

Comparisons between photographic equipment for dental use: DSLR cameras vs. smartphones

Comparações entre equipamento fotográfico para uso odontológico: câmeras DSLR vs. smartphones

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Abstract

Objective: to compare the image quality obtained by six cameras used for dental documentation, including four DSLR cameras and two smartphones with different sensor size. Methods: the equipment determined the groups: APSCcan18-55 – Sensor APS-C Canon (EOS T5i) + 18-55 mm lens; APSCcan100 – Sensor APS-C Canon (EOS T5i) + 100 mm macro lens; APSCnik18-55 – Sensor APS-C Nikon (D5100) + 18-55 mm lens; APSCnik100 – Sensor APS-C Nikon (D5100) + 100 mm macro lens; ip1/3" – iPhone with 1/3-inch sensor; ga1/2.6" – Galaxy with 1/2.6-inch sensor. Two set of images – "dental documentation" and "small objects" – were obtained. The photographs were evaluated by three groups: US, undergraduate students; DS, dentists; and DP, dentists with photography experience. Scores between 0 and 10 were assigned. The results were compared by RM Anova and Tukey ($\alpha = 0.05$). Results: the highest overall scores were obtained with APSCnik100 (8.5). For "dental documentation", APSCcan18-55 and APSCnik18-55 showed the lowest values, even compared to ga1/2.6" (for US, DS and DP evaluators) and ip1/3" (for US evaluators). For "small objects", DSLRs resulted in higher mean values compared to smartphones for US and DS. Conclusions: DSLR cameras with 18-55 mm lens and no circular flash should not be used for documentation photographs. DSLR cameras, regardless of lens, are superior to smartphones for small objects photographs.

Keywords: Dental Photography. Photography. Smartphone.

<http://dx.doi.org/10.5335/rfo.v24i2.10437>

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Introduction

Photographic images can be very useful in dental treatment, especially for patient documentation, communication between professionals and laboratory technicians, patient orientation, marketing and evaluation of the results. In addition, they are important for detecting facial pattern changes, often used in orthodontic treatment, surgery, oral rehabilitation, and more recently, digital smile planning¹⁻⁵.

There are several models available, from simple compact devices, to robust sophisticated models. The first requirement is a basic knowledge of photography: light control, diaphragm aperture, shutter speed, and sensor sensitivity⁶. Compact models, which include smartphones, usually have few adjustable features, are easy to manipulate and the camera body and lens are contained in a single unit. The lens also has fixed focal length, between 29 and 33 mm, determined by the manufacturer⁷. Low focal lengths are indicated for wide-angle photographs (panoramic views) because of their wide range. When these lenses are used for close-up images, they generate unexpected distortions in the image¹. Moreover, compact models do not allow the use of external flashes, only built-in or pop-up flashes. When used incorrectly, these types of flash can generate shadow in the oral cavity⁶.

Digital single lens reflex (DSLR) cameras are more robust in terms of construction. They have a wide range of adjustable functions, and the

camera body and lens are separate units. Thus, the lens can be changed depending on what the situation requires. The camera body contains the viewfinder, trigger, photosensor and shutter, and quite frequently includes a flash, among other functions. The lenses are responsible for transmitting the image to the camera body. Macro lenses are normally used for dental photographs, since they allow you to focus on small objects with high quality^{8,9}.

Considering the accessibility, price, and improvements in smartphones, compared with DSLR equipment, their cameras are used for dental photographs in numerous situations. A comparison of images obtained with different devices should aid dentists in choosing the most useful equipment. Thus, the objective of this study was to compare the quality of dental photographs obtained with six different photographic cameras, evaluated by three groups of participants: undergraduate students, dentists, and dentists with photography experience.

Material and methods

Four DSLR cameras and specific accessories were compared in this study with two smartphones with different sensor size. Table 1 presents the equipment used and the respective accessories, sensor type and operational mode, including resolution, mode, ISO, flash and, where applicable, opening and shutter speed.

Table 1 – Equipment used in the study according to the group, sensor and their operational mode

Group name	Equipment set	Sensor	Operational mode
APSCcan18-55	Camera body: Canon EOS T5i Lens: Canon EF-S 18-55 mm Flash: Pop-up	APS-C 22.2×14.8mm	Resolution: 18 MP Mode: automatic ISO: 200 Flash: on
APSCcan100	Camera body: Canon EOS T5i Lens: Canon EF 100 mm f/2.8 Macro IS USM, Flash: Canon Macro Ring Lite MR-14EX, in mode ETTL	APS-C 22.2×14.8mm	Resolution: 18 MP Mode: Manual ISO: 100 Opening: f/32 Shutter speed: 1/100
APSCnik18-55	Camera body: Nikon D5100 Lens: Nikon AF-S DX Nikkor 18-55 mm Flash: Pop-up	APS-C 23.6×15.6 mm	Resolution: 16.2 MP Mode: automatic ISO: 200 Flash: on
APSCnik100	Camera body: Nikon D5100 Lens: Sigma 105mm f/2.8 EX DG OS HSM Macro Flash: Sigma EM-140 DG Macro Ring, in mode ETTL	APS-C 23.6×15.6 mm	Resolution: 16.2 MP Mode: Manual ISO: 100 Opening: f/32 Velocity: 100

cont.

ip1/3"	Apple iPhone	1/3-inch - 4.9×3.7 mm	Resolution: 8 MP Mode: automatic ISO: automatic Flash: on
ga1/2.6"	Samsung Galaxy	1/2.6-inch - 5.8×4.0 mm	Resolution: 16 MP Mode: automatic ISO: automatic Flash: on

Source: authors.

Following approval by the Research Ethics Committee (#1.256.135), two groups of photographs were obtained with each equipment:

Composed of extraoral (frontal, frontal smiling and profile) and intraoral photographs (frontal, right and left lateral, maxillary and mandibular occlusal). After obtaining the photographs, the images were downloaded to a computer and

cropped using Adobe Photoshop software (version CS3). The cropping tool was used with a ratio of 3:2. The image output size was 30×20 cm, with no changes in the original image resolution. Then, the images were saved in JPEG format at maximum quality and in no compression mode. Images were not treated in relation to illumination, color correction, saturation, or any other adjustments.



Image 1 – Small objects of clinical use: print layout of 20 × 30 cm. Each object is shown in real size and at 2×, 3×, 5×, 10× and 15× magnification.

Source: authors.

The small objects used for this group were a dental prophylaxis brush (Microdont, Monsey, USA), a carbide #6 bur (KG Sorensen, Cotia, Brazil), and a disposable applicator (Aplik Angelus, regular size, Lindoia, Brazil). These objects can be compared by any professional since they are commonly used. The photographs were printed in full size as well as magnified 2×, 3×, 5×, 10× and 15×. To verify the same magnification for all three objects, they were positioned next to a millimeter rule. The cropping tool was used at a 6:4 ratio. All images were saved in JPEG format at maximum quality and in no compression mode, and organized in a 30×20 cm layout (Figure 1).

The sets of images were printed in a photographic laboratory using a Frontier LP 7500 printer (Fujifilm Holdings Corporation, Tokyo, Japan) with the dimensions 20 × 30 cm. Then, each set of small objects images taken by the same equipment received a random number from 1 to 6. Similarly, each set of documentation images received a random number from 7 to 12. This meant that the evaluators were blinded to the specific equipment used to produce each photograph.

The evaluators received a questionnaire to assign individual scores to each image set. They were allowed to score individually or by comparing the set of images. No interference occurred between evaluators regarding their judgment and perception. The scores were based on the sharpness, quality, color fidelity, and general context of the photographs. Scores between 0 (zero) and 10 (ten) were assigned. A term of free, informed consent was attached to the evaluation form, together with the inclusion criteria of the research.

A total of 136 evaluators were included in the study, divided into three groups: undergraduate students (US; n=60); dentists (DS; n=37); and dentists with photography experience (DP; n=22).

The scores given to the set of images by each evaluator group were tabulated and analyzed using RM ANOVA, followed by the Tukey test ($\alpha = 0.05$).

Results

Comparison of the values obtained for the documentation photographs by US, DS and DP is

shown in Table 2. The groups APSCnik18-55 and APSCcan18-55 obtained the lowest values. The evaluation of these cameras by US indicated they were significantly inferior to the others. For DS and DP, only APSCcan18-55 was significantly inferior to the other equipment. The greatest values were obtained for the APSCcan100; however, it showed no statistically significant differences from APSCnik100 and ga1/2.6" for all the evaluators.

Table 2 – Mean, standard deviation (SD) and statistical grouping* of the mean values attributed to each equipment by the US (n=60), DS (n=37) and DP (n=22) for dental documentation images

Equipment	US	DS	DP
APSCcan100	8.3 (1.2) ^A	8.3 (1.4) ^A	8.3 (1.7) ^A
APSCnik100	7.8 (1.5) ^A	7.9 (1.6) ^{AB}	8.3 (1.6) ^A
ga1/2.6"	8.0 (1.4) ^A	7.8 (1.4) ^{AB}	7.7 (1.4) ^A
ip1/3"	6.6 (1.5) ^B	7.0 (1.5) ^{BC}	6.0 (1.7) ^B
APSCnik18-55	5.9 (1.6) ^C	6.4 (1.8) ^{CD}	5.0 (2.4) ^{BC}
APSCcan18-55	5.9 (1.7) ^C	5.6 (1.4) ^D	4.2 (2.3) ^C

* Different capital letters in the same column indicate statistically significant difference.

Source: authors.

Comparison between the mean values obtained in the evaluation of the small objects by the US, DS and DP is presented in Table 3. For all groups of evaluators, DSLR cameras were attributed the highest mean values. The APSCnik100 and APSCcan18-55 had the highest scores, statistically superior to the APSCcan100 and APSCnik18-55 in the assessment of the US. In addition, the evaluation of the US resulted in statistically higher values for the APSCcan100 and APSCnik18-55 compared with the smartphone cameras.

Table 3 – Mean, standard deviation (SD) and statistical grouping* of the mean values attributed to each equipment by the US (n=60), DS (n=37) and DP (n=22) for photographs of small objects

Equipment	US	DS	DP
APSCnik100	8.6 (1.5) ^A	8.0 (1.8) ^A	9.4 (0.8) ^A
APSCcan18-55	8.5 (1.2) ^A	8.4 (1.8) ^A	8.9 (1.0) ^{AB}
APSCcan100	7.6 (1.5) ^B	7.6 (1.9) ^A	7.8 (1.3) ^{BC}
APSCnik18-55	7.3 (1.0) ^B	7.3 (1.4) ^A	7.2 (1.4) ^C
ga1/2.6"	6.0 (1.6) ^C	6.3 (1.7) ^B	6.1 (2.0) ^C
ip1/3"	5.3 (1.5) ^D	5.9 (1.9) ^B	5.0 (2.1) ^D

* Different capital letters in the same column indicate statistically significant difference.

Source: authors.

Discussion

Analyses of the results indicate DSLR cameras were better evaluated compared with smartphones for small objects photography. This can be attributed to sensor size, which is higher for DSLRs. The Canon and Nikon cameras used for this study have 22.2 mm × 14.8 mm and 23.6 mm × 15.6 mm APS-C sensors, respectively. In contrast, the smartphones have sensors with 4.9 mm × 3.7 mm (ip1/3") and 5.8 mm × 4.0 mm (ga1/2.6")^{8,9}. Large sensors have larger pixels, which capture a greater amount of light compared with small sensors, resulting in higher quality images with regard to definition and sharpness¹⁰. Moreover, the superior lenses of DSLR cameras also contribute to the results.

DSLR cameras used without a macro lens and particularly without an external flash did not produce good photos of dental documents. The pop-up flash positioned over the camera body of the camera is far from the lens, creating poor illumination in close-up images. For intraoral photographs, this can result in shadows on the posterior teeth and overexposure on anterior teeth, since the flash power increases to compensate for the lack of back lighting^{1,10}. On mobile phones, the flash is located close to the lens, generating enough illumination for documentations. The same occurred when DSLR cameras were used with an external macro ring flash¹¹⁻¹⁴. The deficiency in illumination likely explains the poor performance of APSCnik18-55 and APSCcan18-55 for dental documentation.

Dental documentation photographs do not need high magnifications like small objects. Therefore, in general, the smartphones showed good performance for the set of dental documentation, in contrast to the set of small objects. The equipment's resolution is largely responsible for image quality. Megapixel values only affect the size of the output image, and the smartphones used for this study had sufficient megapixels for an image size of 9×6 cm¹¹.

The focal length of the smartphone lenses is much shorter than that of DSLR cameras, which is directly related to the fidelity in the proportion of objects. According to the manufacturers (Apple

and Samsung), smartphones have lenses with a short focal distance, generating undesired distortions when the image is obtained at a short distance. Macro lenses, with focal lengths of 100 mm and 105 mm, do not present this problem. The ideal distance for documentation photography is between 30 and 40 cm from the patient. DSLR cameras associated with macro lenses can accommodate this. However, smartphone images obtained at this distance must be cropped, since the full image contains a lot of information, such as the eyes, nose, cheeks, and even retractor devices^{15,16}.

The ga1/2.6" smartphone has slightly superior characteristics compared to ip1/3"¹⁷. The diaphragm aperture is f/1.9, which allows greater light input compared to the f/2.2 diaphragm aperture of ip1/3"¹⁸. Moreover, the superior sensor allows for better image quality, which explains the better mean scores for this equipment in some evaluations.

The evaluations of the three groups of evaluators were quite similar, both for small objects and for documentation. The differences in the cameras was more significant in the evaluations by the undergraduate students, probably due to the higher number of evaluators (60) compared with dentists (37) and dentists with photography experience (22). To our knowledge, there are no studies in the literature comparing the use of DSLR cameras and smartphones for dental photographs, thus this study should assist the clinician in deciding which equipment is the best to use in their daily practice.

Conclusions

DSLR cameras with 18-55 mm lens and pop-up flash should not be used for dental documentation photographs. In this case, the smartphone with 1/2.6-inch sensor generated images comparable to DSLR cameras + 100 mm macro lenses + a macro ring flash. DSLR cameras, regardless of the lens, were superior to smartphones for small objects photography. Despite certain specific divergences, the evaluations of the three groups of evaluators were quite similar.

Resumo

Objetivo: comparar a qualidade da imagem obtida por seis câmeras utilizadas para documentação odontológica, incluindo quatro câmeras DSLR e dois *smartphones* com diferentes tamanhos de sensor. Métodos: a divisão dos grupos foi realizada pelo tipo de equipamento: APSCcan18-55 - Sensor APS-C Canon (EOS T5i) + lente 18-55 mm; APSCcan100 - Sensor APS-C Canon (EOS T5i) + lente macro de 100 mm; APSCnik18-55 - Sensor APS-C Nikon (D5100) + lente 18-55 mm; APSCnik100 - Sensor APS-C Nikon (D5100) + lente macro de 100 mm; ip1 / 3 "- iPhone com sensor de 1/3 de polegada; ga1 / 2.6 "- Galaxy com sensor de 1 / 2,6 polegadas. Dois conjuntos de imagens – “documentação odontológica” e “pequenos objetos” – foram realizados. As fotografias foram avaliadas por três grupos de examinadores: estudantes de graduação (US); dentistas (DS); e dentistas com experiência em fotografia (DP). Foram atribuídas pontuações entre 0 e 10. Os resultados foram comparados por Anova e Tukey ($\alpha = 0,05$). Resultados: os maiores escores foram obtidos com o APSCnik100 (8,5). Para “documentação odontológica”, APSCcan18-55 e APSCnik18-55 apresentaram os menores valores. Para “objetos pequenos”, as DSLRs resultaram em valores médios mais altos em comparação aos *smartphones*. Conclusões: as câmeras DSLR com lentes de 18 a 55 mm e sem *flash* circular não devem ser usadas para fotografias de documentação. As câmeras DSLR, independentemente da lente, são superiores aos *smartphones* para fotografias de objetos pequenos.

Palavras-chave: Fotografia odontológica. Fotografia. *Smartphone*.

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Recebido: 22/02/19. Aceito: 19/06/19.