Original Article

Orthodontic extraoral photography: Comparative subjective analysis of five digital single lens reflex cameras

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Abstract

Objectives: To compare 5 digital single lens reflex cameras (DSLRs) for extraoral photography in the orthodontic office, to recognize the best camera and the best mode for each camera. **Materials and Methods:** 5 DSLRs namely Canon 500D, Canon 550D, Nikon D3100, Nikon D40 and Nikon D5000 were compared. Images were clicked in auto mode, program mode, manual mode, macro mode and aperture priority mode. Same settings were used for all cameras. Thirteen orthodontists were asked to rank the images for quality. Data was collected and statistically analyzed using Kruskall Wallis analysis of variance. **Results:** Canon 500D ranked the highest ($P < 0.001$) for auto, program and macro mode, closely followed by Canon 550D ($P < 0.001$), which ranked highest for portrait mode and manual mode. **Conclusion:** Images by Canon 500D and Canon 550D were perceived better than Nikon for the chosen settings, establishing ease of use for these cameras. This study gives a basic idea regarding technical specifications that can be used for a particular camera for extraoral photography.

Key words: Digital, extraoral, orthodontics, photography

INTRODUCTION

Extraoral photos are indispensable for documentation, communication and as a diagnostic tool in orthodontics. The art of diagnosis has evolved from intraoral aids such as plaster models to cephalometric radiography, digital imaging and to 3D reconstruction of images to life like models using computer software. Nonetheless, simple 2D digital imaging forms the most commonly employed tool for orthodontic diagnosis. It is simple, inexpensive (except for the initial investment) and very informative in terms of diagnostic value. Furthermore, there is ease of editing, improved communication; no film expense and easy and quick deletion of poor images with the advent of digital photography.[1] The digital single lens reflex (DSLR) cameras available commercially are commonly employed for the same, as these have become quite affordable over time.[2]

Many of the authors have previously tested DSLRs for intraoral photography.[3,4] Since extraoral imaging is equally important for orthodontic diagnosis and treatment planning, the same was considered in this study. Such comparative studies have been conducted previously,[5] but none has been undertaken recently. All DSLRs used for this study are comparable in terms of technical specifications and are capable of producing images of good resolution, with a wide range of depth of field, good color reproduction and sharpness once properly adjusted. Therefore, this study aims at comparing the images produced by these cameras at a specific setting with minimal adjustments, thus assessing user friendliness of the camera.

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AIM

Aim of this study was to compare five different DSLR cameras in different modes for extraoral photography in orthodontic clinic.

OBJECTIVES

- To determine, which camera produced the best image in a particular mode
- To recognize the best mode for a particular camera for extra oral photography.

MATERIALS AND METHODS

The study was conducted in the Department of Orthodontics and Dentofacial Orthopedics, SDM College of Dental Sciences, Dharwad, Karnataka, India. Five different commercially available DSLR cameras were selected for the study. Following are few important technical specifications [Table 1].

All pictures were taken in the photography room with wall mounted flood lights-110 V AC units [Figure 1]. The subject was photographed by the same operator using all cameras. The camera was stabilized using a tripod placed at a fixed distance of 3 feet from the subject being photographed against a white background. 18-55 mm lens was used with all cameras. Only full face extra oral view was taken for the comparison. The images were taken in Auto mode, Program mode, Portrait mode, Macro mode, Aperture priority mode and Manual mode. Although Auto, Portrait and Macro modes have automatic adjustments in all cameras, manual adjustments were required for Program mode, Aperture priority mode and Manual mode.

Figure 1: Photography room with wall mounted flood units

Auto mode

In this mode, shutter speed, aperture, ISO, white balance, focus and flash are all adjusted by the camera automatically.

Portrait mode

The camera adjusts automatically and depth of field is low in this mode, so that the background appears blurred.

Macro mode

This mode is usually used for shooting close objects, like intraoral pictures. However, to facilitate comparison, here the same extraoral photos were taken in this mode also. Depth of field is again low in this case and focusing distance may vary among different cameras.

Program mode

Here, aperture and shutter speed are adjusted automatically. ISO 800 was used for all cameras. ISO basically determines the sensitivity of the sensor to light. Higher the ISO, higher is the amount of light captured. However, it is not an absolute value as ISO definition relates to the fraction of light relative to the full capacity, not the total light collected. Higher ISO settings are required in low light conditions, but this also increases image noise.

Aperture priority mode

In this mode, aperture and ISO can be changed while shutter speed is adjusted by the camera automatically. Following aperture settings were used:

- $F = 5.6$
- $F = 8$
- $F = 16$
- $F = 29$.

Table 1: Technical specifications of the cameras used for the study

Feature	Nikon D5000	Nikon D3100	Nikon D40	Canon 550D	Canon 500D
Effective pixels (in millions)	12.3	14.2	6.1	18.0	15.1
Sensor size (mm)	23.6×15.8	23.1×15.4	23.7×15.6	22.3×14.9	22.3×14.9
Continuous shooting speed	4 frames/s	3 frames/s	2.5 frames/s	3.7 frames/s	3.4 frames/s
ISO sensitivity	ISO 200-3200	100-3200	200-1600	100-6400	100-1600
Monitor size	2.7 inches diagonal	3.0 inches	2.5 inches	3 inches	3 inches

ISO = International organization for standardization

ISO was kept constant at 800. As the F number increases, the aperture's size decreases and the depth of field increases.

Manual mode

Settings used were ISO: 800, f = 5.6, shutter speed = 1/125 s.

Flash compensation was set at 0 for all cameras. Picture quality was set at fine, large size in JPEG format and white balance was set at auto. Picture saturation, contrast and sharpness were set at zero for all cameras. Images were displayed on a computer screen (Hp pavilion g6 2210 notebook) and thirteen orthodontists were asked to rank the images for quality, which were completely "anonymized" [Figure 2]. The laptop screen was placed at eye level of the observer, who was seated at a distance of 1.5 feet from the screen. Images were given rank from 1 to 5, 1 being the best image and 5 being the worst.

Statistical analysis

All the results were collected and analyzed using "SPSS 10.0., IBM corporation" The collected data was subjected to Kruskall Wallis test.

RESULTS

Canon 500D was ranked the best out of all cameras in auto mode, macro mode, aperture priority with settings $f = 16$ and $f = 29$ and program mode ($P < 0.001$). It was closely followed by Canon 550 D, which gave best images in the remaining modes, i.e., Aperture priority mode with settings $f = 5.6$, $f = 8$, portrait mode and manual mode ($P < 0.001$). Nikon D3100, Nikon D40 and Nikon D5000 produced relatively inferior results than Canon 500D and 550D ($P < 0.001$) [Table 2]. Mode wise comparison is as follows:

Auto mode

Canon 500D was ranked best ($P = 0.04$). Image was sharp, with good colour reproduction. Canon 550D was the next best, with image slightly lacking in exposure ($P = 0.93$). This was followed by Nikon D3100, which gave an image with increased emphasis on red ($P < 0.001$). Nikon D40 image was slightly underexposed, while Nikon D5000 image put more emphasis on blue.

Portrait mode

Canon 550D produced the best image ($P < 0.001$) followed by canon 500D, for which color temperature was slightly low. Nikon D40 image ranked third with good color reproduction and adequate exposure. Nikon D3100 and Nikon D5000 lacked in exposure.

Program mode

Canon 500D gave the best image ($P < 0.001$). Canon 550D image color temperature was considerably increased, putting great emphasis on red. Nikon D3100 and D40 lacked exposure, while Nikon D5000

Figure 2: Images were displayed on the computer screen. The mode and camera were not disclosed to the observer

Table 2: Comparison of quality of orthodontic photography taken by different modes using 5 different SLR cameras

SLR type	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5	Mode 6	Mode 7	Mode 8	Mode 9	Chi square value	*P* value*
Canon 500D											
Mean	2.23	2.15	1.77#	1.62#	1.54#	1.46#	2.54	2.08	1.92#	15.87	0.04
Median	2.00	2.00	2.00	2.00	1.00$	1.00	2.00	2.00	2.00		
SD	1.09	0.99	0.60	0.65	0.66	0.78	0.97	0.86	0.86		
Canon 550D											
Mean	1.92#	1.77#	1.85	2.15	2.23	2.31	2.15#	1.92#	2.00	3.01	0.93
Median	1.00	1.00$	1.00	2.00	2.00	2.00	2.00	1.00	2.00		
SD	1.19	1.01	1.14	1.21	1.24	1.25	1.14	1.19	1.08		
Nikon D3100											
Mean	2.69	2.46$	3.31	4.38	3.23	2.69	2.69	3.77	2.77	32.43	<0.001
Median	2.00	2.00	3.00	4.00	3.00	3.00	3.00	4.00	3.00		
SD	1.18	1.05	1.18	0.65	1.01	0.63	1.18	0.83	1.09		
Nikon D40											
Mean	3.38	3.85	3.54	2.77	3.85	4.54	2.62	2.54$	3.62	39.81	<0.001
Median	4.00	4.00	4.00	3.00	4.00	5.00	3.00	3.00	4.00		
SD	0.96	0.38	1.05	1.09	0.90	0.97	1.26	1.05	0.77		
Nikon D5000											
Mean	4.77	4.77	4.54	4.08	4.15	4.00$	5.00	4.69	4.69	31.41	<0.001
Median	5.00	5.00	5.00	4.00	5.00	4.00	5.00	5.00	5.00		
SD	0.60	0.83	0.78	1.04	1.34	0.71	0.00	0.85	1.11		
Chi square value	32.79	40.74	35.82	36.88	30.90	40.36	33.09	36.35	34.91		
P value^	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		

SLR = Single lens reflex; SD = Standard deviation. #The best camera for a particular mode; $The best mode for each camera;*Comparison of different modes within a SLR camera (Kruskall Wallis ANOVA); ^Comparison of different SLR cameras within a mode (Kruskall Wallis ANOVA). Mode 1 = Aperture priority mode (*f*=5.6); Mode 2 = Aperture priority (*f*=8); Mode 3 = Aperture priority (*f*=16); Mode 4 = Aperture priority (*f*=29); Mode 5 = Auto mode; Mode 6 = Macro mode; Mode 7 = Manual mode; Mode 8 = Portrait mode; Mode 9 = Program mode

lacked exposure as well as color reproduction. These results, however, were with one particular setting for all cameras, as described above.

Manual mode

Canon 550D produced best image ($P < 0.001$). However, color temperature was slightly higher. Canon 500D was ranked next best, followed by Nikon D40, Nikon D3100 and Nikon D5000 respectively.

Macro mode

Canon 500D gave the best image ($P < 0.001$) followed by Canon 550D, Nikon D3100 and Nikon D5000. Exposure was low for Nikon D5000. Nikon D40 image was highly overexposed.

Aperture priority mode

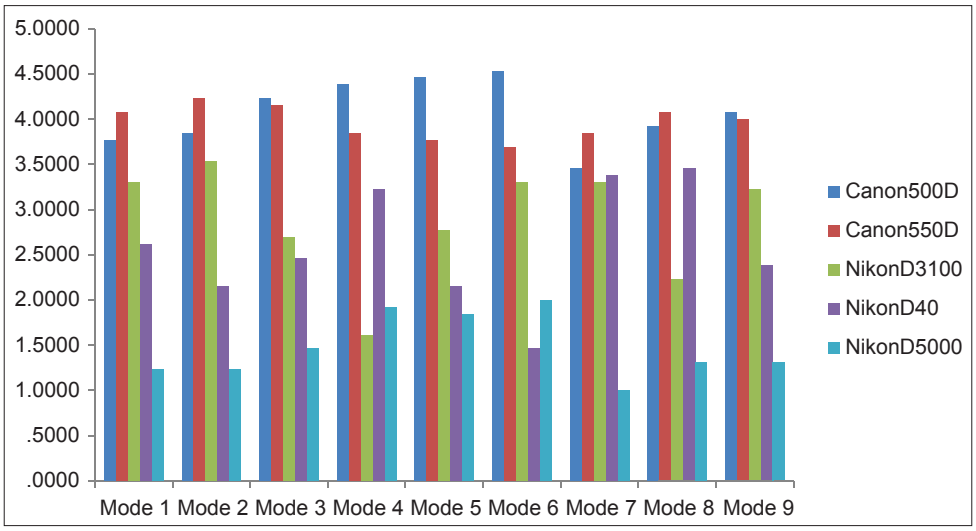
For $f = 5.6$ and $f = 8$, Canon 500D gave the best image ($P < 0.001$) followed by Canon 550D, Nikon D3100, Nikon D40 and Nikon D5000 respectively. However, for $f = 16$, Canon 550D ranked better than Canon 500D ($P < 0.001$). Overall, an aperture setting of $f = 16$ produced acceptable images for all cameras. For $f = 29$ setting, Nikon D3100 image was ranked least with considerably reduced exposure.

Best results were obtained for Canon 500D using Auto mode, for Canon 550D and Nikon D3100 using aperture priority mode with $f = 8$ setting, for Nikon D40 using the portrait mode and for Nikon D5000 using the macro mode [Graph 1].

DISCUSSION

This study was principally aimed at comparing 5 DSLRs for extraoral photography. The results obtained show that Canon 500D produced subjectively superior images, followed by Canon 550D, which produced comparable results. Nikon D3100, D40 and D5000 gave relatively poor images for the same settings.

It was found that images obtained by Nikon DSLRs were often ranked low owing to underexposure. In order to obtain correct exposure, the ISO speed setting can be adjusted. When a higher ISO setting is used, the camera sensor becomes more sensitive to light, thus increasing exposure. However, this increases image noise and should therefore be used cautiously. Other functions like flash compensation and exposure compensation can also be altered when



Graph 1: Comparison of the results for each camera in every mode. Mode 1: Aperture priority mode (*f* = 5.6), Mode 2: Aperture priority (*f* = 8), Mode 3: Aperture priority (*f* = 16), Mode 4: Aperture priority (*f* = 29), Mode 5: Auto mode, Mode 6: Macro mode, Mode 7: Manual mode, Mode 8: Portrait mode, Mode 9: Program mode

using the manual mode. In modes where aperture settings can be changed, using a lesser *f* value will increase the aperture size, thus increasing the amount of light entering the camera. However, it should be kept in mind that changing *f* value alters depth of field as well. Lesser *f* value gives lesser the depth of field. This is desirable for extraoral portrait photography, as it blurs the background, keeping only the subject of interest in focus. Other than these settings, various computer softwares provide the options to alter the image exposure and brightness. The drawback here is that in case the image is already overexposed, not much can be done to fix it, even if the image is taken in RAW format, which generally gives greater freedom of processing. It is always better to produce slightly underexposed image than an overexposed one.

In many modes, Canon 550D produced image with increased color temperature accounting for lower ranking obtained as compared to Canon500D. To assess color reproduction, the image must be compared with the actual subject. The difference in color reproduction reflects manufacturing difference in color weighting. All cameras color render images, i.e., they alter the actual colors while constructing the image. To avoid color rendering, image may be taken in RAW format. This reduces the image processing by the camera, but does not completely eliminate color rendering. To obtain the desired color, the "white balance" function may be manually adjusted. This was set at auto for the present study.

Color rendering may also occur when the image is displayed on the computer screen, or is printed. To minimize this, various color management systems have evolved (International color consortium).[6]

If we compare Nikon D40 and Nikon D5000, images produced by Nikon D40 were better ranked. This is interesting, considering the fact that Nikon D40 is a 6.1 Megapixel camera compared to Nikon D5000, which is a 12.3 Megapixel. This is probably because since the sensor size of the two is the same, size of pixels is smaller for Nikon D5000. Pixel size, though less considered, is an important factor that affects image quality. Greater pixel size allows greater detail to be captured per pixel, thus decreasing image noise, particularly at high ISO levels.[7]

This study was conducted using popular entry level DSLRs available at the time. Quite recently, new cameras have been announced by Canon and Nikon. Nikon D3200, announced in April 2012 and Nikon D5200, announced in November 2012 are the new entries, which lie within the same price range. Nikon D3200 is said to have good image quality and might be very useful if one is willing to invest in good lenses. Nikon D5200 has a sophisticated 39 point autofocus system and improved version of D3200 sensor.[8]

CONCLUSION

Extraoral photography is an important part of orthodontic diagnosis and effort should be made to produce quality images, which are also necessary for publications and case presentations. This study compared 5 commonly used DSLRs and results showed Canon 500D and Canon 550D to be better than Nikon

D40, D5000 and D3100 with minimal adjustments. This assessment was subjective and may be attributed to one's perception of color saturation and vibrance. Comparable images may be produced by all cameras by altering various settings as described, but this requires experience and time. This study also provides baseline data for further studies, which may focus on comparison of more recent cameras, with other settings that may provide better results. Since technology is a constantly advancing field, it is important to keep one-self updated if one strives for excellence.

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