Alternate Light Sources (ALS) and Bruising from Strangulation: **Beliefs and Controversies**

by Dr. William Green and Attorney Gerald Fineman

This document was prepared by Dr. William Green and Attorney Gerald Fineman to serve as a written version of the presentation that was originally given on August 1, 2023 to the Forensic Section of the American College of Emergency Physicians. This is not a transcript but rather a concise description of the material presented. In several areas there have been minor changes in the sequence of some topics to more clearly outline the arguments. The focus of this presentation is the current discussions and controversies related to specific applications of alternate light technology and the various truth claims being promoted to use this technology to identify unseen bruising or to enhance or clarify poorly seen skin findings after a history of trauma.

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ALS in Evaluation of Injuries

There has been significant interest in the forensic nursing community in being able to use ALS in the diagnostic evaluation of injuries. The topic of alternate light sources in general forensic applications is huge, as is the specific issue of alternate light sources and injury diagnosis.

Bruising of the neck in strangulation is common, but it is certainly not universal. Only about 50% of strangled patients will have any visible findings on their neck whatsoever. Two studies have looked at strangulation homicide victims, and up to 40% of those patients will also have normal external neck exams.

What Is a Bruise and How Does a Bruise Evolve?

Bruising occurs following some type of blunt force trauma that ruptures blood vessels underneath the skin, and the blood extravasates into the surrounding tissue. If that blood is within about three millimeters of the skin surface, it's likely to be visible. If it's deeper than three millimeters, it will not be visible.

A bruise may or may not be tender. That is an important clinical determination and decisions will need to be made regarding follow-up of the tenderness found during the exam. Extravasated blood is likely to migrate, and may be reabsorbed before it ever becomes visible. If it never gets within three millimeters of the surface, bruising will never be visible. Almost everyone has experienced a bruise, and is aware that when one sustains some blunt force trauma, even minor, it is often painful and/or tender. Initially, the injured area may appear normal or have faint erythema (from the inflammatory response) that fades quickly, but there is no visible bruising. Over the next day or two the bruise may become visible, because the extravasated blood has migrated closer to the skin surface. That blood can also migrate by gravity and show up as an ecchymosis somewhere distant from the original injury which will not be tender because there is no underlying injury.

Bruises evolve and change color with time. Those color changes have to do with the initial inflammation from the trauma and then the metabolism of the extravasated hemoglobin itself. Breakdown products from the hemoglobin become important in terms of whether a bruise may or may not be visible when digital technology is applied. The issue about how old a bruise may be, based on the coloration, is another longer discussion. Suffice it to say, the only color-related determination that has been proven to be scientifically valid is the color yellow, which doesn't appear until about 18 hours after the injury occurred. Any other determination about bruise age based on color is not reliable.

Clinical Significance of Bruises

From a medical standpoint, bruising may influence how clinicians evaluate and manage the patient. Forensically, bruising may help determine the mechanism of injury and, potentially, even the manner in which the injury was caused (whether it was intentional, accidental, or medical). There are many legal significances to injuries and bruises. For example, a bruise can certainly be consistent with blunt force trauma. It substantiates the use of force causing bodily injury. There may be specific elements of criminal statutes that require visible injuries.

There are other practical considerations that the presence or absence of injury, or bruising, may influence. One of those issues is whether or not the victim participates in the criminal justice process. There is some data to indicate that patients who have visible injuries are more likely to engage with a criminal justice process. Whether or not bruises are apparent may affect things like whether or not arrest occurs, what goes on in the investigation, and the rigor of that investigation. Other factors related to victim injury include filing and charging decisions, risk assessment and, in some contexts, determination of consent.

Prosecutors sometimes press the forensic community for evaluation of a potential injury site and want to know if bruising is present. The more visible a bruise is to a prosecutor, the easier it is to demonstrate to a jury that the victim has given a statement which is consistent with the history of trauma in the case. The issue of using ALS technology to make a visibly faint injury "easier for the jury to appreciate" will be discussed at the end of the presentation.

Documenting a Visible Bruise

Visible injuries need to be documented beginning with a description of exactly what happened in order to determine the mechanism of injury. A thorough, detailed history is critical. Next, the documentation of the injury needs to include measurements, and an indication of whether or not the area is tender to palpation. There should also be some type of a diagram that the examiner will be asked to interact with and do their best artistic rendition of that particular injury finding. Finally, standard forensic documentation will include photographs (using specific forensic technique) in regular ambient light or flash to document the visible findings.

An important practical issue is the fact that the identification of a bruise requires a certain amount of contrast between the normal skin and the bruised skin. That contrast is more difficult to appreciate if the individual is darkly pigmented. Hence, the obvious difficulty identifying and documenting bruises on darkly pigmented victims is a very problematic. One way to attempt to validate the injury is by using tenderness. For example, if a victim gives a history of an injury occurring, they may have pain at the site and they also may have tenderness (both of which should be documented), but there is no visible bruising. An excellent option in this situation is to bring that patient back in a day or two to re-evaluate the area in question and see if visible bruising has then developed. At that point, an addendum would be created documenting and forensically photographing the now visible injury.

Photographs as Evidence

In order for an image of an injury to be introduced as evidence in a legal proceeding, two criteria must be met. First is relevance. For this, the judge must make the determination that the image being proffered is appropriate to the case at hand. The next step is authentication. The person who took the photo is responsible to authenticate that image, and be able to testify that that photo **fairly** and **accurately** portrays the scene exactly as they saw it at the time of the exam.

Photos can be enhanced to more accurately show details, or it can be manipulated. Enhancing is permissible since it involves adjusting the color, the exposure, the contrast, or other photographic variables to make the image more accurately represent what was seen at the time of the exam. The original image must be saved and unaltered. Any enhancement must be performed on a copy. The software that does the enhancement typically documents the steps that were taken (which is required for admission of an enhanced image).

What is not permissible is manipulation, in which digital information is added or removed. For example, a graphic artist can take an image and quickly make it look like the person in the picture was beaten to a pulp, when they actually had no injuries. This is not acceptable. A common clinical scenario occurs when a clinician sees what they think is may be a bruise, but is not certain. How can actual tissue damage underneath the skin surface be confirmed? The first approach would be to have the patient return later and look for the emergence of visible bruising and then do the appropriate documentation. Another technique that is very reliable, but also difficult, is to get an

MRI. This may be the best gold standard for identifying subtle subdermal and subcutaneous bleeding. This is scientifically valid, but is difficult (and expensive) to obtain in most situations. Another option for determining if an injury is actually present is directly inspecting the tissue underneath the surface of the skin. That is easy to accomplish at an autopsy with dissection of the body. This may also occurs at surgery where the incisions exposes the underlying tissue to confirm the presence of a bruise. A third option is to perform direct tissue sampling using a punch biopsy of the area in question.

The use of alternate light sources plus filters (either on the camera or by using goggles) to identify or clarify subdermal injury is the current topic of controversy. There are also computer software programs that can manipulate the pixels in digital images to purportedly identify or clarify unseen or poorly seen injury. The discussion of these "computer enhancement" programs is detailed and beyond the scope of this presentation.

Digital Technology for Bruise Identification and Documentation

Light is part of the electromagnetic spectrum. Visible light is between 400 and 700 nanometers. The lower end of the visible spectrum between about 400 and about 470 nanometers (also known as "narrow band visible light" or NBVL) is of particular interest in discussion of ALS and bruise identification. Many other wavelengths and technologies have been studied for this objective, but the narrow band visible light source (in the blue-violet visible range) is the focus of this discussion. When electromagnetic radiation (e.g. ALS) is directed to the skin surface, multiple effects are possible. The radiation can scatter, it can penetrate, or it can be reflection either from the skin surface or from something under the surface. The radiation may create fluorescence in which the "incident" wavelength excites specific molecules that then emit radiation at a higher wavelength (the Stokes Shift) which can be seen visibly or with the aid of filters. An example of this type of fluorescence is the identification of potential semen in sexual assault victims when and ALS is used. Note the ideal wavelength for semen identification is about 450nm (not the 360nm from the commonly used Woods' Lamp). When this is done, the alternate light causes temporary fluorescence of the substance on the skin.

Another consequence of electromagnetic radiation directed to the skin can be absorption. Blood absorbs electromagnetic radiation and the area appears darker than the surrounding tissue. For example, hemoglobin absorbs and is best seen at about 415 nanometers, de-oxyhemoglobin at about 430nm. Bilirubin, which is one of the breakdown products of hemoglobin, absorbs at 460nm and then another band slightly higher than that. This helps explain why the spectrum of interest for bruise identification is the NBVL band in the range of about 400nm to 470nm. Electromagnetic radiation penetrates the skin to different depths depending on which frequencies are used. The spectrum of light in the NBVL range is on the lower end of the visible spectrum, and it penetrates the skin less than a millimeter. Infrared light (700nm-1000nm) penetrates deeper than three millimeters, which may ultimately be the most effective technology for evaluating subclinical bruising, but that is beyond the current discussion.

This discussion focuses on the technology being proposed or being used by many SAFE or SANE nurses, which is the NBVL at lower end of the visible spectrum. When this type of ALS is used, clinicians may generate and then photograph findings that are presumed to be subclinical bruising. It is essential to understand that this "finding" is something that is not seen in nature and not seen in plain light. This finding only appears with the application of technology and that finding does not exist in real life without the use of the alternate technology.

There are two different scenarios to consider. First, the technology is applied to normal skin and generates a new image of an ostensibly unseen injury. The argument here is that the technology proves an injury is present despite the normal appearance of overlying skin. The second scenario occurs when something is visible on the skin that may or may not be a bruise. Again, ALS technology is employed to create a new image that does not exist in nature without the technology. The argument in this scenario is that the technology proves the injury is real and may offer additional information to promote conclusions that that injury is bigger, deeper, or more severe than it appears in plain light.

These are the two different variations of interpretation and argument regarding what ALS can do in the context of potential bruising that is unseen, poorly seen or equivocal. It is essential to understand that the proffered image, generated by the application of technology, it's not what the examiner saw in the real world in plain light. This image (and the interpretation and conclusions connected to it) is something different. The new image is now being offered to prove additional information about the area in question that cannot be reasonably concluded just based on the plain light appearance alone.

The Challenge of Authenticating Technologically Created Images

Once a clinician, either an emergency medicine provider or a SAFE/ SANE nurse has this technologically generated finding and its image, the examiner is no longer offering authenticated photographic evidence of what they saw. **They are now giving expert testimony regarding the product of a scientific process.** The examiner proffering the ALS image now has the responsibility to explain and justify why this new image (and the related interpretations and conclusions) should be trusted as reliable science. This process has historical correlates regarding the introduction of other medical technologies. For example, consider showing a picture of a normal neck and then showing a CT image revealing a fractured larynx. Another example would be showing that same photo of a normal neck then showing an MRI image of the neck that documents bleeding into neck muscles and lymph nodes. None of these underlying pathologies could have been proven based on just the photograph of a normal neck. Before either technology could be trusted in clinical decision making, both had to extensively tested and scientifically validated to prove their images corresponded to the alleged anatomy and pathology. This is analogous to the ALS image that alleges underlying pathology beyond what the visible image shows.

Assessing Reliability for Admissibility of Novel Scientific Evidence

The medical world has specific techniques and procedures for validating the reliability of new technology. The highest priorities are optimum patient care and patient safety. The legal community has its own methods for assessing reliability and validity of novel scientific information and technology. Because accused parties in criminal cases may be convicted on the basis of testimony from forensic science experts, much depends upon whether the evidence offered is reliable. Reliability rests on establishing that the technique or process has been validated by **methodologically sound** research. Expert scientific testimony (in support of a technique or process) is subject to judicial scrutiny for a "reliable foundation" and relevance.

Historically, the courts have used two tests for admissibility of novel scientific evidence. First is the *Frye* test (*Frye v. United States, 54 App. D.C. 46, 293 F. 1013 (1923)* which assessed "General acceptance" within the "relevant scientific community". This seemingly simple assessment is potentially very problematic because of all the vagaries and non-specifics in the two basic questions. In 1993, the Daubert case (*Daubert v. Merrell Dow Pharm., Inc.*, *509 U.S. 579, 586 & n.4 (1993)* produced a much more rigorous approach to assessing the reliability of novel scientific evidence. In part, the court concluded expert testimony should be "scientific knowledge," so "evidentiary reliability will be based upon scientific validity". Trial judges were instructed to focus "solely" on experts' "principles and methodology," and "not on the conclusions that they generate." Daubert produced a number of specific factors related to the technique or procedure in consideration of admissibility:

- Whether a theory or technique can be (and has been) tested
- Whether the theory or technique has been subjected to peer review and publication
- The known or potential rate of error of a particular scientific technique
- The existence and maintenance of standards controlling the technique's operation
- A scientific technique's degree of acceptance within a relevant scientific community (***Frye*** criteria continues to be included as a factor)

In addition to the technique-specific inquiries, the court added criteria to consider regarding the expert's testimony related to interpreting the technique or process:

- Has the expert adequately accounted for alternative explanations?
- Has the expert unjustifiably extrapolated from an accepted premise to an unfounded conclusion?

Each state determines how scientific technology and testimony will be assessed. Most, but not all, states use the Daubert criteria. Some, including California, still rely on Frye or some modification of "general acceptance" theory.

The Nursing Literature Related to ALS and Bruising

In 2013, Holbrook and Jackson published an article in the Journal of Forensic Nursing (*Use of an Alternative Light Source to Assess Strangulation Victims*). This paper was not just widely accepted in the forensic nursing community, but revered and continues to be so in much of this community. As a result, many nurse examiner teams are apparently using Holbrook's methodology to evaluate strangled patients for occult bruising and some prosecutors are embracing the resultant interpretations and conclusions. Unfortunately, this paper is fatally flawed because it does not employ methodologically sound research and fails to provide any reliable validation of its technology, truth claims, interpretations or conclusions.

The paper describes the use of the SPEX Crimescope (which generates variable wavelengths of electromagnetic radiation)

"*to reveal soft tissue injuries that are not visible to the naked or unaided eye in patients who report strangulation.*"

This was a two-year retrospective review that involved 172 patients reporting strangulation. The authors report that 93% of these patients had no visible evidence of external injury on initial exam under ambient light. They then claim that after the application of their ALS technique (wavelengths from 415-515nm plus multiple colored goggles) 98% of the group had ALS revealed "intradermal injuries".

Careful analysis of this paper reveals a multitude of flaws, including:

- Non-standard format – mixes methods, results and discussion
- No specific study protocol
- Unsupported/unreferenced physiology claims
- Inaccuracies in basic science and physics
- Only 172/399 cases in the study period were used – no explanation of inclusion/exclusion criteria was given
- No strangulation to exam time frame information
- No consistent positive ALS finding occurs with any one wavelength or color goggle (unreferenced explanation)
- Image examples were vague with no description of "findings", no paired examples of "with and without" ALS, and an undescribed vendor image

The authors report that only 7% of the 172 study patients had any visible findings on initial exam. This is a significant departure from other published studies regarding visible neck injuries in strangulation victims. The range of visible findings is 31% to 50% with a median of 49%. This huge discrepancy is unexplained. One possible mitigating factor might have been that 69% of their patients were African-American in whom bruising may be under-recognized due to increased pigmentation creating less contrast between normal and bruised skin. But the authors dismiss this possibility:

"The review of our series revealed no clinical relevance in relation to the patient's age or whether the patient was light or dark skinned".

The claim that 98% of all their study patients were found to "intradermal injury" revealed by ALS application is not credible for two significant reasons. First, there was no control group. No normal, uninjured subjects were studied to see if any of them demonstrated false positive "intradermal injuries". Ignoring the potential for false positives is a serious error. Second, no method was employed to independently corroborate or validate that ANY of their positive ALS findings actually corresponded to proven tissue damage. The combination of these two omissions represents very seriously flawed methodology.

Their bibliography has 11 citations, but none of these citations support their methodology, findings or conclusions. Two of the papers only discussed infrared imaging, a completely different technology. Seven of the papers were general or epidemiological discussions just about strangulation. There was not a single mention in those seven papers of anything having to do with an alternate light source. One of the papers came from the child abuse literature and that paper used ultraviolet light. Again, not a technique used by Holbrook and Jackson. ***And the author of that paper concluded that the lack of scientific validation of this technique prevents admissibility!*** Finally, the authors listed the product website, the SPEX Forensics website, which makes claims regarding ALS use for bruise detection but provides no bibliography, no experimental work, no citations, and no scientific publications that support any of their claims.

This combination of unreferenced truth claims, serious methodological flaws and omissions coupled with a totally non-supportive bibliography renders this paper solidly in the realm of "junk science".

Published Literature Refuting the Claims of Holbrook and Jackson

Lombardi, et al, published an important study in 2015 using induced injuries on the forearms of 56 volunteers and 62 normal forearms. Two blinded examiners then examined all forearms with 7 spectrums of electromagnetic radiation from 300nm-555nm (which includes NBVL); each with red, orange and yellow goggle filters (very similar to Holbrook and Jackson). They concluded:

"…our results demonstrate that more than half of the time, positive

fluorescence is something other than a bruise. There is no evidence base, therefore, to support the use of an alternate light source as an independent tool to definitively interpret fluorescence as a sub-clinical bruise (i.e., bruising that is not visible to the naked eye)."

Olds,et al, published several studies, including one that used pigskin injected with tiny amounts of blood between the muscle and superficial skin layers to simulate bleeding from bruising. They then scanned these pigskin injected samples using the same wavelengths employed by Holbrook and Jackson. All 26 of the "bruised" regions enhanced but they also observed enhancement in 6 areas with no injected blood (23% false positives). They concluded:

"…the findings of this study indicate that alternate light sources are not specific; their use in identifying inapparent bruising should be undertaken with caution and further evaluation is recommended in a setting of controlled trauma created bruises in human volunteers".

Another study published by Olds, et al, used cadavers, both embalmed and un-embalmed. They scanned the cadavers with ALS (350nm-700nm, similar to Holbrook and Jackson) and performed punch biopsies on any area that enhanced. They analyzed the biopsy specimens for glycophorin as an indicator of extravasated blood (i.e. bruising). They concluded:

"Non-bruised regions (such as a hemangioma) enhanced in both non-embalmed and embalmed cadavers producing false positive results (17%, 32%) . Therefore, alternate light sources may not be specific for bruises."

The same group looked at the existing literature on the subject of ALS for detecting bruising in 2016 and concluded the sensitivity and specificity of these methods need to be clearly defined so that the number of cases of false positives can be ascertained. They warned that until these issues are resolved with further research, the use of ALS in bruising should be approached cautiously.

In 2019, Nijs, et al, published a study using 73 volunteers and inflicted forearm injury using a dropped object. Only 39 (53.4%) developed a visible bruise; those without visible bruising were excluded. All visible bruises were studied in both ambient light and under 415nm light (within the NBVL spectrum) with the objective to determine if ALS improved the appearance of already visible bruises. Note: this is analogous to the issue of "helping the jury appreciate the injury", discussed later. They concluded:

"…bruises after standardized blunt force impact were slightly better visible with an alternate light source than with a white light source after 1 and 2 days, but not after 0.25, 7 and 14 days. The value of using an alternate light source at 415nm to improve bruise visibility was limited in this study".

In concluding the analysis of the Holbrook and Jackson paper, it should be obvious that from a scientific standpoint this work falls short on so many criteria that it cannot be considered reliable or credible in any serious discussion of ALS in the detection or interpretation of bruising. It performs no better in the context of a legal assessment for reliability. Consider subjecting their technology and claims in this paper to a Daubert analysis:

- Can the technique be tested? **YES**
- Has the technique been subjected to peer review and publication? **YES** (Lombardi and Olds)
- Is the error rate known? **YES,** false positives >50% (Lombardi), 17% and 32% (Olds); 23% (Olds)
- Are there standards controlling the technique's operation? **None specified**
- Is there general acceptance of the technique in the relevant scientific community? **NO**
- Has the expert adequately accounted for alternative explanations? **NO**
- Has the expert unjustifiably extrapolated from an accepted premise to an unfounded conclusion? **YES**

ALS and Unseen/Poorly Seen Injury: Summary and Conclusions

- The field needs a reliable tool that can identify and image sub-clinical (equivocal or unseen) bruising
- The system(s) advocated by Holbrook and others have not been adequately researched or validated

- The paper by Holbrook and Jackson (2013) is an observational study that offers no proof or confirmation (either in the text, bibliography or ALS product information) that the highlighted areas seen with ALS reliably correlate with actual injury
- The high rate of false positives (experimentally identified by both Lombardi and Olds) renders the Holbrook ALS procedure unreliable forensically and legally

The Courts Cannot be Trusted to Adequately Assess the Validity and Reliability of Technology or Expert Testimony Regarding ALS and Bruising

The appellate process in the Baltimore region (near where Holbrook practices) has failed to properly assess the reliability and validity of the Holbrook method of ALS and bruise assessment. Data is somewhat limited, but what is clear is that at least 4 defense motions for a *Frye-Reed* (general acceptance standard used in the Baltimore region) hearing on the validity and reliability of this type of ALS technology have either ruled supporting the Holbrook method or have been denied because the issue had been previously "deemed reliable". In one of these actions, nine references were submitted to the court supposedly supporting the Holbrook method; Like the Holbrook bibliography, **NONE** provided **ANY** support for the proffered technology. The court **inappropriately** assumed the ALS procedure is widely accepted, accurate, reliable and validated. The court's analysis of the validity and reliability of the proffered ALS technology to detect sub-clinical bruising was **scientifically inadequate, inaccurate and flawed.** The most dangerous outcome in this matter is the fact that once the first court inappropriately "deemed" the Holbrook method "reliable", subsequent challenges were rejected without analysis. The defense bar must be better informed regarding the pertinent scientific facts in order to press for a more accurate judicial review.

The failure of adequate judicial review not only lays a foundation for more accurate challenges on future cases but risks defense challenges on adjudicated cases in which unreliable scientific technology and testimony were allowed in order to obtain conviction. These judicial failures also suppress the application of reliable science and promote the continuation of pseudoscience. As an example, consider these statements from Holbrook in an interview with Catholic Health World on December 1, 2022:

"When I go to court and I sit on the stand and I'm asked, 'Are your peers using this instrumentation?' or 'Is this respected technology within the industry in which you work?' I'm able to say now, 'Absolutely, yes.' And I'm able to name cities that are using this across the United States and across the world,"

New Scientific Research on ALS and Bruising

In 2020, Scafide, et al, published *Detection of Inflicted Bruises by Alternate Light: Results of a Randomized Controlled Trial* in the Journal of Forensic Science. This study induced bruising injury (by two different methods) on the arms of 157 volunteer subjects with 6 different skin tones and assessed these known injury sites with ALS of ten different wavelengths (350-555nm) plus various filters. They assessed their study subjects multiple times over 4 weeks. They found 415nm and 450nm + a yellow filter had greater odds of detecting evidence of bruising than white light (assessed on skin, not photos). Their methodology was good and their work added important information about the ALS behavior of known bruises over time. It is important to note that their ALS technology was not applied to "unknown" areas of the body and the only confirmation of injury was the experimentally induced bruises. Therefore, they could not, and did not address the potential of false positive ALS findings. Also, they made no assessments or conclusions regarding severity. The authors offered two warnings:

- *"ALS is not a diagnostic tool for bruising"*
- *"…in the absence of trauma-related history or other physical findings consistent with bruising, caution should be used when interpreting light absorption in isolation"*

As stressed previously, any ALS technology claiming to identify or enhance unseen or equivocal bruising must address false positives and include a reliable method to unequivocally confirm tissue damage in the ALS positive areas.

There seems to be a developing strategy in the forensic nursing community that Scafide's work on known bruises and ALS could be leveraged to assess and identify or enhance unseen or equivocal bruising in assaulted patients. The argument appears to be based on another Scafide quote:

"While absorption is not pathognomonic for bruising, it can support a patient's history of blunt or squeezing trauma and other physical assessment findings, such as pain/tenderness and swelling on palpation"

This quote highlights a technical issue that may be significant but is unresolved by the current research. Scafide is correct, much of the mechanism of injury in strangulation is from squeezing forces and much less from direct blows (which is the only method she tested with both types of inflicted trauma). The resultant tissue damage and ALS behavior may or may not be identical from squeezing or direct blow but the current assumption is speculative and not proven.

Apparently, proponents of stretching Scafide's methodology to assess "unknown" or "uncertain" bruise situations relies on the argument that the patient's description of blunt force trauma and/or the finding of tenderness is sufficient to confirm underlying tissue damage (by this reasoning the area in question is now no longer "unknown"). And hence, if the area darkens under ALS, this proves the presence of underlying extravasated blood from blunt force tissue injury and the patient's history is "supported".

This line of argument is flawed for several reasons. The requirement for reliable confirmation of actual tissue damage is not satisfied by either patient history or tenderness at the site. Both of these factors are subjective and vulnerable to bias (recall bias, confirmation bias). What is the level of diagnostic certainty that "supports" the patient's history of blunt or squeezing force (with or without tenderness) causing unseen bruising? The highest level of certainty in this scenario is not diagnostic but consistency; in forensics, **consistency means possible.**

Neither Scafide's work nor this argument addresses the possibilities of false positive findings. Simply finding darkening with ALS does not exclude the real possibility the finding is actually something other than a bruise. In this scenario, positive ALS absorption is a **screening finding** for possible bruising. This screening finding must be confirmed (or refuted) by another method that is reliable. The necessity of scientifically excluding other possibilities is highlighted by all the published studies using similar ALS technology that all found significant false positives. **Without a validated confirmation method, the highest level of ligitimate conclusion is "consistent" with bruising, but unproven.**

There is a straight forward, highly reliable path to conclusively validate (or not) whether Scafide's methodology accurately identifies only unseen or poorly seen bruises. MRI is very sensitive for identifying sub-dermal bleeding and injury. The other reliable methods to confirm extravasated blood from blunt force tissue damage (dissection and punch biopsy) are invasive, painful and unrealistic for research on living victims. MRI is expensive and often logistically challenging to obtain and, when used for a forensic purpose, would not be paid for by health insurance. These issues aside, a research project that was adequately resourced could end the controversies and speculation regarding ALS as a tool to reliably identify unseen or identical bruising.

Enhancing a "Known" or Suspected Bruise…"To help the jury appreciate the injury"

A concept promoted by many vendors who market ALS equipment (and also endorsed by some prosecutors) is to start with some type of visible skin finding and apply ALS technology to make it "easier for the jury to appreciate". There are two versions of this concept. First, is with an equivocal or non-specific finding which cannot be reliably diagnosed as a bruise just based on the visual appearance. This situation is essentially identical to proving an underlying bruise under normal appearing skin. The examiner/photographer is not testifying to authenticate an image of a known bruise but is offering expert testimony regarding the product of a scientific process with all the requirements and limitations discussed previously.

The second version is just a problematic as the first, but in different ways. This second version starts with a visible finding that has been diagnosed as a bruise. At this point there are two possible scenarios. First, is the application of ALS technology to a known bruise in order to confirm it is a bruise and to supply more information about size, depth, severity or mechanism of injury than cannot be reasonably concluded from the plain light image alone. This scenario requires the same approach as for the normal skin or equivocal visible finding. The examiner/photographer must prove that this technologically produced image is reliable and validates the conclusion that the injury is bigger, deeper, more severe and/or caused by a different mechanism than could be gleaned from the original image.

The second scenario is the most difficult. Here, the diagnosis of bruise is accepted. Ostensibly, there is no expectation that the ALS technology applied to this known bruise will provide any additional information about the nature or cause of the injury. The new image was generated for the sole purpose of making it easier for "the jurors to appreciate the injury". The reason this scenario is problematic is that the issue is no longer in the realm of science, but rather a matter of persuasion versus information. The first question is that if this known bruise already has an accepted interpretation and testimony, why is alteration of the visual appearance necessary for jury "appreciation"?

What is to be gained? The answers probably have more to do with theatrics, tactics and juror impact than "appreciation". Zachariah Parry is a law professor who has written extensively on digital and technical evidence. In a 2009 article in the Journal of Law, Technology & Policy, he wrote:

"Because jurors may retain as much as 85% of what they learn visually and as little as 10% of the information they hear, the verdict the jury renders may have more to do with how memorable a photograph is, rather than what the jury has heard from lawyers and witnesses"

When known bruise images are altered by technology to make them "easier to appreciate", they will inevitably look more dramatic. Without a word of testimony or endorsement, the jurors are tacitly invited to interpret the significance of the injury, as depicted on the new and dramatic image, any way that seems logical to them. Is this practice "fair and accurate"? This will have to be decided in a legal, not scientific, framework. The expert's obligation is to objectively inform the jury regarding the science at issue. When the objective shifts to persuasion in support of a narrative, the analysis of what is appropriate or permissible will have to include the issues of morality, ethics, integrity and legal standards.