Original Article

The Effect Of Mobile Cameras On The Quality Of Intraoral And Extra Oral Imaging Using Software

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Abstract

Background: One of the worries and concerns of dental clinics for high-quality photographic images with cameras are more accessible. If dentists about the quality and capability of the mobile camera with professional digital cameras do not know, tend to produce lower quality will be poor photography. Given that such a study has not been conducted, the need to justify addressing this gap.

Materials and Methods: An experimental study on 4 mobile Camera includes Samsung s4, Apple 5s, SONY Xperia Z and HTC one and a digital camera DSLR Canon 550D were performed. The images were taken from a person in the Department of Orthodontics Faculty. The photos in 10 different view including 5 Extra-oral views and 5 intra-oral views. Total is 50 photos. Imaging in the same conditions, such as light and distance were determined with MATLAB software. Then using the results of the corresponding parameters of the camera, the camera quality was calculated and with the Kruskal-Wallis test and the MANN-U-WHITNEY were analyzed.

Results:

Conclusion: Now, the digital camera is the best recording quality, But if certain targets are needed in dental photographs Can be used with mobile cameras that are more accessible and easier to get good pictures. It seems Samsung Mobile Phone In intra oral views and SONY mobile phone in extra-oral views of the highest quality images compared to other mobile camera recorded. However recommend doing more research. .

Keywords: Intra Oral Photography, Extra Oral Photography, Color, Resolution, Mobile Camera, DSLR Camera, software.

INTRODUCTION

Providing high-quality photographs using the more widely available cameras is a major concern of dental clinicians(1). Given the growing application of photographic imaging in dental treatments, this field of technology demands serious advances(2). In 1999, Wald started using digital cameras for the first time in orthodontic treatments for medical and documentation purposes and then compared three different cameras in terms of their digital imaging capabilities(3). Considering the growing use of digital cameras, the production of new brands and models, and the availability of advanced mobile cameras in the market, failing to carry out such study on the cameras available in the market and the dentists' lack of information about the quality and capabilities of these cameras only further assist the use of poor quality cameras and the production of poorer results(4, 5).

One of the methods used for choosing a superior camera is to compare the quality and performance of a number of cameras in taking photographs of the same object. Various factors are examined in the images produced by a camera, including mainly the quality of the image from various aspects, such as color, resolution and the ability to produce a realistic image, and other features such as accuracy(6). Some people believe that advanced expensive cameras are required for capturing higher quality photographs; however, others recommend mobile cameras as

widely available tools that produce a suitable quality for images. These differing opinions further display the want of information about the subject(7, 8). Many studies have made visual comparisons between different intraoral and extraoral images, including a study being conducted at the Dental school of Azad University of Tehran at the present moment, in which photographs taken by mobile cameras are compared visually to one another (9). The present study has sought to eliminate visual errors and the preference factor through making a robotic comparison of the differential features of these photographs and to achieve a universal datum through assessments made on a consistent scale and based on a general trend. The present study compares the quality of images taken by 5 cameras, including 4 mobile cameras (Samsung S4, Apple 5S, Sony Xperia Z and HTC One max) and one digital camera (Canon DSLR 550D). These images were taken of a single individual at the School of Dentistry, Islamic Azad University, under consistent conditions, in 2014.

Materials and methods:

The present experimental study was conducted on 4 of the latest models of mobile cameras available in the market, which was claimed by their manufacturers to have superb imaging quality. These mobile phones included Samsung S4, Apple 5S, Sony Xperia Z and HTC One max. One digital camera (Canon DSLR 550D) was also included in the study with features including a 100mm Macro-Lens and an MD 140 Ring flash, which is most often used in doctor's offices and imaging clinics as an ideal camera for digital photography.

Images were taken of a single individual at the Orthodontics Department of the dental school from 10 different views, including 5 extraoral views (full-face resting, 3/4 smiling, resting right profile, smiling right profile and resting left profile) and 5 intraoral views (Occlusal front, maxillary Occlusal View, mandibular occlusal View, right buccal occlusion and left buccal occlusion). Pictures were taken under consistently measured lighting at 150 cm distance for the extraoral images and at 20-25 cm for the intraoral images. All photos were taken with flash by a professional photographer. All the cameras were set to the manual mode and the WB setting with the flash mode. The DSLR camera had extra settings, including F-stop=22, shutter speed=1.250 second and ISO=800. Pictures taken were then transferred to a computer and pre-edited to eliminate any sections of the pictures that were irrelevant to the study and whose elimination did not interfere with the images' resolution. The pictures were then analyzed in MATLAB. Every pixel of the picture was stored in an array of matrices. The camera quality or resolution was calculated by multiplying the length by the width of the matrix. To identify the picture's color values, every pixel was classified under a range of 0 to 256 (with 0 representing absolute white and 256 representing absolute black), with various color spectra falling in between. The histogram was then made, representing the values of each color in a diagram. By comparing the histograms made for different images, the images' resolutions could then be compared. The contrast of each image, i.e. its brightness, was measured through the histograms and compared with the other images. The histogram tended toward zero in every photo. This procedure helped identify which camera was more capable of producing quality images (given their availability) and helped assess mobile cameras' place in dental photography without resorting to digital cameras.

Results:

The present study was conducted on a total of 50 images taken by 4 mobile cameras and one digital DSLR camera from 10 different intraoral and extra oral views. Table 1 presents the general quality features of the images, including color, resolution and realistic imaging by camera type.

In terms of resolution, the DSLR camera performed significantly better than the mobile cameras (P<…); the difference between the DSLR camera's performance was less pronounced with Samsung, more with HTC and similar in degree with Sony and Apple. Of the mobile cameras assessed, Samsung had the highest resolution (36.1) and HTC the lowest (10.2), which was a statistically significant difference, according to the ANOVA (P< …). The post hoc test showed that Samsung's resolution was different from all the other mobile cameras and that Sony and Apple had identical resolutions while HTC had a significantly different resolution compared to the latter two (P<0.05). As for the color factor, no differences were found between the DSLR camera and Sony in terms of the color red, while a significant difference was noticed between the DSLR camera and Samsung (P<0.05). In the two-by-two comparisons of mobile cameras, there was a significant difference between Sony and Samsung (P<0.05), but none between the rest, including Apple, Sony and HTC (P<0.4). No significant differences were observed between the DSLR camera and Sony in terms of the color blue, and none between the DSLR camera and the rest of the mobile cameras either (P<0.2). No significant differences were observed in the two-by-two

comparisons of the mobile cameras either (P<0.4). As for the color green, Sony was ahead of all the other mobile cameras with a rate of 134.7 and Samsung behind with a rate of 109.1, comprising a statistically significant difference (P<0.05). In the two-by-two comparisons between the cameras, no significant differences were found between Sony and HTC (P<0.4), but a significant difference was noticed between Sony and its two competitors Apple and Samsung (P<0.05). There were no significant differences between Sony and the DSLR camera.
With respect to the realistic imaging factor, the DSLR camera was the best with the score of 100 as the accepted standard, and Apple and HTC took the less realistic images with the score of 106.2. There were significant differences between the DSLR camera and the mobile cameras (P<0.01); however, the two-by-two comparisons of the mobile cameras showed no significant differences with one another (P<0.4).

Table 1: Color quality and image resolution according to type of camera

Factors / Camera	Realistic		Color						Resolution million	
			Green		Blue		Red			
	cv	x ± sd	cv	x ± sd	cv	x ± sd	cv	x ± sd	CV	x ± sd
DSLR	0	100 ± 0.0	35	132.6 ± 45.4	40	122.9 ± 47.6	20	168.6 ± 33.2	30	137.2 ± 48.5
HTC	5	106.2 ± 4.2	30	126.1 ± 35	25	104.9 ± 27.9	30	154.6 ± 45.1	20	10.2 ± 2.7
SONY	3	103.6 ± 3.8	25	134.7 ± 30.7	25	121.5 ± 30.1	15	165.9 ± 28.2	40	17.9 ± 8.3
SAMSUNG	2	104.1 ± 2.9	20	109.1 ± 21.2	20	99.3 ± 18.4	20	136 ± 30.4	40	36.1 ± 16.1
APPLE	5	106.2 ± 5.4	30	121 ± 35.2	25	98 ± 25.8	30	160.4 ± 49.9	30	18.8 ± 7.3

Table 2: presents the color, resolution and realistic imaging of intraoral images according to the type of camera (mobile and DSLR).

Factors / Camera	Realistic		Color						Resolution million	
			Green		Blue		Red			
	cv	x ± sd	cv	x ± sd	cv	x ± sd	cv	x ± sd	CV	x ± sd
DSLR	0	100 ± 0.0	5	173 ± 7.3	5	166.6 ± 7.4	5	191.3 ± 7.6	0	1800.5 ± O
HTC	3	109.6 ± 0.1	10	119.4 ± 11.9	10	113.1 ± 11.6	10	121.7 ± 12.3	5	11.5 ± 0.1
SONY	2	105 ± 0.1	5	148.5 ± 8.1	10	141.1 ± 9.8	5	160.7 ± 7.6	15	25.3 ± 3.5
SAMSUNG	3	104.4 ± 0.2	10	97.9 ± 10.1	10	93.2 ± 9.3	10	107.5 ± 11.6	20	48.5 ± 10.2
APPLE	2	102.6 ± 0.1	5	114.7 ± 4.1	5	101.3 ± 4.2	5	126.4 ± 5.1	10	23.4 ± 2.2

In terms of resolution, the DSLR camera had the highest score (1800.5), comprising a highly significant difference

with the other cameras. This difference was less significant with Samsung, but more with HTC, and equally significant with Sony and Apple. In the two-by-two comparisons of mobile cameras, HTC showed highly significant differences with the others. With the highest score, Samsung was significantly different with all the others (P<0.05); however, no significant differences were observed between Sony and Apple (P<0.4). As for the color factor, the DSLR camera had the highest value in terms of displaying the color red (191.3), comprising a highly significant difference with the others. Sony came next in ranking and was significantly different with the other mobile cameras. In the two-by-two comparisons of mobile cameras, no significant differences were observed between Apple, Samsung and HTC (P<0.2). In terms of displaying the color blue, DSLR received the highest score (166.6) and Samsung the lowest (93.2), which is a highly significant statistical difference (P< …). The DSLR camera was also significantly different with the other mobile cameras (P<0.002). Sony received the highest score and was significantly different with the others (P<0.01). The difference was significant between Samsung and HTC (P<0.02); however, HTC was not significantly different with Apple and Samsung (P<0.2). In terms of displaying the color green, the DSLR camera received the highest score (173) and Samsung the lowest (97.9), with the highly significant difference between them (P< …). In the two-by-two comparisons of mobile cameras, significant differences were observed between Samsung, Sony and HTC (P<0.002), but not between HTC and Apple (P<0.6). As for the realistic imaging factor, the DSLR camera received the highest score of 100 and HTC was deemed to take the most unrealistic images with a score of 109.6, comprising a highly significant difference (P< …). There were significant differences between the DSLR camera and mobile cameras, and between the mobile cameras themselves (P< …).

Table 3: presents the color, resolution and realistic imaging features of intraoral images according to the type of camera (mobile and DSLR).

Factors / Camera	Realistic		Color						Resolution	
			Green		Blue		Red		million	
	cv	x ± sd	cv	x ± sd	cv	x ± sd	cv	x ± sd	CV	x ± sd
DSLR	0	100 ± 0.0	30	92.1 ± 28.4	30	79.3 ± 25.9	20	144.2 ± 32.3	30	94 ± 24.8
HTC	1	102.8 ± 1.3	35	132.7 ± 47.1	35	96.7 ± 35.8	30	174.2 ± 50.4	40	8.9 ± 3.4
SONY	4	102.2 ± 4.8	30	121.0 ± 38.0	30	101.9 ± 30.8	25	164.7 ± 39.1	10	10.4 ± 1.2
SAMSUNG	3	103.8 ± 3.2	20	120.3 ± 23.3	20	105.4 ± 22.7	15	157.2 ± 21.9	30	23.7 ± 8.2
APPLE	4	109.8 ± 5.3	40	127.4 ± 48.8	35	94.8 ± 35	30	180.1 ± 59.4	60	14.1 ± 7.9

In terms of resolution, the DSLR camera received the highest score (94) and HTC the lowest (8.9), comprising a significant difference (P< …). The DSLR camera had the least difference with Samsung. In the two-by-two comparisons of mobile cameras, Samsung was significantly different with Sony and HTC (P<0.01), but not with Apple (P<0.1). No significant differences were observed in the two-by-two comparisons of Sony, HTC and Apple (P<0.4).

In terms of the color factor, the DSLR camera received the score of 144.2 in terms of displaying the color red while Apple received the score of 180.1, comprising the biggest difference, yet not considered statistically significant (P<0.1). The difference was not significant in the two-by-two comparisons of mobile cameras (P<0.8). In terms of displaying the color blue, the DSLR camera received the score of 79.3 while Samsung the score of 105.4, comprising the biggest difference, yet not considered statistically significant (P<0.2). The difference was

not significant in the two-by-two comparisons of mobile cameras (P<0.8). In terms of displaying the color green, the DSLR camera received the score of 92.1 and HTC the score of 132.7, comprising the biggest difference, yet not considered statistically significant (P<0.2). There were no significant differences in the two-by-two comparisons of mobile cameras (P<0.4).

In terms of the realistic imaging factor, the DSLR camera received the score of 100 and took the most realistic images while Apple received the score of 127.4 and took the least realistic images. Significant differences were observed in the comparison of the DSLR camera to Apple and Samsung (P<0.01); however, no significant differences were observed between Sony and HTC (P<0.4). In the two-by-two comparisons of mobile cameras, Apple was shown to be significantly different with Sony and HTC (P<0.05); however, there were no significant differences between Sony and HTC and between Apple and Samsung (P<0.1).

Discussion

The present study compared a DSLR camera to 4 mobile cameras in terms of the three factors of resolution, color, and realistic imaging. The DSLR camera yielded the most positive results.

In terms of resolution, the DSLR camera showed highly significant differences with the mobile cameras examined, showing the least difference with Samsung and the most with HTC, and equal differences with Sony and Apple. The three colors red, blue and green were examined to assess the cameras' performance with regard to color. The DSLR camera received the highest score in terms of displaying red and blue, with Sony close in score, thus comprising no significant differences. In terms of displaying the color green, Sony received the highest score and HTC, Apple and Samsung were ranked next after Sony, in respective order, and displayed these colors with less intensity. In terms of the color representation factor, it can generally be said that, with the exception of Samsung, the DSLR camera showed no significant differences with the mobile cameras. In terms of the realistic imaging factor, the DSLR camera was identified as the standard, and the other cameras were all compared against it in terms of the image clutter factor, showing significant differences. In terms of realistic imaging, the mobile cameras showed no significant differences with one another.

Previous studies had only made general comparisons between mobile cameras and DSLR cameras and had not conducted comprehensive specialized examinations of the quality of the various types of mobile cameras available.

Wonse Parle studied three different types of cameras, including a DSLR camera, an oral imaging camera, and a remote image transmission camera. He also found the digital camera to have captured higher-quality images; however, he also concluded that mobile cameras were easier to use. These findings are consistent with the findings of the present study (5).

Shorey proposed DSLR cameras as the best devices for capturing higher-quality images, which is consistent with the findings of the present study (4).

Machado studied resolution as an important aspect of images without any regards for the camera's mega-pixel offering and found that improved resolution is not related to increased mega-pixels. The present study also examined cameras with different mega-pixels and found that Sony mobile cameras, which had the highest mega-pixels offered, produced intra-oral images of a lower resolution compared to the other cameras examined (7).

Mladenovic conducted a study to find an easy method for image transmission in telemedicine and used remote data transmission through a mobile camera and a computer and concluded that, due to their easier availability, mobile cameras were able to capture acceptable images and transmit them with relative ease, which is consistent with the findings of the present study on mobile cameras (10).

In a study conducted in 2006, Bister compared 10 DSLR cameras with respect to the features of image depth, resolution and color and found significant differences between the cameras in color, but none in resolution. The present study contradicted these results and found DSLR cameras to be significantly different with mobile cameras in terms of resolution, but not in terms of color. The inconsistency of results might be due to the present study's comparison of mobile cameras while the one conducted by Bister compared only DSLR cameras (3).

In a study conducted in April 2015, Sajadi *et al*. compared the quality of images taken by Canon DSLR 550D and 4 mobile cameras including Samsung S4, Apple S5, Sony Xperia Z and HTC one. For the quality assessment of the images, the factors of color and resolution were visually judged by a number of dentists. The results obtained ranked DSLR first in all aspects and attributed a better performance to Samsung in terms of taking intraoral images, which was consistent with the results of the present study. As for extra-oral images, Sony performed

better than all the other cameras, which was not consistent with the results of the present study. The disparity of results might be due to the present study's assessment of images' quality based on the three factors of color, resolution and realistic imaging while the study conducted by Sajadi *et al.* assessed images based on the two factors of color and resolution.

Limitations of the present study include the use of only one DSLR camera, which may have affected the assessment of DSLR cameras. In addition, the study examined only a few mobile cameras. It may also have been better if the cameras studied were selected from among the ones commonly used by dentists in their offices. The want of a software expert was evident throughout the study and may have affected the speed of progress. Another weakness of the present study was that it took images only of a single individual (however, from different views); that is, the study had no sample diversity.

The study's points of strength include the use of commonly-used DSLR and mobile cameras so that the results can be beneficial to users. The assessment of images in terms of the three factors of color, resolution, and realistic imaging was another point of strength for the present study. Moreover, accurate distinctive statistical tests were used for the data analysis. According to the results obtained, the DSLR camera received the highest overall score, which might have been due to the camera's special features, including separate lenses and strong sensors. In addition, the large diaphragm in these cameras allows for a greater absorption of environmental light, thereby producing higher-quality images. The Sony mobile camera was found to score very closely to the DSLR camera in terms of color, which may have been due to Sony's use of newer light sensors that can produce much livelier colors even in bad lighting. Samsung ranked well in terms of resolution, which may have been due to the accurate image analysis software used in this camera.

Conclusion

DSLR cameras were found to be the best in terms of taking realistic images and, more importantly, providing good resolution. In terms of color, most of the cameras studied competed on the same level; however, Sony held a competitive edge over all the others. In terms of intra and extra oral views, Samsung captured better intraoral images while none of the mobile cameras stood out as capturing the highest-quality extra oral images with respect to all the three factors.

Recommendations

The present study considered the three factors of color, resolution, and realistic imaging. Future studies are recommended to consider other features involved in the quality of an image. The images taken in the present study were from different views of a single individual. More accurate statistical results can be obtained if images are taken from several people. Further studies are recommended to be conducted on this subject taking into account the recommendations offered.

Running title: Effect of mobile cameras on the quality of Images
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REFERENCES

1. Kreinbring M. The American Dentist: A Pictorial History with a Presentation of Early Dental Photography in America. Bulletin of the Medical Library Association. 1991;79(1):104.
2. Galante D. History and current use of clinical photography in orthodontics. Journal of the California Dental Association. 2009;37(3):173-4.
3. Bister D, Mordarai F, Aveling R. Comparison of 10 digital SLR cameras for orthodontic photography. Journal of orthodontics. 2006;33(3):223-30.

4. Shorey R, Moore K. Clinical digital photography: implementation of clinical photography for everyday practice. Journal of the California Dental Association. 2009;37(3):179-83.
5. Park W, Kim D-K, Kim J-C, Kim K-D, Yoo SK. A portable dental image viewer using a mobile network to provide a tele-dental service. Journal of telemedicine and telecare. 2009;15(3):145-9.
6. Chossegros C, Guyot L, Mantout B, Cheynet F, Olivi P, Blanc J. [Medical and dental digital photography. Choosing a cheap and user-friendly camera]. Revue de stomatologie et de chirurgie maxillo-faciale. 2010;111(2):79-83.
7. Machado AW. What's new in digital photography? Dental Press Journal of Orthodontics. 2010;15(2):20-3.
8. Mutalik S. Digital clinical photography: Practical tips. Journal of cutaneous and aesthetic surgery. 2010;3(1):48.
9. Zuiderveld K, editor. Contrast limited adaptive histogram equalization. Graphics gems IV; 1994: Academic Press Professional, Inc.
10. Mladenović D, Tošić G, Živković D, Đinđić N, Mladenović L, Mladenović S, et al. Telemedicine consulting in the patient preparation and planning of prosthetic tooth replacement. Vojnosanitetski pregled. 2013;70(9):866-70.