

Digital image characteristics for enhanced interpretation in child sexual violence case examinations

Yuli Budiningsih¹, Agus Purwadianto¹, Aria Yudhistira¹, Agusalam Budiarso²



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Authors' affiliations:

¹Department of Forensic and Medicolegal, Faculty of Medicine, Universitas Indonesia, Cipto Mangunkusumo Hospital, Jakarta, Indonesia, ²Serang City Health Department, Serang, Banten

Corresponding author:

Agusalam Budiarso
 Serang Regional General Hospital, Jalan Raya Jakarta Km. 4 Lingkungan Kampung Baru, Penancangan, Cipocok Jaya, Serang 42124
 Tel/Fax: +62-54-7932007
 E-mail: goezthedoctor@gmail.com

ABSTRACT

BACKGROUND Photography is an integrated part of standard forensic examination procedures, acting as a guide and the evidence itself. Despite its potential, no research has yet explored the use of 35mm format cameras (digital single-lens reflex [DSLR]) in sexual violence cases. This study aimed to assess the impact of DSLR camera image characteristics on the interpretation of child sexual abuse cases.

METHODS This cross-sectional study used 55 digital photos selected through a convenience sampling. The samples were interpreted by two independent forensic experts who were not affiliated with this research and were compared with the results of the doctor's examination from the medical records.

RESULTS The metadata extraction results (EXIF data) indicated that all characteristic values had an abnormal distribution. The digital photos' characteristics were associated with the use of a 50mm focal length ($p = 0.011$). A range of lens opening values (aperture = f7.1–f8.0), shutter speed (1/100–1/125 sec), and sensor sensitivity (ISO = 800–1600) were not associated with the experts' interpretation conformity. Additionally, the conformity index for the overall interpretation by the two forensic experts differed in each area.

CONCLUSIONS Focal length of 50mm was significantly related to interpretation conformity. The exposure triangle settings, including aperture (f7.1–f8.0), shutter speed (1/100–1/125 sec), and ISO (800–1600), can serve as fundamental guidelines for digital camera settings in examining child sexual violence cases.

KEYWORDS clinical medicine, forensic medicine, photography, physical examination, sexual child abuse

Photography is integral to forensic examination. It serves as a guide, substitutes information for evidence, and provides valid and legal electronic evidence, thus ensuring legal certainty.¹ Forensic photography offers distinct advantages, particularly in cases of suspected child sexual abuse. This method provides clear visual evidence, reduces the need for repeated and potentially distressing examinations, and serves as a valuable educational resource for expert consultation and peer review.²

Conducting genital examination of child victims is challenging because of their uncooperative nature. Doctors are required to swiftly assess the intricacies of female genital anatomy and subtle injuries, making visual interpretation difficult.³ Accurate forensic documentation of examination findings is crucial. However, while the existing guidelines emphasize the equipment and positioning, they lack specific guidance on camera settings, such as aperture size, shutter speed, sensor light sensitivity measured using the

International Organization for Standardization (ISO) standards, and lens focal length, which are essential for capturing high-quality photos. Aperture, shutter speed, and ISO form the exposure triangle, which comprises a series of basic adjustments to provide sufficient light capture, resulting in good image quality. The exposure triangle concept emphasizes the balance required between these three settings (aperture size, shutter speed, and sensor sensitivity) to achieve optimal exposure and capture well-exposed photographs in various lighting conditions. The only recommendations are to use a 35mm format camera, such as a digital single-lens reflex (DSLR) camera, because of its ease of use, minimal training requirements, accurate color balance, optimal lighting, and life-size reproduction capabilities.⁴

The baseline requirements for forensic photography in suspected cases of child sexual abuse are comprehensive. The examination must be tailored to the circumstances and needs of the child and their parents. Informed consent is crucial before proceeding with documentation, and standardized procedures should be followed. High-quality images must be captured using the examination team's equipment to ensure victim confidentiality through secure storage. Access to and transmission of photographic records are strictly limited, and only the examination team is responsible for maintaining image integrity over time.⁵ The image-capturing process involves several steps, starting with identity photographs and progressing to detailed images of relevant anatomical locations and positions. Close-ups of specific body parts and different lighting techniques may be employed as needed. The final identity photograph marks the conclusion of each patient's photographic record.⁶

Despite being user-friendly, cost-effective, and capable of producing high-quality and accurate images compared with colposcopy, no research has used 35mm format cameras (i.e., DSLRs) to assess injuries in cases of sexual violence. In contrast, research on colposcopy cameras has demonstrated their reliability in examining cases of both adult and child sexual assault.^{7,8} Therefore, this study aimed to assess the impact of digital camera image characteristics on the interpretation of genital examination results in cases of child sexual abuse and identify the optimal values for lens aperture, shutter speed, ISO (sensor sensitivity), and lens focal length, which can lead to consistent interpretations between two forensic experts.

METHODS

This cross-sectional observational study was conducted at the Department of Forensic and Medicolegal, Faculty of Medicine, Universitas Indonesia, Cipto Mangunkusumo Hospital from April to May 2019. It used 55 close-up digital photos taken by DSLR cameras in the RAW, TIFF, or JPEG formats. This study had passed ethical review by the Health Research Ethics Committee of the Faculty of Medicine, Universitas Indonesia (No: KET-363/UN2.F1/ETIK/PPM.00.02/2019).

These photos were captured using flashlights to ensure clear anatomical boundaries of the genitalia. Photos that met the inclusion criteria were then selected through convenience sampling and screened by forensic photography experts based on the technical aspects of photography. Subsequently, the samples were interpreted by two independent forensic experts unaffiliated with this research at different times and places. Nevertheless, they conducted the interpretation in similar room lighting, using the same laptop, with maximum magnification (zoom in) of 3 times for the digital images, and without seeing/knowing the photos' characteristic data (metadata/EXIF data) or the doctor's examination results in the medical records. The forensic experts had over 5 years of experience, actively practiced medicine, and were not colorblind.

Mann-Whitney *U* test was conducted to determine the relationship between the digital photo characteristic values (aperture size, shutter speed, sensor sensitivity, and lens focal length) and the forensic experts' interpretation conformity. The Kappa index was obtained for the labia minora and posterior fourchette areas based on the presence/absence of a wound. The Kappa index for the hymen area was obtained by considering if the hymen was intact (normal interpretation, normal variant, widened diameter, or bruising) or torn (old or new tears).

RESULTS

From 112 cases of child sexual abuse reported in an accessible population, 43 cases (~38.4%) were selected because they were accompanied by interpretable photographs; the remaining cases (61.6%) did not have such photographs. Thus, a total of 55 digital images were obtained for analysis.

Sample quality was analyzed based on the technical aspects of photography (naturalness), especially when interpreting the results of the two forensic experts for the hymen area. Both interpretations had the same mean value (standard deviation) of 6.28 (1.36), indicating that the samples met the acceptable criteria.

Based on the results of metadata extraction (EXIF data), all characteristic values showed an abnormal distribution (Kolmogorov–Smirnov test, $p < 0.05$). The most common frequencies (modes) were the aperture size of f.80 (29 samples), shutter speed of 1/125 sec (22 samples), sensor sensitivity of 1,600 (21 samples), and lens focal length of 27 mm (10 samples).

There was perfect conformity (100%) observed between the forensic expert and examining doctor, as no abnormalities or injuries were found in the mons

pubis, labia majora, and clitoris areas of the study samples (Table 1). The highest assessment differences were in the hymen (22%), labia minora (16–27%), and posterior fourchette (5–13%) areas.

The lens aperture size, shutter speed, and sensor sensitivity (ISO) had no significant relationship ($p > 0.05$) with conformity between the forensic experts' interpretations compared with the doctor's examination results (Table 2). In contrast, lens focal length was significantly related to conformity between the forensic experts' interpretations ($p = 0.011$). The receiver operating characteristic analysis found that the lens focal length had a good area under the curve of 0.698 (95% confidence interval: 0.560–0.889). Results of calculating the Kappa index showed strong conformity between the two experts' interpretations for the hymen area ($\kappa = 0.643$), but it was only acceptable (fair) for the labia minora ($\kappa = 0.238$) and the posterior fourchette ($\kappa = 0.230$).

Table 1. Conformity of the first and second forensic expert's assessment based on the examining doctor's reference

Anatomy	n (%) (N = 55)	
	1 st forensic expert	2 nd forensic expert
Mons pubis		
Conform	55 (100)	55 (100)
Labia major		
Conform	55 (100)	55 (100)
Labia minora		
Different	9 (16)	15 (27)
Conform	46 (84)	40 (73)
Clitoris		
Suitable	55 (100)	55 (100)
Posterior fourchette		
Different	3 (5)	7 (13)
Conform	52 (95)	48 (87)
Hymen		
Different	12 (22)	12 (22)
Conform	43 (78)	43 (78)

Table 2. Comparison of digital image characteristic values toward forensic expert's interpretation conformity

Characteristics	Interpretation conformity		Total	p^*
	Conform	Different		
Aperture	7.1 (3.5–14.0)	8.0 (5.0–9.0)	8.0 (3.5–14.0)	0.328
Shutter speed	125 (25–200)	60 (20–180)	100 (20–200)	0.197
Sensor sensitivity (ISO)	1600 (100–6400)	800 (100–5000)	800 (100–6400)	0.262
Focal length (mm)	37 (24–105)	55 (24–105)	50 (24–105)	0.011

*Mann–Whitney U test

DISCUSSION

Based on the photography location, abnormalities were rarely found in the mons pubis, labia majora, and clitoris areas; however, they were frequently found in the hymen area, labia minora, and posterior fourchette, requiring better interpretation of wound assessment. This is consistent with several studies on cases of sexual violence in which the posterior fourchette, labia minora, hymen, and fossa navicularis were the most commonly injured genital areas in women and adolescents.^{9,10}

Only <50% of cases had interpretable photographs that indicates forensic photography in cases of child sexual violence at the Integrated Crisis Center, Cipto Mangunkusumo Hospital still did not meet the basic techniques of forensic photography and lacked operational standards. In this study, the examiners tended to use a similar exposure triangle setting on

DSLR cameras when examining cases of child sexual violence, resulting in no significant relationship with the exposure triangle in camera settings. Ranges of the lens opening value (aperture = f7.1–f8.0), shutter speed (1/100–1/125 sec), and sensor sensitivity (ISO = 800–1600) had no relationship with the experts' interpretation conformity. These various results show that these exposure triangle settings in DSLR cameras are often used when photographing cases of child sexual violence. However, these value ranges were set as references for further experimental research to prove the relationship between these three values and the experts' interpretation conformity. The best cut-off point for the conformity rating was 50mm, with a sensitivity of 60%, specificity of 67%, and diagnostic accuracy of 64%. This is consistent with the theory that a lens of 50mm focal length generally matches normal eye vision.¹¹

This study had several limitations. It relied on a single digital image selected to represent cases of child sexual violence. Each image was captured from a relatively similar angle, which may contribute to a lower Kappa index, particularly in the labia minora and posterior fourchette areas, compared to the hymen area. Thus, forensic experts may require more than one digital image to accurately interpret cases of child sexual violence. Additionally, this study adhered to forensic photography guidelines that recommend at least three images, each taken at a specific position and angle perpendicular to the surface of the object.⁶ Furthermore, the application of focal length and exposure triangle developed in this study was used only to assess sexual violence in children. Therefore, further research is needed to explore its application across age groups, body parts, and case types.

In conclusion, a focal length of 50mm was significantly related to interpretation conformity. Aperture size of f7.1–f8.0, shutter speed of 1/100–1/125 sec, and ISO 800–1600 can be used as basic references for digital camera settings for examining cases of child sexual violence. The Kappa index in the labia minora and posterior fourchette areas was acceptable (fair), with values of 0.238 and 0.230, respectively. However, it was notably strong (substantial) in the hymen area ($\kappa = 0.643$). Therefore, doctors should attend continuous

education and training in forensic photography and establish a standard forensic photography procedure. High-quality, accurate, and interpretable photographs in the framework of health services and medical learning are needed to improve diagnostic accuracy in cases of child sexual violence. Furthermore, forensic photography learning modules should be provided from the beginning of forensic specialist education as an integral part of handling forensic cases.

Conflict of Interest

The authors affirm no conflict of interest in this study.

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