MOBILE DENTAL PHOTOGRAPHS: An Innovative alternative for shade determination

Radhika Chheda, Dr. Pratik Chheda, Dr. Jyoti B Nadgere

Reader, Prosthodontist, HOD and Professor

MGMDCH, Kamothe

Abstract:

Aim: Esthetic dentistry involves shade determination. The conventional shade guide is a subjective method whereas spectrophotometer is an accurate but an expensive method. The need for determining the shade using an effective and inexpensive method is a clinical requirement. The study is aimed at comparing mobile dental photographs to spectrophotometer as an effective means of shade determination.

Material and Method: 50 participants with no restorative or traumatic changes on the left central incisor were selected. Shade was determined using spectrophotometer and mobile photographs. The L*a*b* values obtained from each were noted. ΔE was determined and the agreement between the readings obtained by the two different methods was compared and subjected to appropriate statistical analysis.

Results: The results showed that there was a statistically non-significant difference seen for the values between the 2 techniques ($p>0.05$). The mean ΔE was 1.5. There was a statistically significant difference between the proportion of ΔE more than and <2, between spectrophotometric and mobile dental photography methods ($P < 0.01$) with higher proportion of <2 ΔE.

Conclusion: The mobile dental photograph is an effective reliable means of shade determination. It also can be used as an adjunct for shade communication and establishing the characterization for an esthetic restorations.

Clinical significance: Mobile dental photographs has been established as one of the effective means of shade determination and communication without an additional expenditure. It can help mimic not only the shade but also the characterization by the lab personnel as the photograph communicates these details for reference.

Keywords: Color, Colorimetry, Dental prostheses, Esthetics, Photographs.

Introduction:

Digital photographs have become an integral and important aspect of modern dentistry. There are many reasons for using dental photography today; the primary purpose of digital dental photography is recording accurately the clinical manifestations of the oral cavity. As a spinoff, secondary uses include legal documentation, publishing, education, communication with patients, dental team members, colleagues and technicians, and finally marketing [1].

With ever-increasing emphasis on esthetics in dentistry and patient demands to fabricate ceramic restorations that mimic natural teeth, that are indistinguishable from adjacent natural teeth, the ability to correctly evaluate tooth shade information and effectively communicate it to the ceramist is now more critical than ever [2].

Conventional visual method of shade guides have a subjective perception towards shade. The use of instrumental method with spectrophotometer has been more prevalent for effective and accurate shade analysis and communication. Spectrophotometers are among the most accurate, useful, and flexible instruments for color matching [3]. However, the expense of such devices limits its use to some clinician and laboratory. Therefore, the digital photographs with DSLR was analyzed. Evidence based dentistry has revealed that DSLR and the use of Adobe Photoshop combined yields almost the same shade determination [4].

The evolution of mobile cameras has made an enormous impact on digital photography and its accessibility: high-quality pictures can now be easily taken. Smart phones have come a long way in digital photography due to the fact that those cameras have some interesting features and characteristics that are beneficial for dental photography: very small aperture due to the small size of the camera and its diaphragm. Therefore, a very high depth of field is achieved on a regular basis. Good ISO settings adding more light sensitivity to the camera with low noise. It has rather good resolution to show small details, large display to preview and view the images, especially when using smart phones with large screens. The white balance, exposure, focus, ISO, metering and the shutter speed can be modified manually in some cameras [5]. However, mobile dental photograph has not been yet proven to be as accurate as the spectrophotometer.

Therefore, this study aims to evaluate the accuracy of Mobile dental photographs compared to spectrophotometer.

Material and Method:

This in- vivo study was conducted on 50 participants in the age group of 25-40 years with no history of trauma, restoration or modification on the left central incisor. Age group was standardized as it is known to affect the shade [6]. Sample size determination was based on the effect size results from the previous studies. Consent from each of these participant was taken.

The above study subject selection led to a more than 80.0% statistical power (type II error = 0.20) and 5% type I error probability (a = 0.05) to be able to detect the clinically important difference in outcome measures, coefficient of agreement with a two-tailed alternative hypothesis.

After retracting the patient's cheek with a cheek retractor, a circular cut out from 18% gray card (which was dipped in 25% alcohol for disinfection) was placed on the patient's right central incisor with the help of petroleum jelly. The left central incisor was divided into 9 equal parts and the center was selected for measuring the shade using spectrophotometer and mobile photographs (Figure 1).

The shade determination with the help of the spectrophotometer (VITA Easy shade Spectrophotometer Advance 4.0 [VITA, Germany]) was done according to the manufacturer instructions (Figure 2). The spectrophotometer was first calibrated according to the protocol suggested by the manufacturer. The measuring tip (probe) was covered by an anti-infection cover and placed on the middle one-third of the left maxillary right central incisor. The "Tooth single" program was selected for recording the shade and the L* a* b* values of the tooth (L* a*b*).

Shade selection using a mobile phone was done using a smartphone Samsung A30, with the following settings described in Table 1.

The vertical arm of the camera stand was adjusted at the level of the patient's occlusal plane. The optical axis of the camera was oriented perpendicular the patient's frontal plane [7]. The distance between the camera and the patient was 25 cm [8] in order to record a dimensionally accurate image. A digital photograph was captured for each subject and stored as a JPEG file with the same degree of image compression.

The photograph so obtained was then analyzed with the help of Adobe Photoshop. The white balance of the photograph was adjusted with the help of the grey card neutralization [7]. The L* a* b* values of the middle of the left central incisor was then noted down as L_1* a_1* b_1*.

The delta E was determined with respect to the spectrophotometric value using the formula [9].

$$\Delta E = \sqrt{\{(L^* - L_1^*) + (a^* - a_1^*) + (b^* - b_1^*)\}}$$

Where L*, a*, b* were values obtained from the spectrophotometer and the L_1*, a_1*, b_1* were the data obtained from the mobile photographs.

The color difference between two objects is clinically not discernable to the human eye if the delta E score is less than 2 as suggested by Della Bona et al [10]. Therefore, agreement scores for delta E <2 and more than 2 was also calculated.

Data Analysis:

Data obtained was compiled on a MS Office Excel Sheet (v 2019, Microsoft Redmond Campus, Redmond, Washington, United States). Data was subjected to statistical analysis using Statistical package for social sciences (SPSS v 26.0, IBM). Descriptive statistics like Mean & SD for numerical data was calculated. Inter group comparison (2 groups) was done using t test. Cronbach's alpha and Intra class correlation was done to check the internal consistency and agreement between 2 techniques.

Agreement between spectrophotometric and digital photography methods was checked using z-test for proportions. A number of measures having a ΔE value above and below 2 were also compared using z-test for proportions.

For all the statistical tests, $p<0.05$ was considered to be statistically significant, keeping α error at 5% and β error at 20%, thus giving a power to the study as 80%.

Results:

In this study, a combination of tooth color data (L* a* b* values) was collected by the spectrophotometer and mobile photography method as seen in Table 2.

The mean for the ΔE calculated was 1.5 which is less than the standard value of 2.

The mean and the standard deviation for each of the L* a*b* values obtained by spectrophotometer (Designated as S) and Mobile Photography (designated as M) were determined. Inter group comparison for each of the values was determined using t- test. It was found that there was a statistically non-significant difference seen for the values between the 2 techniques ($p>0.05$) which implied that the measurements / values by 2 techniques were almost similar (Table 2).

The comparison of a number of measures having a ΔE value above and below 2 using z-test for proportions revealed Z-score of −8 and P = 0.00001. This was statistically significant with a higher proportion of <2 ΔE (Table 3).

Discussion:

Shade determination forms a vital aspect of modern esthetic dentistry. Digital era has revolutionized many aspects including the shade determination. The use of smartphones has emerged as a means of dental photography and record keeping [1]. The accuracy of the photographs taken by the mobile phones has yet not been established. Therefore, this study aims at determining the accuracy of shade determination from the photographs by mobile phone and comparing it with the values obtained by spectrophotometer.

Spectrophotometer has been established as the gold standard of shade determination. A spectrophotometer functions by measuring the spectral reflectance or transmittance curve of a specimen [11, 12]. Also, it is not affected by the surrounding lighting condition or the operator based errors. Therefore, spectrophotometer has been used as the standard reference for the evaluation of accuracy of mobile photographs.

Although spectrophotometer is proven to be highly accurate, it has been reported that errors in shade selection from the "edge loss error," is a frequent shortcoming of contact type spectrophotometric devices [13]. Also, the expenditure involved in these electronic devices limits its use by the clinician.

A mobile digital photograph helps to exactly replicate the color of the restoration due to its high image quality. Furthermore, the information of the image is available as numerical color data (L* a* b*) which helps in determining the shade of that region of a tooth [7]. In order to determine an inexpensive and easily accessible means for the shade selection and communication to the laboratory technician, mobile dental photographs has been evaluated in this study.

A smartphone was used to take the photograph and the image so obtained was analyzed with the help of Adobe photoshop software as directed by Bengel [7]. A grey card (18%) has been used in the study as neutral target as its red, blue, and green values are equal.

It represented the middle tone used for exposure determination, halfway between pure black and pure white and was the same tone of gray, for which a camera meter is calibrated. Since the gray card had definite values, the software also interprets it as gray, thus eliminating the color cast of the whole picture [9].

The internal consistency and agreement between 2 techniques as determined by Cronbach's Alpha analysis was excellent ($p<0.001$). This could be because of the standard protocol followed and the use of software and the grey card to balance the exposure parameter. Similar results has been observed in many other studies wherein the photographs were taken with DSLR [4, 14].

Since there was statistically non-significant difference ($p>0.05$) between the L*a*b* values obtained with the help of mobile photographs and spectrophotometer, it can be used as the means of recording the shade in this system.

Also, the ΔE value i.e the mean color difference between the L* a* and b* values obtained by the spectrophotometer and mobile photography was 1.5. This value is below the clinical discernible value of 2 reported to be accepted. However, this value was much smaller than the thresholds of around 6 which were reported by Douglas et al [15] and Johnston and Kao [16] in in vivo situation. Therefore, it can be concluded that the perception of shade by the mobile photographs can be accepted.

The difference in the mean can be attributed to many factors like the tooth selected, the phone features, the level of experience of the investigator, material and also the nature of color pairs.

Therefore, the result of this study establishes the newly emerging mobile dental photographs as an effective means of shade determination and communication. In addition, it also allows the technician to evaluate not only one point for the shade but the entire tooth for different shade at different regions. This would enable the technician to mimic the shade and different characteristics and yield a restoration which is life like.

Limitation of this study includes the expertise in photography and software management. Also the technician should be trained to use such software and determine at each point the correct shade. Laboratory environment should also photograph the restoration fabricated using the same settings and grey card to establish the ΔE less than 2 so as to assure the clinically acceptable esthetic restoration.

Clinical Significance: In the modern world, every individual has a mobile phone. It is being used for various purposes in dentistry. Along with it, mobile dental photographs has been established as one of the effective means of shade determination and communication without an additional expenditure. It can help mimic not only the shade but also the characterization by the lab personnel as the photograph communicates these details for reference.

Conclusion:

Within the limitation of this study, Mobile dental photograph can be established as an effective and reliable adjunct for shade determination and communication. It helps the technician to determine the various aspects and accordingly characterize the restoration or prostheses to achieve esthetics.

References:

1. Casaglia A,De Dominicis P,Arcuri L,Gargari M,Ottria L. Dental Photography Today. Part 1: Basic Concepts. Oral Implantol 2016;8:122-129
2. Manimaran P, Sadan DS. An *in vitro* study to evaluate the difference in shade between commercially available shade guides and glazed porcelain. J Pharm Bioall Sci.2016; *8*(1):S110–S115.
3. Paul SJ, Peter A, Rodoni L, Pietrobon N. Conventional visual vs. spectrophotometric shade taking for porcelain-fused-to-metal crowns: A clinical comparison. Int J Periodontics Restorative Dent. 2004;24:222–31.
4. Miyajiwala JS, Kheur MG, Patankar AH, Lakha TA. Comparison of photographic and conventional methods for tooth shade selection: A clinical evaluation. J Indian Prosthodont Soc. 2017;17(3):273.
5. Hardan L. Mobile Dental Photography (MDP): A New Era in Dental Documentation: Winner of Best of Class Technology Award. Int. Arab J. Dent. 2017;392(5647):1-4.
6. Rodrigues S, Shetty SR, Prithviraj DR. An evaluation of shade differences between natural anterior teeth in different age groups and gender using commercially available shade guides. J Indian Prosthodont Soc 2012;12:222-30.
7. Bengel WM. Digital photography and the assessment of therapeutic results after bleaching procedures. J Esthet Restor Dent 2003;15 Suppl 1:S21-32
8. Loiacono P, Pascoletti L. Photography in Dentistry: Theory and Techniques in Modern Documentation. Quintessenza Edizioni; 2012 Feb.
9. Commission Internationale de l'Eclairage (CIE). Recommendations on Uniform Color Spaces, Color-Difference Equations, Psychometric Color Terms. Bureau Central de la CIE; 1978.
10. Della Bona A, Barrett AA, Rosa V, Pinzetta C. Visual and instrumental agreement in dental shade selection: Three distinct observer populations and shade matching protocols. Dent Mater 2009;25:276-81.
11. Khurana R, Tredwin CJ, Weisbloom M, Moles DR. A clinical evaluation of the individual repeatability of three commercially available colour measuring devices. Br Dent J. 2007;203:675–80.
12. 15. Jain C, Bhargava A, Gupta S, Rath R, Nagpal A, Kumar P. Spectrophotometric evaluation of the color changes of different feldspathic porcelains after exposure to commonly consumed beverages. Eur J Dent. 2013;7:172–80.
13. Bolt RA, Bosch JJ, Coops JC. Influence of window size in small-window colour measurement, particularly of teeth. Phys Med Biol 1994;39:1133-42.
14. Anand D, Kumar GP, Anand DY, Sundar MK, Sharma R, Gaurav A. Shade selection: Spectrophotometer vs. digital camera– A comparative in vitro study. Ann Prosthod Restor Dent. 2016 Jul;2:73-8.
15. Douglas RD, Steinhauer TJ, Wee AG. Intraoral determination of the tolerance of dentists for perceptibility and acceptability of shade mismatch. J Prosthet Dent 2007;97:200-8.

16. Johnston WM, Kao EC. Assessment of appearance match by visual observation and clinical colorimetry. J Dent Res 1989;68:819-22

Tables :

Table 1: Camera settings for mobile dental photographs

Feature	**Camera settings**
Mode	Professional
ISO	400
White balance	Auto
Aspect Ratio	1:1
Grid lines	On
Distance	25mm

Table 2: CIE L*a*b* values obtained from spectrophotometer and mobile photographs, ΔE and the mean ΔE.

Sl no.	Spectrophotometer			Mobile			ΔE	t value			p-value		
	L*	a*	b*	L_1*	a_1*	b_1*		L	a	b	L	a	b
1.	74.3	-1.3	17.8	75	-2	18	1.0	.243	.859	.114	.808#	.393#	.910#
2.	75.2	-0.7	11.8	75	-1	11	0.9						
3.	71.7	-1.2	16.7	72	-2	15	1.9						
4.	74.5	-2	10.7	74	-2.6	11	0.8						
5.	76	-1.4	17.4	76	-1.8	17	0.6						
6.	77.6	-1.3	20	77	-2	21	1.4						
7.	77	-0.8	16.7	78	-1.8	16	1.6						
8.	76.7	-1.3	17.8	77	-2.3	17	1.3						
9.	66.1	1.6	17.1	66	1.5	17	0.2						
10.	77.5	-1	23.7	77	-2.8	23	2.0						
11.	74.6	-1.4	23	75	-2	24	1.2						
12.	71.7	-1.6	14.6	70	-2	14	1.8						
13.	77	-1.1	17	78	-2.3	16	1.9						
14.	77.6	-1.6	19.2	78	-1.8	20	0.9						

15.	74.2	-1.6	14.6	75	-2	14	1.1	
16.	69.2	-1.2	15	70	-2	16	1.5	
17.	61.2	0	16.2	62	1.1	17	1.6	
18.	66.1	-1.3	14.6	66	-1.3	18	3.4	
19.	67.5	0.5	19.2	67	0.3	18	1.3	
20.	64.6	1	12.6	64	1.4	14	1.6	
21.	69.2	0.2	18.6	70	0.3	18	1.0	
22.	75	-0.3	18.6	75	-0.8	17	1.7	
23.	70.7	-0.6	12.6	71	-0.5	14	1.4	
24.	70.7	-0.2	14.5	72	0.8	15	1.7	
25.	79.3	-1	15	79	-2.4	14	1.7	
26.	66	0.1	19.7	66.1	1	19	1.1	
27.	68.7	-0.7	10	70	-1.4	10	1.5	
28.	73.9	-0.9	15.1	74	-0.7	12	3.1	
29.	68.7	2.6	18.5	70	2.4	19	1.4	
30.	67.9	-1.1	10.9	67	-1.2	10	1.3	
31.	70.7	-1.5	11.3	72	-2	12	1.6	
32.	78.4	-0.9	15.6	79	-1	16	0.7	
33.	68.7	0.6	19.5	68	1	20	0.9	
34.	74.8	-0.4	20.9	76	-0.8	22	1.7	
35.	75	-0.3	18.6	74	-0.6	17	1.9	
36.	76.9	-1.1	11.9	78	-2	12	1.4	
37.	74.3	-1.5	9.9	76	-4	11	3.2	
38.	75.5	-3.2	7.9	77	-3.1	7	1.8	
39.	73.2	-1.5	10.1	72	-2.5	10	1.6	
40.	74.4	-1.3	11.6	75	-2	10	1.8	
41.	75.5	-3.2	17.9	76	-3	19	1.2	
42.	74	-1.4	11.6	75	-1.3	11	1.2	
43.	61.5	-0.1	12.2	62	-0.3	14	1.9	
44.	65.5	1.4	15.8	66	3	16	1.7	
45.	66.5	0.9	14	66	2	14	1.2	

46.	67.5	0.5	19.2	67	2	18	2.0	
47.	73.2	-1.5	10.1	74	-2	11	1.3	
48.	75.2	-1.7	12.8	75	-2	12	0.9	
49.	74.2	-1.6	14.6	73	-2	14	1.4	
50.	67.5	1	23.7	67	2	23	1.3	
Mean ΔE							1.5	

Table 3: Number of samples with ΔE values <2 and >2

Delta E	Frequency (%)	P value for z-test
<2	45 (90)	0.00001*
>2	05 (10)	
Total	50	

*p<0.05

Figure Legends:

Figure 1: Preparation of the tooth for shade determination with grey card and the grid lines

Figure 2: Clinical spectrophotometer (Vita Easy shade)