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Colposcopic photography of genital injury following sexual intercourse in adults

Birgitte Schmidt Astrup · Jens Lauritsen ·
Jørgen Lange Thomsen · Pernille Ravn

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Abstract The aim of this study was to evaluate interpretations and the reproducibility of interpretations when looking at colposcopic photographs in a forensic setting, as well as discussing some of the dilemmas and pitfalls of forensic colposcopic photography. A total of 316 colposcopic photographs from 51 women taken on three occasions following consensual sexual intercourse, and 78 colposcopic photographs from 39 rape victims, were evaluated by four different observers. Photographs were taken in the same setting, by the same group of investigators, before and after application of toluidine blue dye. The overall Kappa-value for the four observers' judgment of lesion vs. no lesion was 0.41 which can be interpreted as moderate agreement. Intra-observer agreement was calculated for two of the observers looking at photographs with a 10 months' time-gap, and the Kappa-values were 0.41 and 0.52. Positive and negative predictive values of the photographs were 82 and 81 % respectively. This study demonstrates relatively poor reliability of colposcopic

photography. Some would argue that this makes colposcopic photography a low-quality method of evaluation and that forensic science should aim for higher standards because of its use in court. Others would argue that as long as the limitations of a scientific method are acknowledged then it is still eligible for use. The moderate agreement and accuracy stresses the need for quality control in the gynecological part of a rape examination. Colposcopic photography also provides a good option for supervision and teaching in an ethically difficult setting. It strengthens the legal rights for both victim and perpetrator.

Keywords Colposcopic photography · Consensual sexual intercourse · Rape · Agreement · Toluidine blue dye · Genital injury · Genital lesion

Introduction

Colposcopic photography has been used in the evaluation of child sexual abuse victims for decades. Since its introduction by Teixeira [1] in the early 1980s it has been the foundation of an evidence-based approach to childhood sexual abuse by making peer-review, standardization, and research possible. This is not the case in adult sexual assault, and research on adult colposcopic photography is sparse.

There are several reasons for this discrepancy. The fact that photography of the genitals in an already victimized population is seen as ethically problematic plays a role, as well as economy and local court practices. However, the technique of adult colposcopic photography is already in use in some countries and districts. Forensic experts and courts are being presented with adult colposcopic photography and research is needed to validate interpretations.

B. S. Astrup (✉) · J. L. Thomsen
Department of Forensic Pathology, Institute of Forensic
Medicine, University of Southern Denmark, J.B. Winsløvsvej
17, 5000 Odense C, Denmark
e-mail: birgitte@schmidtastrup.dk; bastrup@health.sdu.dk

J. Lauritsen
Department of Orthopedics, Odense University Hospital, Sdr
Boulevard 29, 5000 Odense C, Denmark

J. Lauritsen
Department of Public Health, Biostatistics, University of
Southern Denmark, J.B. Winsløvsvej 9, 5000 Odense C,
Denmark

P. Ravn
Department of Gynecology and Obstetrics, Odense University
Hospital, Sdr Boulevard 29, 5000 Odense C, Denmark

The aim of this study was to evaluate interpretations and the reproducibility of interpretations when looking at colposcopic photographs in a setting as close to the reality of forensic routine work as possible, making the results directly applicable in praxis. The dilemmas and pitfalls of forensic colposcopic photography will also be discussed.

Materials and methods

The present study was part of a larger study conducted at the Southern Denmark Sexual Assault Referral Centre (SDSARC) as collaboration between the Institute of Forensic Medicine, University of Southern Denmark and the Department of Gynecology and Obstetrics, Odense University Hospital. Aspects of this larger study concerning genital injury diagnosis and duration using the naked eye, colposcopy, and toluidine blue dye, as well as detection of spermatozoa have been published before [2, 3].

Participants

Women in the rape victim group (RV-group) were included consecutively at SDSARC over a 2-year period (August 2009–July 2011). The inclusion criteria were vaginal penetration at the assault, previous sexual experience and, if age 15–17 years, the presence of a legal guardian. Exclusion criteria were no vaginal penetration, the assault being the first sexual intercourse experienced and incapability of giving informed consent, for instance due to severe intoxication or mental disease.

The women in the consensual sexual intercourse group (CSI-group) were recruited over a 3-week period (spring 2010) from students at the University College Lillebaelt, Health and Social Sciences. A recruitment e-mail with information regarding the study was sent to all students (approximately 1,200) through the intra-net of the school. The first 50 female respondents were included in the study. The inclusion criteria for this group was a steady partner and potential participants were excluded if they were pregnant or had a gynecological disease/symptoms at the time of sexual intercourse and examination. The women were instructed to have sexual intercourse in accordance with their normal routine, including penile penetration within 48 h of the first examination. They were examined three times: on day 1, on day 3/4, and on day 6/7. They were sexually abstinent until the last examination.

Clinical investigations

Examinations of both groups were performed by the same five physicians (registrars) from the Institute of Forensic Medicine, University of Southern Denmark. All were

experienced in the examination and evaluation of findings in sexual assault victims. The colposcope used was a Zeiss 150 (Carl Zeiss, Meditec, Inc. Dublin, California), with an integrated Medilive® digital camera. The toluidine blue dye was applied using Forensic Blue Swabs® (National Forensic Nursing Institute (NFNI), Inc. USA).

The examinations all followed the same sequence

1. Naked eye examination of external genitalia. Recording of all findings; positive or negative.
2. Colposcopy of the external genitalia. Recording of all findings seen directly through the colposcopic lenses during the examination; positive or negative.
3. Digital photography using the integrated camera of the colposcope. The investigator was instructed to check the sharpness of the photographs and to be sure that any abnormality seen at the direct colposcopy was included in the photographs. Any photographs that were out of focus or of poor quality were retaken. The number, angle, and magnification of photographs were decided by the investigator at the examination.
4. Toluidine blue dye was applied to the external genitalia and removed with 1 % acetic acid after drying as recommended by NFNI [4].
5. Point 3 was repeated.
6. Inspection of the vagina and cervix using speculum and colposcope. Findings were noted.
7. Point 3 was repeated.

Victims of rape had trace evidence secured at appropriate times during the above routine. The women of the consensual sexual intercourse group were examined three times, by the doctor on duty, as a system of same/different doctor for each woman was logistically impossible. The results of the first examinations were blinded on follow-up.

The nature of lesions

Three types of lesions were described in accordance with international literature on the subject [5]: lacerations, abrasions, and hematomas. More ambiguous lesions, such as redness or swelling were not included.

1. Laceration: discontinuity of epidermis and dermis. Often caused by blunt force such as tearing, crushing or overstretching.
2. Abrasion: traumatic exposure of lower epidermis or upper dermis. The outermost layer of the skin is scraped away from the deeper layers. Often caused by lateral rubbing or sliding against the skin in a tangential rather than a vertical manner.

3. Contusion/hematoma/bruise: extra-vasation of blood in tissues below an intact epidermis. Often caused by blunt force.

Photographic analysis

The photographs were evaluated by a panel of four investigators: One registrar and two senior forensic pathologists experienced in the evaluation and interpretation of findings in rape victims and a senior gynecologist from local gynecologic department. The senior gynecologist had experience in the evaluation of female genitalia, but not from a forensic perspective. The registrar and one of the senior forensic pathologists were a part of the group performing the clinical examinations. Two of the four investigators, the registrar, and the senior gynecologist, evaluated the photographs twice with a 10 months time interval between the first and second evaluations.

The photographs were arranged in an electronic questionnaire in a Microsoft Access[®] database and the investigators could select one or more of the following possibilities for all pictures: Normal, laceration, abrasion, hematoma. They were also able to add a comment. The photographs were identified by a random id-number, but all photos of the same woman were placed together. The investigators were blinded to the initial evaluation and the evaluations of the other investigators. As the aim of this study was to test the correlations of spontaneous interpretations of colposcopic photographs (which is the reality of most forensic experts) no consensus meetings or test evaluations were performed, only clarifying questions were dealt with.

Statistical analysis

Analysis of data was carried out using STATA (version10) statistical software package (www.stata.com). Inter- and intra-observer agreement or the precision of the evaluation of photographs was assessed using Cohen's Kappa. Agreement was considered moderate if $K > 0.40$, substantial if $K > 0.60$ and almost perfect if $K > 0.80$. Bootstrap based 95 % confidence intervals for Kappa values were calculated using the st0076 ado file by Reichenheim ME, Instituto de Medicina Social, Universidade do Estado do Rio de Janeiro, Brazil [6]. The number of bootstrap replications was set at 1,000.

Sensitivity and specificity was calculated using the subset of photographs where all four investigators agreed on interpretation. In this subset the investigators' interpretation was seen as the "true" interpretation of the particular photograph which then in turn could be compared with the results from the initial examination.

Ethical considerations

The study was approved by the Medical Research Ethics Committee of Southern Denmark. Written consent was obtained from all participants. Full anonymity was secured by anonymous e-mail addresses for communication and an anonymous, secured storage code for data and photographs. If any significant medical conditions were discovered at the initial physical examination, the woman was referred to the gynecologist on duty.

Results

In the CSI-group 316 colposcopic photographs from 51 women taken on day 1, day 3/4, and 6/7, before and after toluidine blue dye application were evaluated. Of these photos, 114 were taken on day one, making them comparable with the RV-group. In the RV-group of 71, women were seen by a forensic physician at SDSARC in the inclusion period. Of these, 32 were excluded: 12 did not wish to participate, nine were unaccompanied minors, eight were excluded due to mental disease/intoxication, and three cases were excluded due to technical problems. A total of 78 colposcopic photographs from 39 women were evaluated.

Inter-observer agreement

Inter-observer agreement of photographs showing "no lesion" versus "any type/number of lesion" is shown in Table 1.

We found that inter-observer agreement including all four observers on overall findings was fair to moderate in all comparisons.

When results were analyzed according to diagnosis of different types of lesions, agreement was poor. In the CSI-group, $K = 0.14$ (c.i 0.07–0.21) in terms of overall agreement of the presence of an abrasion and $K = 0.06$ (C.I. 0.004–0.14) when assessing agreement on the presence of a hematoma. In the RV-group, $K = 0.27$ (c.i 0.08–0.48) in terms of overall agreement of an abrasion and $K = 0.22$ (C.I. 0.04–0.40) when assessing hematomas. The results regarding lesion types are seen in Table 2, which shows the actual number of each kind of lesion diagnosed by each observer, as well as the number of pictures where all 4 observers agreed on specific diagnosis. When looking at all four investigators evaluation of pictures of the CSI-group with toluidine blue dye alone ($n = 160$) $K = 0.40$ (C.I. 0.36–0.42) compared with pictures without toluidine blue dye ($n = 156$) where $K = 0.39$ (C.I. 0.35–0.40), there was no significant difference. There was also no significant difference in pair wise agreement of

Table 1 Inter-observer agreements between four investigators (lesion vs. no lesion)

	CSI-group (n = 316)	CSI-group. Day 1 (n = 114)	RV-group (n = 78)
Kappa*	0.39	0.52	0.41
all 4 investigators	C.I. 0.31–0.45	C.I. 0.42–0.63	C.I. 0.28–0.53
Overall agreement	48 %	55 %	47 %
Kappa*	0.34	0.46	0.43
Senior forensic pathologist doing clinical exam versus not agreement	C.I. 0.22–0.44 68 %	C.I. 0.29–0.62 73 %	C.I. 0.23–0.63 72 %
Kappa*	0.38	0.40	0.36
Senior forensic pathologist versus senior gynecologist Agreement	C.I. 0.28–0.47 69 %	C.I. 0.24–0.57 70 %	C.I. 0.15–0.57 69 %
Kappa*	0.43	0.60	0.51
Senior versus junior forensic pathologist Agreement	C.I. 0.33–0.53 74 %	C.I. 0.45–0.74 80 %	C.I. 0.31–0.70 76 %

CSI consensual sexual intercourse, RV rape victim

*Cohen’s Kappa with bootstrap based 95 % confidence intervals calculated using STATA

photos with or without toluidine blue dye between investigators (data not shown).

Intra-observer agreement

The intra-observer agreement was assessed for two investigators and for the CSI-group only. The same 316 colposcopic photographs were evaluated 10 months apart and

Table 2 The actual number of lesions diagnosed by each of the four observers

No. of lesions diagnosed by each observer. 394 photographs*	Laceration	Abrasion	Hematoma
Junior forensic pathologist	76	32	9
Senior forensic pathologist (did not do research exams of CSI-group)	81	64	14
Senior forensic pathologist (did do research exams of CSI-group)	41	85	24
Senior gynecologist	109	51	11
No. of photographs where all four observers agreed on diagnosis	27	7	3

* It is possible to have more than one lesion on each photograph

values for the 114 day 1 assessments were also calculated. The gynecologist had an agreement of 77 % and a $K = 0.50$ (C.I. 0.40–0.60), and for the day 1 examinations the agreement was 75 % and the $K = 0.49$ (C.I. 0.33–0.65). The junior forensic pathologist had an agreement of 79 % and a $K = 0.52$ (C.I. 0.42–0.62), and for the day 1 investigations the agreement was 81 % and $K = 0.61$ (C.I. 0.47–0.76).

Accuracy, sensitivity, and specificity

In this study the accuracy of colposcopic photography is defined as the agreement of investigators’ evaluation of photographs with results from the original “live” examinations performed 15 months earlier. The accuracy of photograph evaluation of all four investigators is shown in Table 2.

Sensitivity and specificity calculations are shown in Table 3. In the CSI-group, all four investigators agreed on the interpretation of 152 of the 316 colposcopic photographs and in the RV-group the investigators agreed on 37 out of 78, giving a total of complete agreement between investigators in 189 of 394 colposcopic photographs (Table 4).

Discussion

This study is, to the best of our knowledge, the first study to evaluate the reliability of forensic colposcopic photography in an adult population. We found that inter-observer agreement was fair to moderate in all comparisons and the accuracy of the four different investigators ranged from 58 to 80 %. Positive and negative predictive values were approximately 82 and 81 % respectively. Positive and negative predictive values for sensitivity and specificity of colposcopic photography have not been published previously as far as we know.

The inter-rater reliability of colposcopic photography in child sexual abuse cases has been evaluated in several articles with varying results. Results from studies of colposcopic photographs of children cannot be directly compared with the results from the present study because of different entities. In child cases, raters are asked to differentiate between “suggestive of abuse” and “not suggestive of abuse” in a population where the majority have experienced no sexual intercourse, whereas this study measures lesion/no lesion in a population where 100 % have experienced intercourse. McLean et al. and Muram et al. [11, 20] reported Kappa values of 0.70 and 0.69 respectively in large sample child cases. Consensus meetings were held in both studies. These Kappa values are higher than what we found in the present study. In a study

Table 3 Accuracy of photograph evaluation of all four investigators

	CSI- group (n = 316)	CSI- group. Day 1 (n = 114)	RV- group (n = 78)
Junior forensic pathologist	80 % C.I. 75.2- 84.3	74 % C.I. 64.6 - 81.5	66 % C.I. 55.1- 76.9
Senior forensic pathologist (did not do research exams of CSI- group)	67 % C.I. 61.6 – 72.1	64 % c.i 54.5 – 72.8	65 % C.I. 53.8- 75.8
Senior forensic pathologist (did do research exams of CSI- group)	64 % C.I. 58.4 – 69.2	67 % C.I. 57.2- 75.2	58 % C.I. 46.0- 68.8
Senior gynecologist	72 % C.I. 66.9- 77.8	68 % C.I. 59.1- 76.8	60 % C.I. 48.5- 71.2

CSI consensual sexual intercourse, RV rape victim

Proportions with a 95 % confidence interval

Table 4 Results from the 189 photographs where all four investigators agree on a lesion/no lesion interpretation versus the results from the initial “live” examinations in a 2 × 2 contingency table

Investigators' evaluation	Results from the clinical examination: CSI-group + RV-group			Sensitivity: 90 % (C.I. 82.6–94.5)*
	Lesion	No lesion	Total	
Lesion	104	23	127	Specificity: 68 % (C.I. 56.6–78.9)*
No lesion	12	50	62	
Total	116	73	189	Positive predictive value : 82 % (C.I. 74.1–88.2)*
				Negative predictive value : 81 % (C.I. 68.6–89.6)*

*95 % confidence interval

by Sinal et al. [7] agreement was notably lower, with an overall Kappa value of 0.20, between 7 clinicians. This high number of raters will invariably lower the Kappa value. Studies concerning inter-observer agreement of colposcopic photographs in a non-forensic setting generally involves cervical dysplasia and shows 50–70 % agreement on lesion versus no lesion and Kappa values between 0.20 and 0.35 on selected markers [8–10], which is in accordance with our findings.

When comparing child colposcopic photographs to clinical investigations, results are equally varying. Muram et al. [11] reported a high overall accuracy of 94 %, which

was highest in the non-abused and significantly lower in the abused group, where accuracy ranged from 58 to 88 % in accordance with our results. Brayden et al. [12] conducted a study in a setup with 71 clinicians assessing colposcopic photographs from 6 patients, and concluded that leaders in the field of diagnosing child abuse had a high accuracy of 69 %, whereas interns were only marginally better than chance. Adams et al. [13] discusses a physician reviewer assessing colposcopic photographs from adolescent (14–19 years) sexual assault cases. Agreement with the findings of the nurse examiners was 80 % when evaluating tears/abrasion in the posterior forchette, but lower when evaluating other entities. These differences between investigators with varying experience are not in accordance with our findings. We have showed a slight trend toward the forensic pathologists having higher Kappa values than the gynecologist, but the investigators in our study are similar in agreement and accuracy. The explanation for this difference is likely to be the above mentioned difference in outcome; lesion/no lesion versus suggestive of abuse/not suggestive, the latter being a level of interpretation not included in our study.

Sensitivity and specificity calculations are not as important in a forensic setting as the positive and negative predictive values. The “real-life” interpretation of our positive and negative predictive values of 82 and 81 % is a setting where a forensic expert is asked to evaluate colposcopic photographs. He/she will come to the same conclusion on the presence/absence of lesions as the clinical examiner in approximately four out of five cases. We consider these predictive values as rather low and therefore problematic as the basis for court of law decisions, where incorrect interpretations can lead to both personal dire consequences and lowered standards of legal rights. One explanation could be that the two-dimensional still photo lacks the dynamics of real-life observation, where the examiner can change their position and angle of view according to the light source. Also, mucous membranes are difficult to photograph because of reflections, folds and natural differences in color. The examiners were instructed to retake photographs if any observed lesion was not clearly visible on the photograph taken, but at the time of taking the photo they knew that the lesion was there, and could easily identify it, whereas a few months later the lesion might look more like a fold and vice versa. When looking at the three lesion types instead of the dichotomous lesion/no lesion entity, then the agreement of observers' interpretations dropped dramatically. Our results show that there is a considerable difference in spontaneous interpretation of lesions, even in a setting where observers work together and supervise each others' work. One of the explanations for this might also lie in the above mentioned two-dimensional property of the colposcopic photographs

that makes the distinction between lacerations and abrasions difficult in some cases. Also the very sharp light source of the colposcope can produce shadows that can be mistaken for hematomas. The distinction between, for instance an abrasion and a laceration, is not, however, as important as the lesion/no lesion distinction.

Another surprising result is that the pictures taken after using toluidine blue dye are not interpreted more precisely than those without the dye Fig. 1. One of the advantages of toluidine blue dye is said to be enhancement of lesions in the mucosal area where interpretation is difficult [2, 14]. An explanation could be that the previously mentioned limitations of two-dimensional photography have a larger influence on the interpretation of these photographs than might have been thought given the contrast of the very blue lesions against pink mucosa Fig. 2. When doing the live examination it is easier to distinguish artifacts like shadows and folds from real lesions. *Should colposcopic photography be used in the standard examination of a rape victim, as it is the case in childhood sexual abuse?*

Our study shows relatively poor reliability of colposcopic photography. Some would argue that this means that

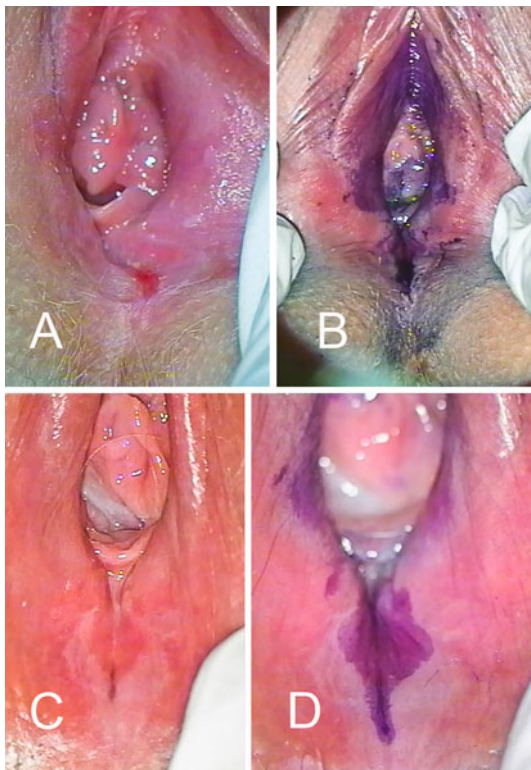


Fig. 1 Four colposcopic photographs where all four investigators agreed on interpretation, (a single laceration). The photos are from the same woman belonging to the CSI-group. **a** before toluidine blue dye, **b** after toluidine blue dye, a few minutes later **c** before toluidine blue dye 4 days after (a) and (b). **d** after toluidine blue dye, a few minutes after **c**

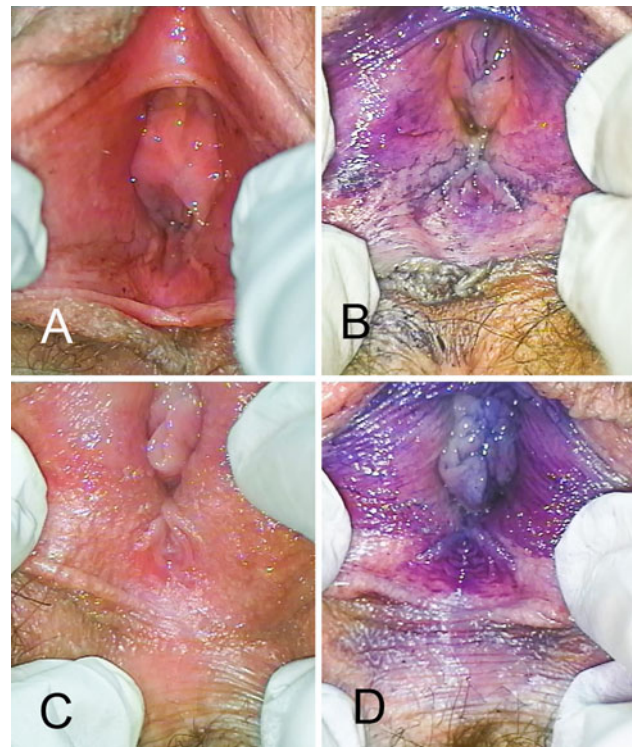


Fig. 2 Colposcopic photographs where the four investigators disagreed on interpretation. **a** and **b** are the same woman from the CSI-group and **c** and **d** are the same woman from the RV-group. Two investigators diagnosed abrasions on all four pictures and two diagnosed redness and excessive toluidine blue dye uptake due to irritation/inflammation of the mucosa, but not a lesion per se

colposcopic photography is a low-quality method of examination in cases of rape and that forensic science should use better methods of evaluation because of its use in a court of law. On the other hand, we argue that as long as the inaccuracy of a science is well-known and accounted for it is suitable for use. The moderate inter-observer agreement and accuracy stresses the need for peer-review and quality control in the gynecological part of the rape examination, for instance in the form of seminars and consensus meetings, which could be online, where colposcopic photographs from specific cases are reviewed and discussed. Another important way of augmenting the quality of colposcopic photography is to take a large number of photos when digital photography is available. These steps would strengthen the legal rights for both victim and perpetrator.

Some studies [15–17] find a significant correlation between ano-genital trauma and cases that go to court, whereas other studies do not find any association. [18–21]. A possible cultural bias as to when a rape is reported to the police could account for some of this discrepancy, as well as different priorities of law enforcement in different areas and times in history. There is no litmus test for sexual

assault. An important point to remember is that just because there is no significant correlation of genital trauma and legal consequence on a large scale, it does not mean that it is not important in some cases.

The use of colposcopic photography, when documenting the findings, is said to be humiliating to a woman who is already in distress. However, the sexual assault examiners are trained in dealing with the sensitive issues of sexual assault and should be able to obtain an informed consent in a respectful manner, if the woman agrees to colposcopic photography.

There are problems with colposcopic photography, however. Firstly, the fact that colposcopy in most countries is not a routine aspect of all examinations could distort the legal rights of rape victims, because rape crisis centers that uses colposcopy will have a higher frequency of observed genital lesions among their patients. Even more concerning is the risk of creating a need for photo-documentation in court rooms; resulting in the possibility that if any given finding was not photographed (allowing for a second opinion etc.) it does not count, regardless of the testimony of the examiner.

Forensic and legal experts around the globe should weigh the need for peer-review and quality control against the conventions of their own legal system. Their decisions regarding these issues may vary between locations and differing legal systems.

Key points

1. Colposcopic photography of genital lesions in adult rape victims is a very important form of documentation allowing for supervision, teaching, and second opinions in an ethically difficult setting.
2. The interpretation of colposcopic photographs is not necessarily straightforward. Inter-observer agreement is not perfect, and interpretations should be peer checked.
3. When colposcopic photography is used for documentation in a court of law, the expert should be aware of possible variations and limitations in the interpretation of the photographs.

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