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ORIGINAL RESEARCH ARTICLE

COMPARISON BETWEEN MOBILE CAMERA AND DSLR CAMERA PHOTOGRAPHY FOR THE EVALUATION OF SHADE OF ANTERIOR TEETH - A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Color accuracy plays a major role in creating an esthetic prosthesis. Photos taken with DSLR cameras have been the most frequent means of recording and transferring the color of teeth. Mobile phone cameras are emerging as a popular alternative to DSLR cameras due to its convenience. Our aim was to compare the color difference (ΔE) between the pictures taken with DSLR cameras and mobile cameras with and without using flash.

Methods: Photos of right maxillary central incisors of patients (n=60) were taken with DSLR camera and mobile camera with and without using flash. The pictures were standardized with gray card and processed in Adobe Photoshop Lightroom CC software and the L*a*b* values of the pictures were compared to find the difference in color.

Results: The percentage of agreement ($\Delta E \leq 2.7$) for the difference of color between DSLR camera and mobile phone cameras without using flash ($\Delta E1$) was 3.3% and with using flash ($\Delta E2$) was 1.7%. The coefficient of agreement (using Kappa coefficient) between ($\Delta E1$) and ($\Delta E2$) showed total disagreement (kappa value =-.02). The mean values of $\Delta E1$ was (8.3±3.3) and $\Delta E2$ was (7.23±2.4).

Conclusions: It was concluded that the color of mobile camera with or without using flash could not be considered as an acceptable method of recording color of teeth.

INTRODUCTION

Pictures play a very important role in modern dentistry. They help in diagnosis, treatment planning, patient education and communication with the dental laboratories.

A natural looking prosthesis can only be made through proper communication to the laboratory technicians by showing them pictures and giving information about the shade of hard and soft tissues. Color of teeth, required for the reproduction in porcelain, is most frequently assessed visually and defined descriptively by means of a code that belongs to a matching shade standard (tab). The defined shade tab is likewise a prescription for the porcelain powder selection for production of the restoration.[1] The knowledge of color is required for both the dentist and technicians to communicate accurately the shade of restoration.[2]

Visual shade selection is the most common method of color determination and communication in dentistry, but color duplication via this process is plagued by unreliable and inconsistent result.[3] Improper shade selection is said to be the second most common reason for remake of a ceramic restoration, the primary reason being problems with tooth preparation and impressions.[4]

A popular instrument in shade selection that has well established itself as a standard in dental photography is the DSLR (digital single lens reflex) cameras. The primary advantage with this camera is that it provides the entire spectrum of color for the tooth or even a part of it, which when analyzed by an appropriate software can provide the color values in various formats [5] Moreover, digital photography is capable of capturing polychromatic color, tooth morphology, surface texture, translucency, color distribution, and details from surrounding tissue.[6,7]

However, there are a few drawbacks of DSLR cameras. They are expensive, heavy and bulky and not too easy to carry around. They may need many accessories e.g. macro lens and ring flashes etc. to perform properly which might be practically hassle some. A suitable alternative for DSLR cameras may be a mobile phone camera. Mobile phones are easily accessible and handy to carry around. Picture quality of mobile phones cameras are in competition with DSLR cameras due to its technological advancement.

There is however a question whether the color of teeth taken by mobile cameras will be comparable to pictures taken by DSLR cameras, even after the help of an image-editing software following the standardization of pictures with a gray card, that gives the pictures a neutralized image colors and fine- tuned image brightness[8] and whether these pictures can be used as a means of communication to the dental lab or not.

For practical reasons a three coordinate color system CIE L*a*b* is most frequently used in dental research, representing lightness (L*), redness-greenness (a*) and yellowness-blueness (b*).[1] The development of CIEL*a*b* which was recommended by the "International Commission on Illumination" helps in the quantification of the shade duplication process.

The color difference of two objects can be determined by comparing the difference between respective coordinate vales for each object[2] which is denoted as "ΔE". With the help of CIEL*a*b* we can compare the difference between the shade of teeth taken with DSLR camera and mobile smart phone cameras in a quantitative method.

Hence the objective of this study was to compare the photos of mobile cameras and DSLR cameras for anterior tooth shade selection after standardization of pictures with a gray card.

METHODS

After attaining the clearance of institutional review committee of KIST medical college and teaching hospital (MCTH), the determined number of subjects (n=60) meeting the inclusion and exclusion criteria was purposively selected from the OPD of prosthodontic department of KIST MCTH. Data was collected from 28th of April to 18th of May.

All subjects having anterior right maxillary central incisor teeth were included in the study while subjects having carious teeth, restored teeth, non-vital /root canal treated teeth, structural and morphological anomalies in the maxillary right central incisors were excluded from the study.

The patients were informed about the study and written consent was taken. The patient was asked to sit in an upright position in front of a wall which had a white tape of 20 cm length on it. The lips and cheeks were retracted by a cheek retractor. The subject's right central incisor was positioned at a right angle to the ground on one side of the tape, and a camera was placed on the other side of the tape. This was done to maintain a distance of 20 cm from the teeth to the cameras.[9] Photos of the subject's teeth were taken, by a DSLR camera (Sony α200 with 10.2-megapixel camera). The DSLR camera with a ring flash (Viltrox Macro ring lite JY670) was mounted on a tripod (Weifeng, WF-6663A) at a perpendicular angle to the right maxillary central incisor with an 18% neutral gray card (JJC GC-3, JJC Photographic Equipment Co. Ltd) held below the right central incisor (Figure 1). The center of the upper area of the gray card was marked with a half circle using a permanent marker to delineate the area to be kept under the central incisor and a picture was taken. Then a mobile phone camera (one plus 2 with 13-megapixel camera) supported by a selfie stick was kept on a tripod (SLIK 38T4, Japan) in the same position as the DSLR camera and photo was taken without altering the position of the patient without flash and again with flash (Figure 2).

Figigure 1: Picture taken with DSLR camera and ring flash

Figure 2: Picture taken with mobile phone camera

To ensure standardization during the study, all the pictures were taken directed toward northern facing sunlight. The pictures were taken in daylight on a clear day.

The settings of DSLR camera with a ring flash was:

Magnification- 1:1 ratio was selected (macro lens, sony.30mm.)
Exposure mode- 1/125 sec
White balance- Automatic
Aperture- F 22
Flash -1/8 ratio
Fixed white balance Off
File type- RAW

ISO value 100 selected and the mobile phone camera was kept in automatic settings and JPEG file format. Two set of pictures were taken of the subject with the mobile phone camera, one with flash and then without flash. Photographs were taken at least 1-minute intervals to allow consistent flash intensity.

The photos taken by both the DSLR camera and mobile phone using flash and without using flash was processed in Adobe Photoshop Lightroom CC software (Lightroom version 6.3, Adobe Photoshop CC; Adobe Systems Inc.). The photos were processed using the following protocols:

1. The three photos were opened and imported into the library of Adobe Photoshop Lightroom CC by clicking the import option.
2. A photo was selected and the develop option was clicked.
3. To calibrate the picture, a screen grid was used by clicking view option, then loupe overlay option and then grid option.
4. Pictures were standardized with the help of a 18% gray card by clicking on the semicircle area of gray card with the white balance selector tool that is present under the treatment panel (Figure 3).
5. The exposure of L* a* b* values (commission internationale de l'Eclairage) was adjusted as close as possible to 54 ,0 and 0 respectively by clicking the exposure, then moving the pointer at the center of the semi-circle of the gray card and adjusting the up and down arrows to increase or decrease the exposure until the L* value reaches 54 as seen in the histogram. It is also possible to manually enter the values of exposure to adjust the lab value to 54 when the pointer is on the semi-circle (Figure 4).
6. The picture was enlarged so that the vertical height of the right central incisor would occupy the full vertical dimension of the screen.
7. The mouse pointer was kept on the central grid of the tooth and the L* a* b* values of the area was noted. If the central area had a reflection on it, then another grid near the center grid was chosen (Figure 5).
8. This procedure was repeated on all three photos making sure that the area of selection was same on every set of pictures.
9. The software derived L* a* b* values thus obtained then converted to the L* a* b* values as given by the CIEL* a* b* system using the follow-

ing formula

- $L^* = L1 \times 100/255$
- $a^* = (a1 - 128) \times 240/255$
- $b^* = (b1 - 128) \times 240/255$

Where L1, a1, and b1 are the L*, a*, b* values obtained using Adobe Lightroom software as explained above

The ΔE (difference in the shade) between the DSLR camera derived L* a* b* values, and the values obtained by the mobile camera photography technique was calculated using the following formula

$$\Delta E = [(L1 - L2)^2 + (a1 - a2)^2 + (b1 - b2)^2]^{1/2}$$

a score of "agreement" or "not in agreement" were given for Δ E ≤2.72 and more than 2.72, respectively.[10] Agreement between color difference of DSLR camera and mobile camera photography without using flash and between DSLR camera and mobile camera photography using flash was checked using Kappa coefficient. A percentage of ΔE value above and below 2.72 was also compared. The mean val-

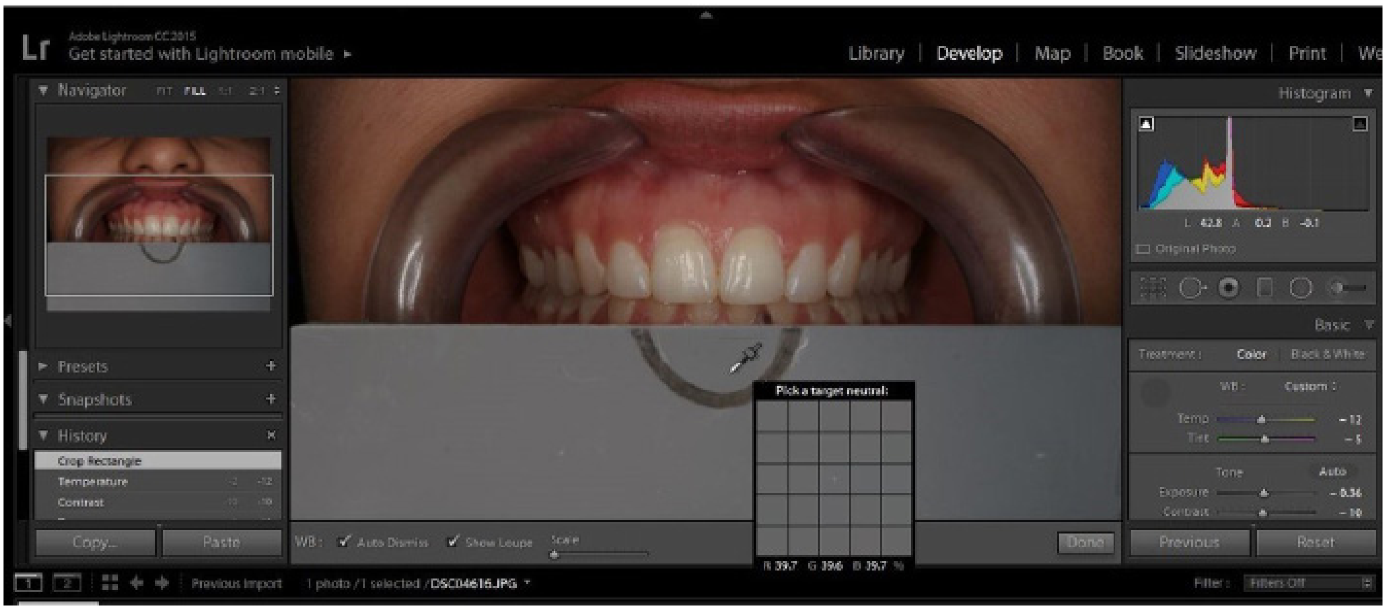

Figure 3: Using white balance selector

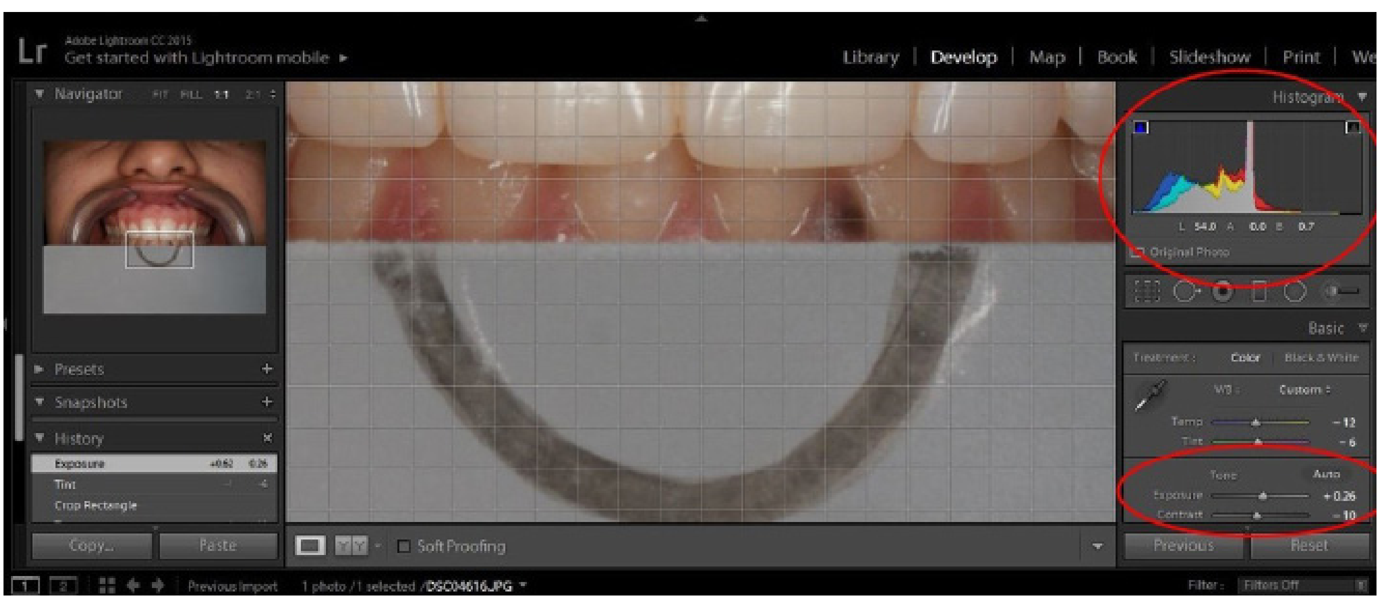

Figure 4: Adjusting exposure to bring the L*a*b* values as close to 54,0 and 0 as possible

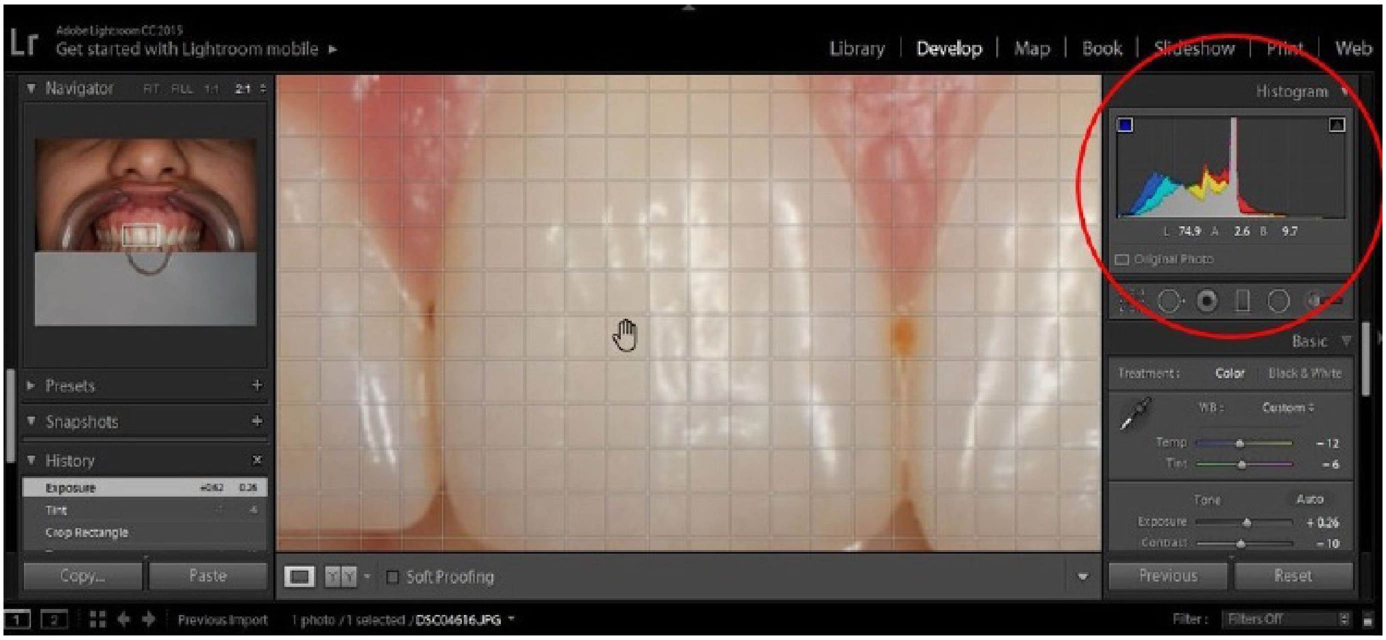

Figure 5: Determing the L*a*b* value of color of selected portion of teeth by keeping the pointer on the selected area

RESULTS

In this study, a combination of tooth color (L* a* b* values) taken by DSLR camera, mobile phone camera without flash and with flash was collected (Table 1).

Table 1: Consolidated results of shade selection of all sixty patients

Serial number	DSLR camera (1)			Mobile camera without flash (2)			Mobile camera with flash(3)			ΔE1	Agreement (Between 1 and 2)	ΔE2	Agreement (Between 1 and 3)
	L1*	a1*	b1*	L2*	a2*	b2*	L3*	a3*	b3*				
1	68.5	5.8	10.7	75.5	6.7	9.9	66.2	5.8	17.8	2.97	No	6.74	No
2	67.4	4.9	10.2	76.5	7.1	12.2	68.6	5	20.3	4.53	No	9.52	No
3	67.5	7.6	16.2	71.1	8.8	16.3	61.2	3.8	23.3	1.81	Yes	7.97	No
4	73.5	6.8	16.2	89.9	4.6	9.9	62.5	4.7	26.5	8.99	No	10.79	No
5	79.9	4.3	10.8	92.4	4.5	5.3	76	3.9	16.4	7.13	No	5.50	No
6	78.1	4.1	10.1	89.3	2.1	6.1	70.1	5.3	20	6.08	No	9.90	No
7	73.6	6.4	10	86.5	1	6.7	66.2	5	18	7.81	No	8.18	No
8	63.7	7.6	13	78.4	5.5	8	57.6	7.6	17.4	7.70	No	4.78	No
9	68.1	7.3	12.5	92.6	1.5	4.8	69	5	18.2	13.21	No	5.80	No
10	73.5	6.6	15.1	93.8	2.3	6.5	63.6	5.6	27.5	12.05	No	12.34	No
11	65.9	7.4	15.1	92.4	4.5	6.3	72.9	6.5	23.9	13.57	No	8.77	No

12	70.1	3.7	7.7	71.6	8.8	12.4	59.8	4.6	13	6.55	No	6.47	No
13	72.4	6.4	13.4	90.2	1.9	8.3	68.9	5.2	19.6	9.47	No	6.10	No
14	71.5	6.4	13.1	71.7	5.1	13.5	77.4	3	17.4	1.28	Yes	5.65	No
15	68.8	6.7	10.8	89.7	4.7	3.3	67.7	4.3	20.3	10.98	No	9.23	No
16	65.3	6	13.6	83.1	4	9.3	74	3.7	20.2	8.29	No	7.41	No
17	76.5	5.1	10.6	79.1	4.4	13.2	67.6	6.6	20.1	2.73	No	9.70	No
18	70	8.7	16	77.6	11.7	13.3	67.1	8.8	24.2	4.83	No	7.80	No
19	74.6	5.5	11.1	82.2	6	11.9	78.3	4.9	20.1	3.11	No	8.61	No
20	75.9	5.6	14	82.6	6.9	11	74.8	3.5	20.9	4.05	No	6.80	No
21	66.6	8.6	17.6	82.3	7.6	10.5	60.2	6	24.7	9.13	No	7.55	No
22	62.8	7.6	15.3	92.1	3.4	4.5	58.5	5.2	23.9	15.84	No	8.57	No
23	71.6	6.8	15.7	86	6.2	9.9	80.5	3.9	25.6	7.87	No	10.32	No
24	74.2	4.8	10.8	85.1	4.9	8.9	68.9	3.9	20.8	4.63	No	9.68	No
25	57.2	9.7	19.9	70.1	10.5	14.4	68.4	6.7	26.3	7.28	No	7.97	No
26	73	5.6	13.9	76.8	8.9	13.8	71	4.7	20.1	3.45	No	5.95	No
27	68.5	4.2	13.6	83.6	7.2	11.9	67.5	6	19.4	6.75	No	5.73	No
28	75.8	3	15.3	81	4.4	23.7	86.3	6.8	13.9	8.27	No	5.61	No
29	61.2	7.3	21.2	87.4	5.7	13.4	67.1	7.6	30.5	12.72	No	9.06	No
30	75.4	3.3	14.4	85.5	5.7	9.4	72.2	5.3	21.7	6.55	No	7.23	No
31	76.7	3.1	16.8	91.6	3.9	13.4	77.7	4.6	25.4	6.70	No	8.23	No
32	76.6	3.1	11.6	82.4	8.7	6.8	71.6	5.9	16.7	7.30	No	5.82	No
33	70.7	4.2	11.5	59.1	15.4	13.9	68.4	4.9	17.2	11.70	No	5.48	No
34	72.8	2.8	16	85.4	6.4	10.9	68.4	5	22.9	7.68	No	7.03	No
35	68.4	5.6	19.4	84.4	6	13.8	69.4	6.6	27.2	8.20	No	7.41	No
36	73.7	4.3	14	90.6	4.4	7.4	79.3	4.2	20.6	9.08	No	6.59	No
37	77.3	3.4	10.9	75.1	10.2	11.5	69.8	6	18.4	6.48	No	8.03	No
38	68.9	5.9	18	83	7.1	8.4	64.4	4.8	23.2	10.65	No	5.30	No
39	70.7	6.2	19.7	85.4	8.3	16	66.3	6.5	29.1	7.02	No	9.02	No
40	72.7	3.8	15.9	87.5	7.6	10.2	77.1	5.6	22.5	8.68	No	6.67	No
41	62.7	5.2	15.1	85.6	5.1	6.3	56.9	5.9	21.5	12.22	No	6.47	No
42	67.5	5	15.9	81.4	5.5	9.7	57	5.7	20.8	8.00	No	6.22	No
43	66.5	5.2	14.3	87.8	6.2	6.7	65.6	5.3	20.6	11.04	No	5.94	No
44	66.7	5.1	13.6	90.4	5	7	65.7	5.7	18	11.18	No	4.20	No
45	63.9	3.1	15.9	91.1	3.3	7.5	66.3	5.1	20	13.28	No	4.40	No
46	78.8	3.6	14	58.9	17.9	24.3	82.3	3.2	20.7	18.33	No	6.46	No
47	72.2	2.5	14.8	80.8	3.8	10.7	73.6	3.8	18.9	5.27	No	4.09	No
48	70.5	4.2	16.3	84.1	8.3	12.3	71	4	22.4	7.58	No	5.75	No
49	74.2	2.7	15.7	70.7	13	16.7	75.4	4	36.9	9.84	No	20.00	No
50	71.2	4.6	18.8	88.3	6.5	12.1	76.5	4.9	24.2	9.38	No	5.50	No
51	67.2	5.1	13.8	84.4	7.2	7.4	60.8	6.9	19.8	9.26	No	6.41	No
52	70.3	3.4	13	88.4	4.8	6.7	65.5	3.1	22.6	9.34	No	9.23	No

53	73.1	3.8	15.5	80.5	6.6	12	73.8	5.1	23.1	5.12	No	7.26	No
54	68.1	7.1	20.2	82.1	6.5	11.7	65.9	6.2	26.8	9.72	No	6.33	No
55	75.2	3.2	12.7	71	15	13.6	75.1	2.8	18.4	11.26	No	5.38	No
56	67.2	3.3	15.4	87	5.3	9.2	79.6	3.7	17.6	9.89	No	5.30	No
57	79.9	5.3	17.3	84.4	8	13	72.7	5.4	22.9	5.09	No	5.98	No
58	68.5	6	18	82.7	6.2	11.6	68.2	7	24.2	8.21	No	5.91	No
59	66.6	2.6	16.9	88.4	4.4	10	73	5.3	21.8	10.87	No	5.83	No
60	72.5	4.6	21.2	82.6	8.4	12.1	72.9	5	23.7	10.09	No	2.39	Yes

ΔE1= color difference between DSLR camera (1) and mobile camera without flash (2)

ΔE2= color difference between DSLR camera (1) and mobile camera with flash (3)

The percentage of agreement of color between DSLR camera and mobile phone camera (ΔE1) (Table 2) and between DSLR camera and mobile phone camera (ΔE2) (Table 3) was calculated.

The coefficient of agreement (using Kappa coefficient) was checked between the difference of color of DSLR camera with mobile phone camera without flash (ΔE1) and DSLR camera with mobile phone camera with flash (ΔE2) were compared. Results revealed a negative kappa value [-.02, (p = .85)] which showed that the color differences were not in agreement (Table 4).

The mean value and standard deviation was also calculated (Table 5). The standard deviation of ΔE1 was (8.3±3.3) and ΔE2 was (7.23±2.4)

Table 2: Percentage of agreement of color between DSLR camera and mobile phone camera (ΔE1)

ΔE1	Frequency	Percent
In agreement	2	3.3
Not in agreement	58	96.7
Total	60	100.0

Table 3: Percentage of agreement of color between DSLR camera and mobile phone camera with flash (ΔE2)

ΔE2	Frequency	Percent
In agreement	1	1.7
Not in agreement	59	98.3
Total	60	100.0

Table 4: Coefficient of agreement (using Kappa coefficient) between color difference Δ E1 and Δ E2

		ΔE2		Total
		In agreement	Not in agreement	
Δ E1	In agreement	0	2	2
	Not in agreement	1	57	58
Total		**1**	**59**	**60**

K value= -.02(p = .85)

Table 5: Mean and Standard deviation of ΔE1 an

	ΔE1	ΔE2
Mean	8.3020	7.2389
Std. Deviation	3.36938	2.48995

DISCUSSION

The digital photography method has emerged as a reliable method for shade selection in a clinical setup.[5] Using a gray reference card produces higher standardized color in general, its effect is statistically significant when DSLR camera is used with a ring flash[11] therefore the photo taken with DSLR and ring flash using a grey card was chosen as the reference.

The difference in color taken with mobile camera with and without flash produced photos whose color was not in agreement with the photos taken with the DSLR camera. This result was in agreement with a study conducted by Sampaio et al in which they had compared pictures of various DSLR photographic techniques with an iPhone 7 (Apple Inc.) mobile camera phone and stated that the mobile phone had the greatest difference of color values ($\Delta E = 7.5 \pm 3.9$).[11]

There have been very few studies that incorporate mobile camera photos in color quality in dentistry but none of them, to the authors' knowledge, have considered the effect of using mobile's flash in the study. The average value of ΔE using flash (7.23 ± 2.4) was less than the value of ΔE without using flash (8.3 ± 3.3) suggests that although using flash create a slightly more accurate picture, it still is not good enough for color referencing.

A probable reason that the color we get from smartphone cameras is not reliable is that the pictures are processed and already modified in JPEG form. In order to make precise calculations it is necessary to have access to RAW camera data which is not possible, because manufacturers want to keep their calculating algorithms in secret.[12] This might also be a reason that photos taken in RAW format in DSLR cameras might give a better result.

CONCLUSION

Although the mobile camera is an accessible tool to take quick and good quality photos, its color cannot be used as a reliable reference for shade selection.

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