection with a reference shade guide is the most common method for shade matching employed in routine clinical practice^{2,3} but it is associated with high degree of subjectivity.⁴ The colour perception between different individuals is variable and is greatly influenced by the individual's experience in shade matching.⁵ The light source, direction and intensity also influence the perception of colour.⁶ Natural teeth show a wide variation in colour that the common shade guides cannot encompass. Visual shade matching owing to its subjectivity is a concern for the dental clinicians

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so different devices have been introduced to aid the colour selection for achieving optimum aesthetics.⁷

The use of electronic shade-matching devices has become common in dentistry. Recently digital devices like colorimeters and spectrometers have been developed to objectively measure the colour.^{8,9} These devices can read the colour data in terms of luminance (L), chroma (C), and hue (h) which can be stored for later comparison and calculate the colour difference (E) between the two objects using the CIELCh formula. Various studies have been conducted to determine their accuracy and reliability which have supported their use for this purpose.^{10,11} Researchers have also used high end digital cameras in combination with graphical software to measure the tooth colour.¹² A digital photograph with a good camera can replicate the true colours and present this information in terms of numerical data. Studies have described different settings and object-to-camera distances to acquire the images for digital shade matching.^{9,12,13}

Numerous devices have been developed to aid the shade selection but there is no consensus regarding the ideal method of shade selection.⁷ These are expensive and may not be readily available in general dental practice. Literature strongly recommends the use of supplementary tools in routine to enhance esthetic outcome.³ The objective of the current study was to compare the visual shade matching versus digital image obtained from a commonly available digital camera using graphical software.

MATERIALS AND METHODS

The study was conducted at the dental clinics and prosthetic laboratory of Aga Khan University Hospital, Pakistan. For the preparation of digital shade guide, all sixteen shade tabs from Vita Classic shade guide were individually mounted on a custom setup to record the baseline values of all the shades for later comparison to the test tabs. All the tabs were illuminated in standard 6500 K light using two light sources (Philips® Tornado 25W Daylight) which were kept at a 45° angle to a perpendicular drawn from center of body of the shade tab to avoid unwanted reflection of light which might influence the colour recording. An ultra-compact digital camera (Sony CyberShot, DSC-W380, 14.1 Mega Pixels, Taiwan) was used to generate the images by a single photographer. For all the pictures, the camera settings were kept constant at ISO: 100, White-balance: Auto, EV: 0, zoom: 1.9 X. Three images of each tab in the shade guide were taken at a pre-set object-camera distance of 10cm, 15cm and 30cm. In this way, 144 reference images were generated. Out of focus or blurred images were discarded and new image was taken to replace it.

For establishing test tabs, six tabs from vita classic shade guide (A1, A2, A3, A3.5, C2 and C3) were used and their identity was masked. The photographer was blinded to the shade number and the above mentioned procedure was repeated to acquire a set of 18 test im-

ages at 10cm, 15cm and 30cm. The two set of images (reference images and test images) were imported in the Adobe Photoshop® CS5 software. A small white area in background of all images was selected and its colour was matched in all the images using the command: Image> Adjustments> Match colour, to standardize the white balance of the images and remove any colour cast. A small area on the middle third of the body of each shade tab was selected and the colour of selected area was averaged using Filter>blur>Average command in photoshop. The grid tool in photoshop was used in order to select the same area on each image. Colour parameters (hue, chroma and value) were recorded for all the images using histogram tool in the photoshop. In order to select the best match, the colour differences between all test tabs and each of the reference tabs at the corresponding distances were calculated using CIE formula: $\Delta E = \sqrt{(\Delta L^2 + \Delta C^2 + \Delta h^2)}$. The reference tab with the least value of colour difference (ΔE) from the test tab at corresponding distance was labeled as the correct match determined digitally.

For visual method, 11 people related to the dental profession participated. All the participants in the study had normal colour vision. The protocols followed for each individual were uniform and standardized. During the shade matching procedure, the participants were made to sit on the chair placed at the same area of the room at the same time of the day. Six masked test tabs (A1, A2, A3, A3.5, C2 and C3) were presented to each of the 11 participants (six males and five females). They were given a full set of Vita Classic shade guide to visually match each masked tab to the correct tab from the shade guide. All the shade matching was carried out under optimal daylight. The evaluators were given up to 20 minutes to select the correct match to each test tab.

DATA ANALYSIS

Data was analyzed using SPSS 19.0. Descriptive measures such as counts of correctly identified shades were obtained. Chi square test was applied to compare the visual and digital methods. Spearman rank order correlation test was applied to determine correlation between object to camera distance and shade matching ability. Chi square test was also used to compare the colour matching skills of the two genders and the dentists and their assistants. A p-value of <0.05 was taken as statistically significant.

RESULTS

There were 11 participants in the study, 6 males and 5 females. Of the six male participants, two were dentists and four were dental assistants while the five female participants comprised of four dentists and one dental assistant. The details are summarized in Table 1. The six male participants assessed 36 tabs (six each participant) and selected correct match for 18, thus resulting in 50% correct shade match. The female participants assessed 30 tabs (six each participant) and selected correct match for 8, resulting in 26.6% of

the correct shade match. The p-value was calculated to be 0.053 which was marginally significant.

When comparing dentists and dental assistants, dentists correctly matched 8 out of 36 shades (22.2%) while the assistants correctly matched 18 out of 30 shades (60%). The difference between the two groups was statistically significant (p -value 0.002). Overall, with the visual and digital method, correct shade was selected in 39.4% and 66% cases respectively. Digital method yielded better shade matching that was statistically significant with a p -value of 0.03. The results are summarized in Table 2.

When using digital camera, it was found that 50% ($n=3$) of the test tabs were correctly identified when images were taken at 10cm and 15cm camera distance. However at 30cm, shades of all the test tabs were correctly identified. The results are shown in Table 3.

DISCUSSION

The restoration and prosthesis indicated in the aesthetic zone of the oral cavity warrants accurate shade selection. Shade matching is both an art and science.¹⁴ Improper shade selection was found to be the second most common reason for re-fabrication of ceramic restorations.¹⁵ Visual shade matching using a shade guide is the oldest method of shade selection which is prone to errors owing to its subjectivity. Different commercial shade guides also vary with respect to hue, value and chroma.¹⁶ Shade selection using digital methods enables the dentist to perform an objective analysis of the shade which is both more accurate and easily reproducible.¹⁷ Nowadays, spectrophotometers, colorimeters and high-end digital cameras are being used for this purpose.^{8,9} The results of the study showed a significant difference in visual and digital methods of shade selection. 39.4% correct shade matching was achieved visually by the participants while the results were 66% for digital method. Visual assessment of the colour by an individual depends on various physiologic

and psychologic factors. It may vary as a result of fatigue, aging, emotions, lightning conditions, previous eye exposure, object position and metamorphism.¹⁸ Numerous studies have demonstrated an improved selection of correct shade by digital methods when compared to the conventional visual method.^{19,20} In a recent study by Miyajiwala and colleagues¹⁴, three methods for tooth shade selection were compared i.e. visual, digital photography and spectrophotometer. They concluded that digital photography is a potential alternative to the use of spectrophotometers for shade selection. Lars Schropp¹² conducted a study using professional camera and visual shade matching and found that correct shade match with visual and digital method was 32% and 67% respectively. He concluded that shade matching assisted with digital photographs and computer software is significantly more reliable compared to the conventional visual methods. The results of this study are comparable to his study. In a similar study by Jarad and colleagues¹³, digital imaging and conventional visual methods were compared. Correct match was observed in 43% and 61.1% by conventional and digital methods respectively. They also found that colour parameters determined by the spectrophotometer and digital photography methods were in agreement to each other and therefore digital radiography can be used for shade selection clinically. Similar results were obtained by study conducted by Farah.²¹ The results of these studies are also in agreement with our study.

Another interesting finding in the study was the

TABLE 1: DEMOGRAPHIC DETAILS OF THE PARTICIPANTS IN THE VISUAL METHOD

Gender	Dentist	Assistant	Total
Male	2	4	6
Female	4	1	5
Total	6	5	11

TABLE 2: COMPARISON OF CORRECT SHADE MATCHING WITH VISUAL AND DIGITAL METHODS

Settings		Shades						Total	%	P-Value
		A1	A2	A3	A3.5	C2	C3			
Visual Method	Correct Shade	5/11	5/11	4/11	7/11	2/11	3/11	26/66	39.4	0.03
Digital Method	Correct Shade	2/3	2/3	2/3	2/3	3/3	1/3	12/18	66.0	

TABLE 3: CORRECT SHADE MATCH BY DIGITAL METHOD AT DIFFERENT OBJECT-CAMERA DISTANCE

Object-Camera Distance	Correct Shade Match					
	A1	A2	A3	A3.5	C2	C3
10 cm	✓	✓			✓	
15cm			✓	✓	✓	
30cm	✓	✓	✓	✓	✓	✓

effect of changing the object to camera distance on the correct shade selection using the digital method. Different studies have used different distances for the shade matching purposes but none have compared its effect on the process of shade matching.^{11,14} In our study, an increase in the distance from 10cm to 30 cm resulted in an excellent match of shade as shown in Table 4. Further studies may be necessary to test this phenomenon as it may ease up the process of digital shade matching using non-contact based method using hand-held photography which is easier chair-side as compared to the use of tripod or other fixed approaches mentioned in previous studies.

In the current study, a compact digital camera was used instead of a professional one because it is easily available and can be used in routine practice. It was found that even a compact digital camera can serve the purpose by demonstrating better colour matching ability compared to the visual method. The use of digital cameras for accurate shade matching has the advantage owing to its easy availability and cost effectiveness.²² There are numerous advantages of the digital photography technique compared to the traditional method of shade selection using shade guides. If this technique is carried out in the correct scientific manner, it is an objective method and is not dependent on the dentist and patient factors. It is easy to perform and the exact colours of different areas of the same tooth can be obtained in the similar manner.¹⁴ The only disadvantage of digital methods is the learning curve associated with the use of computer software and ensuring the standardization of photographs taken with the camera at a stable distance and constant illumination.²³

In the current study, dental assistants showed significantly better colour matching ability for visual shade matching than dentists. The correct shade match was (8/36) 22.2% among dentists and (18/30) that is 60% for dental assistants. The results are supported by various studies in which dental technicians and dentists showed comparable results in shade selection.^{24,25} However some studies showed no significant difference among different occupational groups.^{26,27} Schropp¹² found that the dentists were able to determine the correct shade in 35% of cases and the assistants were able to match the shade in 31% of cases. The difference in shade matching could probably be attributed to the phenomenon of "eye fatigue". Constant stimulation of the nerves involved in colour vision results in a decrease in eye's response.²⁸ It is found that the colour vision capability of the eyes decreases when the tooth is viewed for more than 10 seconds.²⁹ Alvin³⁰ and Azad *et al.*³¹ suggested painting the operatory walls pale blue (contrast to the colour of teeth) to improve the accuracy of shade selection. Focusing on the pale blue colour immediately before and during the shade matching will re-sensitize the eyes to the tooth colour and therefore improve shade selection. As the dentists focus on a limited field of vision during the procedure³² compared to the assistants, the phenomenon affects them more. Therefore based on the results of the current study, it is suggested to

involve the dental assistant in shade matching procedure. Another reason for these results could be the clinical experience of the participants which was not considered in the study. Clinical experience is a crucial factor in shade selection.³³ It is important to compare the capability of different individuals based on their experience in shade matching.

In the study, male participants correctly matched 50% of the shades while females were able to match only 26.6%. The results were marginally significant. This is in contrast to various studies in the literature in which females showed better results than male observers.³⁴ It is considered that men and women differ in their capacity to distinguish shades³⁵ and women are generally better in shade matching than men. Miranda³³ found similar results in their study in which men showed better results compared to the woman. Same results were obtained by Donahue and colleagues.³⁶ Bimler³⁵ explained this in his research that men are less sensitive to stimuli on green-red axis but are more sensitive along the axis of brightness. He proposed that as value of any shade is the most critical component of colour in shade matching, it could possibly account for better shade matching by men. This is perhaps one of the reasons that explain the results of the current study whereby men selected correct shade more frequently.

LIMITATIONS

The limitations of the study show that only one type of shade guide (Vita Classic) was utilized in this study. Only one digital camera (Sony DSC-W380 camera) was used. Convenience sampling was done for the participants in visual method. The clinical experience of the participants plays a major role in shade selection which was not accounted for in the study.

CONCLUSIONS

The process for shade matching using electronic devices like spectrophotometers, colorimeters and digital camera appears to be relatively complex and time consuming. However, when compared to visual method, it invariably results in improved colour matching which can save valuable clinical time by avoiding mismatched restorations. Therefore, the use of hand held photography is a step forward to facilitate the process chair-side. Within the limitations of the study, it can be concluded that:

1. Significantly better shade selection can be done by using compact digital cameras as compared to the visual method alone.
2. It is suggested to involve dental assistants in the shade matching procedure.

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- 1 **Saqib Naeem Siddique:** Conducted literature review, collected all the data and compiled the results, wrote the first draft of this publication.
- 2 **Farhan Raza Khan:** Supervised the entire research, helped in the interpretation of the results, proof reading of the first and final draft for publication.
- 3 **Palwasha Babar:** Helped in literature review and publication writing, refined the first draft written by the first author, wrote the final draft of this publication.