Original Article

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Quantifying the Degree of Bruise Visibility Observed Under White Light and an Alternate Light Source

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Background: Documentation of injuries associated with abuse and assault has pivotal impacts on clinical and legal outcomes. Before this study, no reliable and valid tools to consistently document the clinical visibility of bruises existed. The purpose of this study was to systematically evaluate reliability and validity of the Bruise Visibility Scale for documenting bruises visualized in normal (white) light and the Absorption Visibility Scale for documenting bruises visualized using an alternate light source (ALS).
Methods: Bruises were induced using a paintball on the upper arms of 157 participants stratified into six skin color categories. Bruises were visualized 21 times over 4 weeks under white light and 10 ALS wavelength/goggle color combinations. Bruise size was measured using a metric ruler; bruise color was measured using a spectrophotometer. Interrater reliability was calculated using kappa and intraclass correlations coefficients. Construct validity was evaluated using generalized linear mixed modeling of associations between bruise size and color with both visibility scales.
Results: Interrater agreement for bruise detection was over 90% for all but two ALS wavelength/goggle combinations. Kappa values indicated adequate interrater agreement under white light (κ = 0.76) and ALS (κ = 0.78). The visibility scale intraclass correlation coefficients were .91 for normal light and .93 for ALS. Statistical modeling showed greater bruise size was associated with higher visibility using either scale, and greater contrast in color or lightness was associated with higher Bruise Visibility Scale values.
Implications for Practice: Both visibility scales showed satisfactory reliability and validity. Forensic nurses can use the scales to consistently document bruises.

KEY WORDS:
Alternate light source; bruise; bruise visibility; forensic nursing; injury assessment

The physical assessment of violence-related injuries is one of the cornerstones of forensic nursing practice. Documentation of such trauma post assault can provide pivotal evidence impacting both clinical and legal outcomes (Buel & Hirst, 2009; Foresman-Capuzzi, 2014). For example, most patients who experience intimate partner violence encounter multiple mechanisms of injury in different locations on the body, with the neck, head, and face being the most common (Sheridan & Nash, 2007). Similarly, research has found 70% of sexual assault cases have at least

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one nonanogenital injury, with soft tissue injuries being found most frequently on the extremities and face (Jänisch et al., 2010). Soft tissue injury from blunt, squeezing, or crushing force trauma is the most frequent mechanism of injury contributing to bruising (Langlois, 2007).

A bruise (also called a contusion) is a bodily injury where small blood vessels are broken without damage to the skin (Langlois, 2007). The extravasated blood under the skin can be difficult to detect because of the patient's skin color, depth of the bruise, or age of injury (Scafide et al., 2013; Thavarajah et al., 2012; Vanezis, 2001). Recent research supports an alternate light source (ALS), which emits light at specific wavelengths or colors, may be an effective tool for enhancing the visualization of new and older bruises (Scafide et al., 2020).

Under an ALS, the absorption of light transmitted through the skin's surface can be observed as it interacts with hemoglobin and its byproducts. When viewed by a nurse using filtered goggles, the escaped blood creates a darkened area (called absorption) in contrast to the surrounding skin. The gradation of contrast can vary (Marin & Buszka, 2013), similar to the degree of clarity or visibility of bruises observed under normal lighting conditions. However, guidance regarding how the nurse should document ALS findings and bruise visibility in white light has yet to be definitively established.

Bruise Visibility

The concept of "bruise visibility" refers to the degree of clarity by which the injury is visually perceived (Scafide et al., 2019). The concept is sometimes embedded in forensic nursing documentation via such qualitative and subjective descriptors as "obvious," "clear," "distinct," "faded," and "faint," followed by measurements and subjective descriptions of color and shape. There have been limited attempts to quantify bruise visibility during physical assessment (see Table 1), of which two require the use of expensive, colorimetry instruments (Black et al., 2019; Yajima & Funayama, 2006). Only the study by Limmen et al. (2013) examined bruise visibility in living subjects using the same ordinal scale under both alternate lighting and normal (white) light conditions.

To measure bruise visibility using the same scale for white light and ALS assumes assessment of injury clarity is based on the same characteristics under both lighting conditions. However, assessment of injury clarity under white light and ALS differs in one key characteristic—color. Under white light, wavelengths from the entire visible spectrum (400–700 nm) are shown off the skin's surface. Under ALS, however, only one bandwidth (color) of light at a time is emitted; thus, the reflected color of the skin is limited to that particular wavelength as viewed through colored goggles. Instead of seeing variation in color under alternate light, one sees contrasting areas of lightness and darkness (Scafide et al., 2020). Therefore, it is not appropriate to use the same visibility scale to assess bruise clarity under both white light and ALS.

To account for this difference, we adapted the Bruise Visibility Scale (BVS; see Figure 1) developed by Scafide et al. (2019) to create an Absorption Visibility Scale (AVS; see Figure 2). The BVS was originally designed based on the work of Limmen et al. (2013) and existing scar measurement instruments. The BVS uses a visual analog scale ranging from 1 to 5 with a combination of labels and standardized reference images of actual bruises taken on light and dark skin tones (see Figure 1). The BVS has shown good interrater reliability (intraclass correlation coefficient [ICC] = .88, 95% CI [.78, .94]; Scafide et al., 2019).

To adapt the AVS for alternate light application, the color images of bruises were replaced with digitally created representations of light absorption with similar contrast—from very light to dark, with and without central clearing

TABLE 1. Existing Metrics for Assessing Bruise Visibility in Living Subjects

Article	Concept	Assessment context[a]	Instrument	Values
Yajima & Funayama (2006)	Color difference	Normal lighting	Colorimetry (ΔE^*)[b]	–
Limmen et al. (2013)	Visibility	Normal and alternate lighting	Ordinal scale	No, bare, moderate, sufficient, good visibility
Trefan et al. (2018)	Contrast	Normal lighting	Numeric scale (1–5)	1 = *bruise stands out clearly from the skin*, 5 = *bruise very hard to detect*
Black et al. (2019)	Contrast	Normal lighting	Colorimetry (ΔL^*)[b]	–
Scafide et al. (2019)	Visibility; degree of clarity of perception	Normal lighting	Visual analog scale with reference images (1–5)	1 = *barely* 3 = *moderately* 5 = *clearly*

[a]Normal lighting is standard lighting that is used during typical examinations.
[b]$\Delta E^*_{ab} = ((\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2)^{1/2}$, where L^* is concentration of black versus white, a^* is concentration of red versus green, and b^* is concentration of blue versus yellow.

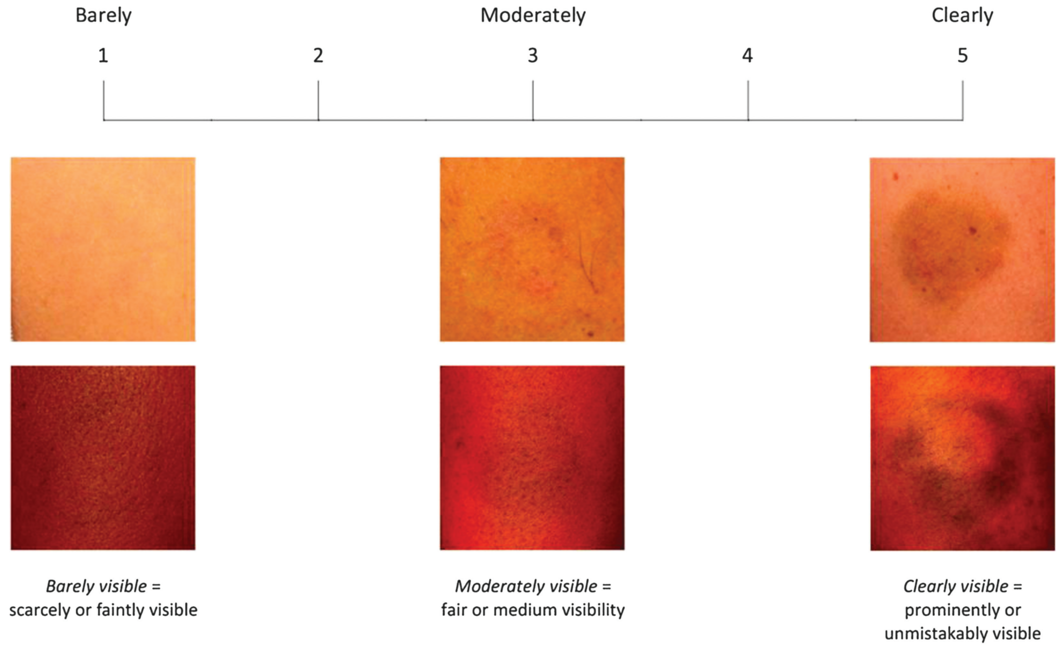

FIGURE 1. Bruise Visibility Scale.

(see Figure 2). Similar to the BVS, the AVS uses a visual analog scale ranging from 1 to 5 to measure the degree of clarity of which visible light absorption is perceived.

Purpose

As part of our larger parent study examining ALS effectiveness in bruise visualization (Scafide et al., 2020), the purpose of the current study was to psychometrically evaluate detection and visibility assessments using the BVS and AVS instruments for potential future application in clinical forensic practice. We examined interrater agreement of detection and visibility of intentionally created bruises assessed under white and alternate light. In the absence of a gold standard for comparison, we chose to analyze whether bruise size (or area of absorption), contrast, and/or color difference contributed to perceived visibility.

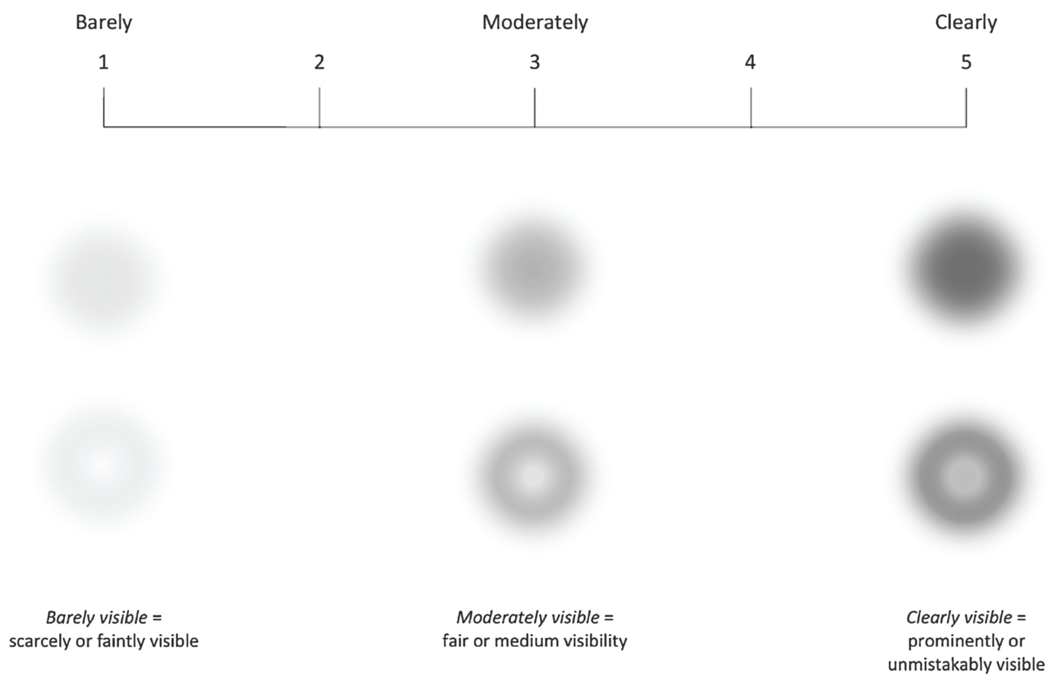

FIGURE 2. Absorption Visibility Scale.

Methods

Design

A longitudinal, randomized controlled trial (N = 157) was executed to compare the effectiveness of ALS to white light in its ability to detect induced bruises (Scafide et al., 2020). During this parent study, cross-sectional data were collected to examine interrater reliability and convergent validity of bruise assessments conducted under alternate and white light sources.

Participants

Healthy adults, aged 18–65 years, were recruited and consented to participate in the parent study at two university campus settings after approval from the respective institutional review boards (George Mason University [GMU] IRB No. 728978 and Texas A&M University [TAMU] IRB No. 2016-0742F). Participants were excluded if they exhibited skin lesions visible under white or alternate light on the area to be bruised—either lateral upper arm. For safety purposes, potential subjects were also excluded for the following reasons: reported health condition or medication use that impacted bleeding, history of delayed skin healing, or upper arm circumference less than 24 cm.

The sample size for the current psychometric study was determined by the number of raters. Fourteen investigators and research nurses collected data during the 2-year parent study (eight at GMU and six at TAMU). Each rater was screened to ensure at least 20/30 corrected vision using the Snellen chart and screened for absence of color blindness using an Ishihara test. A minimum of 15 interrater assessments was planned for each rater. Each assessment involved two raters; thus, the anticipated minimum number of interrater bruise assessments was 105 (14 × 15 / 2 = 105).

Materials and Procedures

Blunt force trauma was induced to a randomly selected lateral upper arm of each participant via the controlled application of a paintball pellet fired from a marker (paintball gun) at a distance of 20 feet (6.1 meters). The resulting bruises were assessed at 21 time points over 4 weeks beginning 30 minutes postinduction. At each bruise assessment, the injury was examined under white light (dimmable 5600-Kelvin Spectro Essential 240 Daylight LED; Generay, New York, NY) and alternate light (Handscope Xenon HSX-5000; Horiba, Piscataway, NJ). The order of the light sources was randomized. Using the ALS, bruises were observed with the following combinations of wavelengths and filter goggles: 350 nm (ultraviolet) with clear goggles; 415 and 450 nm with yellow goggles; 415, 450, 475, 495, and 515 nm with orange goggles; and 515 and 535 nm with red goggles. The goggles were purchased through Horiba (Piscataway, NJ). Both light sources were mounted on tripods and remained stationary while the examiner manipulated the arm freely to facilitate assessment.

During interrater assessments, two raters each conducted the bruise examination independently and were blinded to the other rater's findings. If the injury was detected, raters used the appropriate scale with reference images (BVS or AVS) depending on the light source. Rater assessment findings were individually documented on a paper form. One rater then obtained the length and width of the bruise or absorption area determined by the longest distance of discoloration followed by a second measurement taken at a right angle to the first. Size was then calculated using the formula for an area of an ellipse = (0.5 × length) (0.5 × width) × π.

Each participant's skin and bruise color was measured with a spectrophotometer (Minolta CM-600D; Konica Minolta, Osaka, Japan) using L^* (concentration of black vs. white), a^* (concentration of red vs. green), and b^* (concentration of yellow vs. blue) color values, a standardized method of specifying colors (Commission Internationale d'Eclairage, 2007). Skin color was determined based on the average of three colorimetry measurements obtained from the right, lateral deltoid. The individual typology angle (ITA) was then calculated using the formula: ITA° = $[\tan^{-1}((L^* - 50) \div b^*)] \times 180 \div \pi$ (Chardon et al., 1991). On the basis of the ITA° score, skin color categories were as follows: very light (>55°), light (42°–55°), intermediate (29°–41°), tan (11°–28°), brown (–29° to 10°), and dark (≤ –30°).

The difference in lightness/darkness (ΔL^*) between the bruise and surrounding skin was calculated from the average of three measurements obtained by the spectrophotometer from the bruise center and three measurements taken at different, triangulated points around the bruise. The overall difference in color (ΔE^*) between the bruise and surrounding skin was calculated using the Euclidean formula: $\Delta E^* = ((\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2)^{1/2}$ (Commission Internationale d'Eclairage, 2007). Research has shown excellent test–retest (ICC = .89) and interrater (ICC = .98) reliability of bruise colorimetry measurements (Scafide et al., 2016).

Data Analysis

Interrater data were hand-entered into an electronic spreadsheet, and statistical analyses were performed with SPSS Version 25 (IBM Corp., Armonk, NY) and SAS Software System Version 9.4 (SAS Institute, Cary, NC). Descriptive statistics were used to examine sample characteristics. To determine interrater agreement for detection of a bruise or light absorption between two raters, a kappa coefficient was calculated. Suggested interpretation of the kappa coefficient as it pertains to the strength of agreement is as follows: 0.01–0.20, slight; 0.21–0.40, fair; 0.41–0.60, moderate; 0.61–0.80, substantial; and 0.81–1.00, almost perfect (Landis & Koch, 1977). To analyze interrater agreement of the BVS and AVS, the Shrout and Fleiss (1979) ICC using a two-way, random effects analysis of variance model for absolute agreement was chosen because we assumed our observers were randomly selected from a larger population of raters with similar characteristics. Results of single ICC analyses were reported (Shrout & Fleiss, 1979). The analyses were based on a 95% confidence interval and level of significance of .05. ICC values were interpreted as follows: <.5, poor; .5–.75, moderate; .75–.9, good; and >.90, excellent interrater reliability (Koo & Li, 2016). Finally, Bland–Altman graphical technique was conducted to assess agreement between the two ratings under ALS and white light (Bland & Altman, 2010). In these scatterplots, the differences between ratings are plotted against the mean visibility scores (see Figure 3). Intervals or limits of agreement accounting for 95% of the difference between observers are also included ($M \pm 1.96*SD$).

General linear mixed models were used to quantify factors associated with the BVS and AVS outcomes. The mixed models' framework is the appropriate statistical modeling approach for handling repeated measures data. Because some participant data included multiple assessments (up to five; see Table 2), random effects were introduced into the

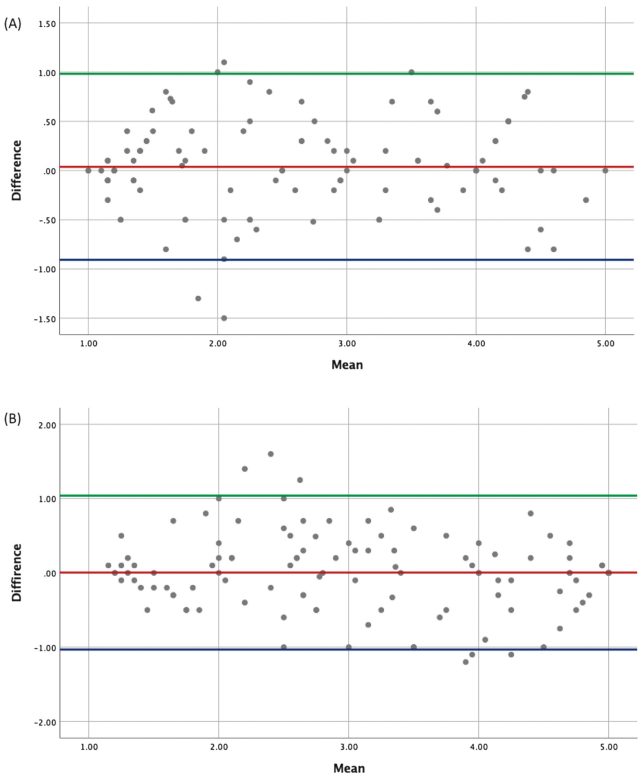

FIGURE 3. Bland–Altman plots of the interrater difference by mean value of the (a) Bruise Visibility Scale scores measured under white light and (b) Absorption Visibility Scale scores measured under alternate light (aggregated from all wavelength and filter combinations). The red line indicates the mean difference between observers, whereas the green and blue lines are the upper and lower, respectfully, limits of agreement (mean ± 1.96*SD).

TABLE 2. Sample Characteristics of Participants and Interrater Assessments

Characteristics	Participants (n = 69)	Assessments (n = 120)
Gender, n (%)		
Female	46 (67)	80 (67)
Male	23 (33)	40 (33)
Skin color, n (%)		
Very light	13 (19)	31 (26)
Light	11 (16)	18 (15)
Intermediate	11 (16)	20 (17)
Tan	9 (13)	15 (12)
Brown	9 (13)	13 (11)
Dark	16 (23)	23 (19)
Race, n (%)		
Asian/Pacific Islander	7 (10)	12 (10)
Black	21 (30)	32 (27)
Caucasian/White	33 (48)	65 (54)
Hispanic/Latino	3 (4)	4 (3)
Multiracial/other	5 (8)	7 (6)
Age, mean (SD), years	24.6 (8.3)	–
Interrater assessments, n (%)		
One	35 (51)	–
Two	19 (28)	–
Three	14 (20)	–
Four	0	–
Five	1 (1)	–
Bruise age, mean (SD), hours	–	227 (11.0)
Bruise size, mean (SD), cm^2		
White light	–	7.7 (5.8)
Alternate light source[a]	–	8.2 (5.6)
Lightness difference[b] (ΔL^*), mean (SD)	–	−1.6 (2.5)
Color difference[c] (ΔE^*), mean (SD)	–	3.1 (2.7)

[a]Aggregate obtained under all ALS wavelength (nm) and filter observations.
[b]ΔL^* = bruise L^* − surrounding skin L^*.
[c]$\Delta E^* = ((\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2)^{1/2}$.

model to account for within-subject correlation resulting from these repeated measurements. Statistical models were fit for each of the AVS and BVS outcomes. Skin color was included as a fixed effect in each model, and wavelength and filter combination were included in the AVS outcome model only. As previously described, ΔL^* is used to calculate ΔE^*, making the two values highly correlated. Thus, we fit separate mixed models for each of these colorimetry values with the BVS. We excluded cases in which bruise size was $\geq$30 cm^2 (112 or 7.2% of observations) from analysis

TABLE 3. Interrater Agreement in Detection Based on 120 Assessments

Light source	Raters who detected a bruise, *n* (%)			Proportion of agreement[a]	Kappa
	One	Both	None		
White light	6 (5)	103 (86)	11 (9)	0.95	.757
Alternate light[b]	102 (8.5)	843 (70.3)	255 (21.2)	0.92	.776
UV	8 (7)	83 (69)	29 (24)	0.93	.833
415 Yellow	3 (2.5)	114 (95)	3 (2.5)	0.98	.654
450 Yellow	6 (5)	109 (91)	5 (4)	0.95	.599
415 Orange	6 (5)	101 (84)	13 (11)	0.95	.784
450 Orange	9 (7.5)	99 (82.5)	12 (10)	0.93	.684
475 Orange	8 (7)	93 (78)	19 (16)	0.93	.785
495 Orange	10 (8)	87 (73)	23 (19)	0.92	.767
515 Orange	6 (5)	81 (67.5)	33 (27.5)	0.95	.881
515 Red	22 (18.4)	34 (28.3)	64 (53.3)	0.82	.611
535 Red	24 (20)	42 (35)	54 (45)	0.80	.597

Note. UV = ultraviolet.
[a]Agreement between raters on the presence or absence of positive finding.
[b]Aggregate obtained under all ALS wavelength (nm) and filter combinations listed (N = 1,200).

as these observations were not representative of injuries typically examined.

Results

Sample Characteristics

In total, 120 interrater assessments were conducted on 69 participants, ranging between one and five assessments per participant (see Table 2). The sample was mostly young (M = 24.6 years, SD = 8.3), female (n = 46, 67%), and Caucasian/White (n = 33, 48%). All six skin tone color categories were represented in the sample. Whereas the largest proportion of participants had dark skin (n = 16, 23%), a slightly larger proportion of interrater assessments was conducted on very light skin color (n = 31, 26%). Most interrater observations (n = 75, 62.5%) were performed at TAMU with fewer (n = 45, 37.5%) assessed at GMU. Raters averaged 17.1 interrater bruise assessments (SD = 13.1, range: 5–59).

Reliability Analysis

Table 3 shows the number of positive findings (bruise or light absorption) detected by one, two, or no raters and the proportion of assessments in which both raters agreed (positive or negative findings). The proportion of agreement was over 90% for all assessments except when using ALS wavelengths of 515 and 535 nm with the red filter. In Table 3, kappa values indicated level of agreement was substantial or nearly perfect under white light and ALS (aggregated) and with most wavelength and filter combinations. A moderate level of agreement was found for assessments conducted using 450 nm with a yellow filter (kappa = .599) and 535 nm with a red filter (kappa = .597).

The mean values and ICCs for the visibility scales assessed under white and alternate light conditions are presented in Table 4. ICCs are further broken down by ALS wavelength and filter. On the basis of the interrater

TABLE 4. Interrater Reliability of Bruise Visibility Scale (BVS) and Absorption Visibility Scale (AVS) Based on 120 Assessments

Wavelength/filter	Mean (*SD*)	ICC[a]	95% confidence interval	
			Lower	Upper
White light: BVS	2.6 (1.1)	.930	.901	.951
Alternate light: AVS[b]	3.1 (1.2)	.919	.885	.943
UV	2.6 (1.1)	.937	.911	.956
415 Yellow	3.0 (1.2)	.928	.897	.949
450 Yellow	2.9 (1.2)	.928	.897	.949
415 Orange	2.8 (1.2)	.934	.906	.953
450 Orange	2.8 (1.2)	.926	.894	.947
475 Orange	2.6 (1.2)	.937	.911	.956
495 Orange	2.5 (1.2)	.938	.913	.957
515 Orange	2.3 (1.2)	.940	.915	.959
515 Red	2.2 (0.9)	.807	.738	.863
535 Red	2.2 (0.9)	.785	.715	.851

Note. ICC = intraclass correlation coefficient.
[a]Single measure [2,1] ICC (Shrout & Fleiss, 1979).
[b]Aggregate of maximum value obtained under any ALS wavelength (nm) and filter combinations listed.

TABLE 5. Factors Associated With Bruise Visibility Scale (BVS) and Absorption Visibility Scale (AVS)

	Parameter estimate	95% confidence interval		p Value
		Lower	Upper	
AVS: Model 1[a]				
Absorption size	0.06	0.05	0.07	< .0001
BVS: Model 2[b]				
Lightness (ΔL)	−0.17	−0.27	−0.06	.0017
Bruise size	0.05	0.01	0.09	.0095
BVS: Model 3[b]				
Color difference (ΔE)	0.15	0.05	0.25	.0039
Bruise size	0.05	0.01	0.09	.0128

Note. Bruise/absorption size was measured in square centimeters.
[a]Based on 1,276 observations; general linear mixed model controlling for wavelength/filter combination and skin color.
[b]Based on 162 observations; general linear mixed model controlling for skin color.

analysis, the BVS showed excellent single measure agreement for assessment of bruises under white light (ICC = .91, 95% CI [.88, .94]). The AVS had similar results when we aggregated the maximum AVS values across all ALS wavelengths and filters (ICC = .93, 95% CI [.90, .95]). When examining ICC results for individual ALS wavelengths and filters, a slight decline from excellent agreement to good agreement was noted at higher wavelengths (515 and 535 nm) with the red filter.

Finally, Figure 3 provides the Bland–Altman plots of the differences between the two raters by the mean value for both BVS and AVS scales. The mean difference for both scales was close to zero, showing no systemic bias (Giavarina, 2015). Limits of agreement were also similar for both scales (±1.0), indicating that, with 95% confidence, any two raters were within 1 point on the BVS and AVS scales. According to the plots, only nine (3.7%) of the 240 observations (120 white light and 120 ALS) fell outside these intervals. Further investigation for the outliers revealed one of the raters was the same in five of the cases. In addition, one participant with very light skin was an outlier on both white light and ALS assessments.

Validity Analysis

Table 5 presents statistical model results in which the degree of congruence between certain bruise characteristics and the visibility scales were examined. When controlling for skin color, bruise size was a significant factor in its association with bruise visibility under white light (parameter estimate [$\hat{\beta}$] = 0.05, 95% CI [0.01, 0.09]) and ALS ($\hat{\beta}$ = 0.06, 95% CI [0.05, 0.07]). For every 10-cm^2 increase in injury size, visibility increased by half a point for white light ($\hat{\beta}$ = 0.05, 95% CI [0.01, 0.09]) and over half a point for ALS ($\hat{\beta}$ = 0.06, 95% CI [0.05, 0.07]). Holding skin color constant, bruises that were assessed by colorimetry as being darker were associated with higher visibility scores under white light ($\hat{\beta}$ = −0.17, 95% CI [−0.27, −0.06]). In addition, a positive relationship was noted between the overall difference in color between the bruise and surrounding skin (ΔE) and BVS scores across skin colors ($\hat{\beta}$ = 0.15, 95% CI [0.05, 0.25]).

Discussion

Visual perception has been described as a complex psychophysical phenomenon (Ohno, 2000); thus, the way clinicians interpret bruise visualization is greatly influenced by language, culture, training, and experience. As a result, qualitative descriptors abound in forensic nursing documentation, resulting in reduced consistency and precision. To address this challenge, we conducted the first known analysis of the reliability and validity of two instruments developed to measure bruise visibility in human subjects using white light and ALS.

We established the BVS and AVS have satisfactory interrater agreement in both the detection and visibility of bruises observed under an ALS or white light conditions. Our results support the earlier findings from a small pilot study (n = 30) examining bruises using the BVS under white light (Scafide et al., 2019). Nijs et al. (2019) also showed sufficient interrater reliability with a numeric (1–10) grading scale (white light: ICC = .66; ALS: ICC = .73). However, their scale assessed bruise visibility during examination of digital images. Given image analysis lacks the physical clues afforded by live assessment, their instrument may not be as reliable during clinical application.

To determine whether the BVS and AVS instruments capture the construct being measured, we examined their association with other injury characteristics expected to also be associated with visibility. Other studies have used bruise size as a measure of an injury's visibility in digital images (Olds et al., 2016, 2017; Trefan et al., 2018). Ultimately, we found the size of the bruise or area of absorption was significantly associated with its visibility score under both light sources. In addition, the degree of contrast between the bruise and surrounding skin as viewed under white light has also been used as an indicator of bruise clarity (Black et al., 2019; Trefan et al., 2018). Our results support both contrast and overall color difference being associated with BVS values.

Our study had some limitations. First, the lack of an existing validated measure for assessing bruise visibility required us to select conceptually similar characteristics to validate the BVS and AVS. By doing so, we may not have captured all elements associated with the construct of bruise visibility. In addition, we did not assess the reliability of the raters' bruise size measurements. One study found bruise diameter measurements were larger and more reliable using digital image analysis than when obtained directly from human subjects (Harris et al., 2018). Future studies examining the validity of the BVS and AVS instruments should consider integrating image analysis to provide a more objective assessment of certain bruise characteristics.

Implications for Practice

Detailed, consistent, and precise documentation can contribute to better quality of care and preservation of evidence (Buel & Hirst, 2009). Injuries identified during physical examination should be described using a method that is both reliable and accurate. Nash and Sheridan (2009) previously published a comprehensive list of objective and narrative measures recommended to document a bruise assessment (see Table 6). Absent in their list is bruise visibility, an essential measurement to communicate the injury's overall appearance. Unfortunately, the subjectivity of assessing bruise visibility is compounded by the use of qualitative written descriptors. To consistently assess and document bruises, forensic nursing programs can easily incorporate the BVS and AVS instruments into clinical practice. Both scales showed good reliability and validity in measuring the construct of visibility when administered under white light and ALS, respectively. Though, more replication studies to validate these findings are recommended.

Before implementing the BVS and AVS into clinical practice, quality assurance of a nurse's use of the scales should be established using an interrater process similar to the one described in this study. Suggested steps are as follows:

1. Print hard copies of the scales or integrate them into the electronic medical record. Avoid repeated photocopying, which may cause fading of the images, making the scales difficult to administer.
2. During a staff meeting, practice as a team applying the scales to at least 10 high-quality bruise images to build confidence and consistency. The images should include diverse skin tones, bruise ages, and body locations. On either scale, we suggest scores of less than 0.5 apart be defined as consistent.
3. If resources are available, forensic nurses should then practice administering the scales during a patient's physical assessment at least 10 times alongside another nurse. Alternatives could include practice on additional quality images or existing bruises on staff.
4. For ongoing quality assurance, conduct calibrations every 6 months to ensure no more than 10% of bruise visibility assessments are outside parameters ($\geq$0.5 difference).

Stakeholders, such as law enforcement and prosecutors, should be advised on the benefits of using more objective, evidence-based measures to document bruises during a forensic examination. Taking a multidisciplinary approach to implementing this change in practice may support standardized assessment practices throughout the criminal justice process.

Some forensic nurse examiner programs routinely use ALS, whereas others have not because of the paucity of research to support its reliability and validity in the detection and visibility of bruises. The recent findings by

TABLE 6. Recommended Documentation of a Bruise Assessment

Characteristics	Documentation
History of physical trauma	Narrative
Size	Measure length (widest dimension) × width (widest dimension at right angle to length); photograph with scale
Shape	Describe; photograph
Location on body	Describe; body diagram; photograph using rule-of-thirds technique[a]
Color(s)	Describe or measure using colorimetry; photograph with color standard
Margins	Describe (i.e., distinct, blurred); photograph
Indurated	Yes/no
Tenderness	Yes/no
Associated with injuries in various stages of healing?	Yes/no; describe
Distance to nearby anatomical structure or heel (if located on the lower extremity)	Measure
Healing process	Repeat assessment and documentation at a later date (if possible)

Note. Adapted with permission from Nash and Sheridan (2009).
[a]Rule-of-thirds technique involves a series of photographs from far-range, midrange, and close-up of the injury (Sheridan & Mudd, 2012).

Scafide et al. (2020) may be a catalyst to support the use of ALS during physical assessments into common clinical forensic practice. The results of our current study will contribute to the future development of evidence-based, clinical practice guidelines in which documentation of absorption visibility observed under ALS will be an integral component.

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