TECHNICAL NOTE

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Photography in Bite Mark and Patterned Injury Documentation—Part 1

REFERENCE: Wright FD. Photography in bite mark and patterned injury documentation—part 1. J Forensic Sci 1998;43(4): 877–880.

ABSTRACT: Photography is an important means of collecting and preserving physical evidence as it relates to bite mark and patterned injuries in skin. Proper use and understanding of color, black-and-white, ultraviolet and infrared photography can greatly aid the collection and preservation of evidence. The techniques and equipment for the photo-documentation of this evidence are presented.

KEYWORDS: forensic sciences, forensic odontology, bite mark injuries, patterned injuries, visible light photography, ultraviolet photography, infrared photography

The utilization of photography in the documentation of injuries in skin is often the only means of preserving the evidentiary value of the injuries. The historical precedent of the use of photography in recording bite mark and patterned injuries in skin is well documented (1–6). Therefore, knowing the proper use of and techniques for the photographic recording of the injuries is paramount to the evidentiary preservation of the injuries. This paper discusses some of the basic types of electromagnetic radiation (light) that are used for this documentation, how to use each for photographic purposes, and the equipment necessary to capture the images photographically. A more detailed rendering of this information can be found in various textbooks (7,8).

Electromagnetic Radiation

Electromagnetic radiation is defined in its simplest form by dividing the spectrum of the radiation into its component wavelengths. The shortest wavelengths utilized for photographic preservation of patterned injuries are those in the ultraviolet wavelength (approximately 250 to 400 nm). Infrared light (approximately 750 to 900 nm) represents the longer wavelengths of light utilized to photograph injuries in skin. Visible light occupies the wavelengths (approximately 400 to 700 nm) between ultraviolet and infrared light. All three can be utilized in the photographic documentation of injuries to show the differences in the details of the injuries as they appear when exposed to the associated wavelengths of incident light—ultraviolet, visible or infrared. The details of the injuries are then captured on photographic film that is sensitive to the specific wavelength of light used. Because of the limitations of the retina of the human eye, it is not possible to see the details of the injuries as they appear in ultraviolet or infrared light with the unaided eye (5). The solution to this problem is to record the injuries on photographic film sensitive to the ultraviolet and/or infrared wavelengths of light, develop the film and print the images on photographic paper, thus making the images *visible* to the unaided human eye. (Note: It is also possible to capture the images electronically in a digitized format using a digital camera. At this time, the digital technology is just gaining scientific acceptance and is not widely utilized. Most of the currently available digital systems have difficulty recording images in wavelengths not in the visible range. For that reason, this paper presents the recording of injuries on photographic film only.)

Injuries in Skin

Bite marks and other patterned injuries represent physical damage in the skin such that the area of the damaged skin possesses biophysical components different from the adjacent associated healthy skin. These differences in the composition of the damaged and healthy skin allow for the discriminate recording of the appearance of the damaged skin relative to the undamaged skin. Utilizing different wavelengths of light to illuminate the injured versus healthy skin will capture the details of the injured skin on the photographic film. In living victims containing bite mark or other patterned injuries, the damaged skin is in an ongoing state of repair and/or regeneration, trying to move toward the composition of the adjacent undamaged skin. As the healing progresses, the biocomposition changes, and thus too the appearance of the injuries in varying wavelengths of light. Therefore, it is important to photograph the injuries sequentially over time as the healing occurs. Depending on the amount of tissue injury, the location of the injury and the wavelength of light utilized to photograph, it may be possible to record the injury for many months after it occurred (2,9).

While the amount of time available to photograph the injuries is certainly much less in non-living victims, attempts should be made to photograph the injuries over time as well. The injuries in the non-living victim often lose detail and thus evidentiary value rapidly in the immediate postmortem interval. When possible, invasive procedures at the site of the injuries (i.e., autopsy) should be delayed until all recoverable photographic evidence has been obtained. This will often require great patience on the part of the medical examiner or coroner as it may delay the autopsy and/or the release of the body for a couple of days.

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Received 20 June 1997; and in revised form 17 Oct. 1997; accepted 1 Dec. 1997.

The injuries in the skin usually appear differently when exposed to different light sources and when recorded on color versus black-and-white film. Since the detail recovered is not known until the film is developed, injuries should be photographed in ultraviolet and infrared nonvisible light as well as in color and black-and-white visible light. (This delay in evaluating the evidentiary value of the injuries using conventional photographic films is certainly a good reason why digitized photography shows such great promise as the digital image is immediately available for review via computer imaging.) Orientation photographs should be taken to show where on the body the injuries occurred and then close-up photographs should be taken to capture the details associated with the injuries, both with a photographic scale (i.e., ABFO #2 scale) and without a photographic scale, showing the scale did not cover up any important details of the injuries. The exposures should be widely bracketed and many photographs should be exposed, especially if only one opportunity to photographically document the injuries exists.

Visible Light Photography—Color and Black and White

The use of visible light photography represents the photo-documentation of the injuries as they are seen by the unaided human eye. Most 35mm SLR cameras with TTL focusing available commercially are ideally set up for visible light photography. Because most of these cameras are also ''auto focus,'' it takes little special equipment to capture high-quality, sharply focused photographs, assuming the injury being photographed is in the focus box in the lens viewfinder. Both color and black-and-white photographs should be taken of the injured skin as each type will usually show different details associated with the injuries. The photographer should use high-quality slower speed films when possible. Color films such as Kodak Royal Gold 100 or FujiColor 100 work well. Black and white films, such as Kodak TMAX 100 or TMAX 400 or 400CN,[2] are also recommended. The slower the ASA rating of the film (the lower the ASA/ISO number), the more dense the grain structure of the film and the sharper the image will appear. This translates to less loss of detail when the photographs are enlarged to life size for examination and comparison. Bernstein (11) describes the basic requirements for camera equipment necessary for forensic photography and should be reviewed if the photographer does not have the necessary camera equipment.

Reflective Ultraviolet Photography

Since ultraviolet light only penetrates a few microns into the surface of the skin (12,13), the use of reflective ultraviolet photography, often referred to as RUV photography, captures the details associated with the surface of the skin and highlights the surface aberrations associated with the injured skin.

Capturing photographic images utilizing RUV requires the use of a light source that emits a strong band of UV light (i.e., Nikon SB 140 flash), a bandpass filter on the front of the lens that allows only UV light to reach the film (i.e., Kodak wratten 18A), a film that has sensitivity to the UV spectrum (i.e., Kodak TMAX 100 or 400, TMAX 400CN, Kodak Plus X 125) and a lens that does not have a filter (covering) to block the transmission of UV light (i.e., Nikon Nikkor UV 105 lens). Most commercially available photographic lenses used for visible light photography filter out both UV and infrared (IR) light, as these wavelengths are undesirable in visible light photography.

Utilizing a photographic flash unit as a UV light source can present problems as most commercially available flash units filter out UV light to prevent the undesirable affects of UV light on visible light photographs. Woods lamps, multiple black lights or older unfiltered flash units can be other sources of UV light.

The camera should be set up to optimize UV photography. The bracketing should include *f* stops 4.5 to 11, shutter speed times from 1/125 to 2 s, the use of the UV bandpass filter (Kodak wratten 18A) and a UV light source. A high-quality black-and-white film should be used with ASA speeds of 100 to 400. Because all cameras, lenses and flash units are different, it will take some experimentation to optimize the proper settings for each camera system and, after experimentation, the bracketing ranges will be narrowed. The film can then be ''push'' processed (slightly overdevelop the film) to improve the quality of the recorded image.

It should be noted that the visible focus point and the UV focus point are not identical. In some systems, a change from the visible focus point to the UV focus point, called the focus shift, may be necessary. It has been found that such a focus shift may not be necessary with many lenses. By decreasing the lens aperture (lower numbered *f* stops), the focus point for both the visible and UV light is brought closer to the same point (15). The Nikon Nikkor UV 105 lens is an unfiltered quartz glass lens that has been specially made such that the visible and UV focus point are essentially the same (13,16).

Infrared Photography

Infrared (IR) light is capable of penetrating up to 3 mm below the surface of the skin (18). Utilizing this property of IR light, the forensic photographer can take photographs of injuries in skin below the surface of the skin. IR light is strongly absorbed by blood and, as such, IR photographs show, among other things, where bleeding has occurred below the surface of the skin. This can define the object that caused the bleeding and render an associated pattern of the object.

Similar to UV photography, photography utilizing IR light requires special techniques. Film that is specially designed for IR photography (i.e., Kodak High Speed Infrared Black and White film) must be used. This special film must be handled in total darkness, as contamination with any stray light renders it useless. A special bandpass filter (i.e., Kodak 87 gel) must be placed in front of the lens to allow only IR light to reach the film. The lens (i.e., Nikon Nikkor UV105 lens) must allow the transmission of the IR light so the image can be recorded on the film. The flash (i.e., Nikon SB 140 flash) must be capable of emitting sufficient amounts of IR light as well. Many commercially available flash units do emit varying amounts of IR light.

The camera setup for IR photography requires special considerations. Because the focus point is below the surface of the skin, more depth of field is required; thus the bracketing for *f* stops should range from *f*11 to *f*22. The exposure times will range from 1/125 to 2 s. The Kodak High Speed Infrared film does not come with an ASA speed rating. It is suggested that the camera be set for a range of ASA 25 to 64 as beginning references. Again, experimentation with specific camera equipment and widely bracketed exposures will fine tune the specific techniques necessary to ensure high-quality IR photographs. As was recommended with UV film processing, it is recommended to ''push'' process the film.

The focus point for IR photographs is below the surface of the

[2] TMAX 400CN is a newer film that is processed C41 and can be processed by ''One Hour'' type photo labs, speeding review of the BW prints.

TABLE 1—*Summary of documentation of bite mark and patterned injuries with photography.*

Photography	Wavelength of Light	Film Recommendation	Lens Filter	Estimate of Time to Recover Image
Color	400–700 nm	Kodak Royal Gold Plus 100, FujiColor 100	none	up to 14 days
Black and White	400–700 nm	Kodak TMAX 100 or 400, TMAX 400CN	none	up to 14 days
UV	250–375 nm	Kodak TMAX 100 or Plus X 125	Kodak wratten 18A	up to several months
IR	750–900 nm	Kodak High Speed IR	Kodak 87 gel	up to 7 days

skin and does require a focus shift from the visible focus (19–21). Fortunately, many lenses have the IR focus shift marked on the lens so the focus correction can be easily accomplished. The technique to correct for the focus shift calls for gaining the visible focus and then moving the focusing ring on the lens slightly from the visible focus to the IR focus mark. This is effectively moving the lens slightly away from the object (22,23).

The IR photographs, when viewed in comparison to UV or visible light photographs, will appear slightly fuzzy looking (20). Because the image being photographed is not on the surface, the IR light scatters as it penetrates to varying degrees which decreases the image focus. This is the expected appearance and is explained by both the optical properties of the lenses and the focus shift required to properly capture the image below the surface of the skin.

Results, Image Interpretations, and Lessons Learned

By using the four photographic mediums described, the forensic photographer can photographically capture the injury in three distinct planes of reference: highlighted surface detail (UV), detail below the surface of the skin (IR)—neither of which can be seen with the unaided eye—and detail readily seen with the eye and captured in both color and black and white. The forensic investigator can design tests using principles of scientific methodology to determine if a valid relationship exists between the photographically recorded injuries and the teeth or other object suspected of causing the injuries. The significance of the conclusions reached when the testing yields positive findings in more than one medium of the photo-documented injuries can significantly strengthen the correlation between the bite mark injury and the teeth suspected of causing the injury or between the object suspected of causing the injury and the photo-documentation of the patterned injury.

The detail recorded in each type of light will not usually appear exactly the same. Some areas of the injuries will appear more strongly and with better definition in some types of light and not as well in others. It is important for the forensic investigator to remember exactly what is recorded and where, in relation to the injury, before trying to interpret what detail is actually present. Unexplainable inconsistencies in any one of the series of photographs will invalidate positive findings relating the bite mark and biter. Conversely, the forensic investigator must not focus only on those areas that are found to have a correlation and ignore stray markings or areas of inconsistent or unexplainable findings associated with the injuries.

Many forensic investigators have become frustrated attempting to document injuries utilizing the non-visible light techniques described herein. Through trial and error by this author and others, the lessons learned yield two main reasons that no image is recovered in nonvisible light techniques. The first, and most obvious, is that there is a flaw in the technique, usually the equipment, preventing proper exposure in the desired wavelength. These types of problems include improper or insufficient light in the specified wavelength to expose the injury, lack of or incorrect bandpass filter, wrong type of film and, most frequently, filtered lenses and flashes.

A second and often overlooked explanation is simply that there was not sufficient damage to that part of the skin to record any injuries. For example, there will not likely be any injuries recorded in IR photographs of injuries where there was no bleeding or in RUV photographs where there were not sufficient changes in the surface of the injured skin. It is not uncommon to fail to capture images on the first attempt at documentation yet, one or two days later, at a subsequent photographic session, images will appear in the photographs. It is strongly recommended that the injuries be re-photographed over time whenever possible. The lack of images does not represent failure of the techniques, but a simple lack of sufficient injuries to the associated skin for the wavelength of light being used. The forensic photographer is being unrealistic if there is the expectation that injury patterns will be recorded every time an injury is photographed in nonvisible light.

Visible light photographs may yield detail from the injuries for up to about two weeks; images recorded in IR tend to fade more rapidly, usually lasting not more than a week. UV images can be recovered, in certain instances, for longer periods of time, such that the injuries may be recorded for months after the injuries are no longer visible to the unaided eye (2,9). These are representative estimates, not doctrine. If there is any question that the injuries may contain any evidentiary value, attempts should be made to capture the associated detail with photographs, utilizing visible light or nonvisible light or both (see Table 1).

Conclusions

Photographic documentation of injuries in skin as a means of preserving physical evidence associated with crimes is vital in the legal processes associated with the prosecution of such crimes. It is critical that the forensic photographer be capable of properly recording all the detail that exists in the injury. The techniques described herein provide the basics for the photographic documentation of skin injuries for the forensic photographer.

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