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STANDARDS AND PRACTICES FOR BITE MARK PHOTOGRAPHY

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ABSTRACT

In most crimes where bite marks are discovered, photographic accuracy is crucial to the investigative process since in many instances the bite mark(s) may be the only evidence linking a particular suspect to the crime. Therefore, the rationale for employing superior photographic principles is mandatory for the investigation team. This paper will discuss current standards, best practice, and armamentaria for digital photography of bite mark injuries on skin. Full spectrum protocols will be described including Alternate Light Imaging, Reflective Ultra-violet, and Infrared techniques for photo-documentation of images of bite marks and other bruise patterns that have been inflicted on human skin.

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INTRODUCTION

Accurate photographic documentation of a crime scene is a crucial component of any venture into evidence collection, especially when it applies to recording bite marks inflicted on humans during crimes of violence.¹ This exactitude of accurate images is particularly important since the comparative analysis of potential suspects to the bite is entirely dependent on how skillfully the photographic images of the injury are recorded. Historically bite mark photography gained relevance with film-based capture of images, where the film negative was used to enlarge the image to a life-sized printed photograph. An acetate or transparent hollow-volume overlay of the traced incisal edges of the anterior dentition of the suspected biter was then compared by hand to the bruise pattern on the victim.

The same fundamental principles exist today in bite mark analysis. However, since the arrival of digital cameras and computer imaging software, most qualified/knowledgeable odontologists today use digital imaging for both the collection of evidence from the victim, the analysis, and comparison to persons of interest. This paper will focus on the techniques used to properly record accurate images with digital camera systems in the visible and non-visible range of the electromagnetic spectrum of light.

STANDARD TECHNIQUE

Ensuring accuracy during the process of photographing bite mark injuries requires a thorough understanding of the basic principles of image capture, including a familiarization with the camera's features, limitations, and other equipment necessary for the task. Attempting to achieve success without first comprehending the fundamentals of photography is tantamount to playing golf in the dark. Familiarization with the essentials should occur long before the photographer ever finds him/herself employed in a real-time situation so that he/she knows exactly what camera settings, filters, and light sources are appropriate for each different protocol. A *Standard Technique* for crime scene photo-documentation includes proper orientation shots, close-up (macro) photography, correct angulation of the lens of the camera to the plane of injury, and inclusion of a scale with identifiers for each case.

ORIENTATION PHOTOS

Orientation shots are for the purpose of showing the location of the bite mark. These are usually captured from three to five feet from the subject and include enough information in the frame to see exactly where on the body the bite occurred (Fig. 1). Inclusion of a scale is not mandatory; however, it is a good idea to acquire a few images with a scale in place from this distance for data reference which can be included on a label attached to the scale. One recommended

scale that is readily accepted by the forensic scientific community is the ABFO #2 scale available from Lightning Powder Corporation² (Fig. 2). This is an L-shaped scale with two arms perpendicular to each other. It includes millimeter indices, neutral grey color blocks, and perfect circles placed at the ends and intersection of each arm. The inclusion of the scale allows the user to determine photographic distortion if any, the ability to correct it later with imaging software such as Adobe Photoshop®, and facilitates enlargement of the injury to life-sized proportion. Johansen and Bowers described the protocol for image handling in "*Digital Analysis of Bite Mark Evidence*" published in 2000³.

MACROPHOTOGRAPHY

Some basic prerequisites apply when taking close-up images of bite marks. Best practice includes first photographing the bite mark without a scale to demonstrate that there is no part of the injury that is obscured by subsequent images with the scale. The scale should then be placed adjacent to the injury without covering any portion of it. Positioning the scale in the same plane as the injury will provide better focal accuracy. Camera lens positioning in relation to the bite mark should be perpendicular to minimize angular distortion. Off-angle images introduce errors in size and shape of the injury, some of which cannot be corrected during enlargement. One simple technique for determining correct camera position is to place a small mirror over the area to be photographed, and oriented in the same plane as the injury. The photographer should look through the viewfinder of a tripod-mounted camera and be able to see his/her own eye looking back through the lens as it is reflected from the mirror. For bites on curved surfaces where it is difficult to achieve correct angulation of the camera for the entire bite mark, each arch of the bite should be photographed incrementally from the correct angle with the scale appropriately positioned for that arch. It is essential that proper labeling of the case being photographed be included in the images. Usually a sticky label can be attached to one arm of the scale, below the measuring ticks and away from the circular references at the ends of each arm of the scale. The data on the label may include either the case number or name of the victim, agency, date and the photographer's initials or name.

In some circumstances it is also appropriate to repeat the photographic documentation of the bite as it ages, particularly in decedents, since the bruise may become more defined as post-mortem changes occur in the tissue. Examination of the injury over a period of a week or two may prove to be valuable if time permits. Serial photographs should also be labeled in the same fashion for each session.

VISIBLE LIGHT IMAGING

Capturing images utilizing the visible part of the spectrum is the area where most photography is accomplished. In the past, there have been recommendations that bite marks should be photographed in both color and black and white film format due to the ability of the human eye to see differing details between these two modalities. With the advent of digital cameras and phasing out of film-based photography, both formats can be accomplished in one digital photo by opening the digital image in a software program such as Adobe Photoshop® and using the de-saturation feature to allow the viewer to see the differences between the color and monochrome details of the bite mark. Images can be acquired at almost any ISO rating using modern digital cameras that utilize improved chip technology and software. However, with film and some earlier digital cameras, higher ISO ratings (800 – 1600+) have been known to produce more grainy photographs due to the film emulsion qualities, or digital noise that may be generated by the camera's software. One advantage of shooting images at higher ISO ratings is improved depth of field from higher *f*-stops. If flash assisted, exposures from automatic digital settings on the camera will usually be adequate, however during macro photography, the user must frequently override those settings due to overexposure. One must familiarize oneself with the manual settings on the camera to correct for under and overexposed images.

If shooting forensic images, one convenient feature in many digital cameras is the advantage of recording in RAW mode. Although true RAW image files can be modified in software programs such as Adobe Photoshop® to correct for exposure and color balance, the modified image must be saved as a different file format such as J-PEG, TIFF, PDF etc., therefore

preserving the original proprietary RAW image. Images shot in automatic mode usually produce J-PEG type files which are generally fine for showing the location (orientation) of the bite mark(s) in the visible part of the light spectrum but a programmable or manual mode features must be available for the Alternate Light, Ultraviolet and Infrared techniques. This will be discussed later.

A sturdy tripod is part of the required equipment necessary in order to achieve successful image documentation. Tripod mounting of the camera is usually applicable in shooting images out of the visible spectrum. In post-mortem photography a tripod is a useful tool for image composition and accurate focus, although sometimes it is difficult to position the camera directly over a bite mark when the gurney presents a hindrance. When the subject is a wriggling child, the use of a tripod is typically out of the question.

The resolution of images (size of digital file) should be large enough for the user to enlarge the image to life-size proportions at a minimum of 300 dots per inch (DPI) without loss of fine detail. The ability to transfer the image to either a hard drive or directly download it from the camera is also a must. The file size of the images should also be selectable through the camera setup mode, as well as the speed (ISO) during exposures.

Some digital cameras are equipped with a fixed zoom lens capable of macro photography, portrait, and telephoto ranges, while other camera bodies require multiple lenses for different camera-to-subject distances. Cost is always a consideration and recommendations for what type of equipment one should acquire is generally determined by the user's ability to purchase it. This author's recommendation is to find a mid-range "Prosumer" level SLR type 35mm format camera with a fixed zoom lens and the aforementioned capabilities.⁴ A liquid crystal diode (LCD) viewing screen, particularly one that articulates, is a highly desirable feature so that one can immediately see whether or not the correct settings were used for each captured image. Some digital cameras also use the LCD as a preview screen for composing the field of view before actually acquiring the image.

ALTERNATE LIGHT IMAGING: (ALI)

Most digital cameras that are purchased with the intent of taking visible light images will also be capable of capturing images using a forensic light source as long as it has a "manual mode" wherein the user can adjust exposure settings either by changing the aperture of the lens and/or the time of the exposure. The exposure time is electronically determined by the software that drives the system and exposes the image to the electronic sensor inside the camera. That information is then written to the flash card as an electronic file, usually numbered according to the sequence of the images acquired. Another positive feature about many digital cameras is that metadata is also acquired simultaneously with the image. Metadata is a history of hidden information about each captured image that includes what settings were used to acquire the image, usually accessible from the "properties" pull-down menu when the image is right-clicked with a computer mouse. Each image, whether in RAW form, TIFF, or JPEG format has its own metadata. This metadata also typically includes the date the image was acquired or modified, type and size of the file, ISO, exposure duration, and *f*-stop.

There are specialized pieces of equipment one must obtain in order to take alternate light images. First, a forensic light source is necessary for illumination. There are numerous light source manufacturers that can be found on the internet. They range in features from a tunable multi-wavelength emitter, portable or hand-held equipment, or ring lights that emit a discreet frequency of light. For bite mark photography on skin, a 450 nanometer (blue) light is best since research has shown that skin has a peak fluorescence at that frequency⁵. Another requisite is a #15 yellow filter placed in front of the camera lens. The filter blocks the reflected blue light and transmits a lower frequency of light to the sensor, in effect, capturing a fluorescing image of the bruise. Without delving into the theoretical aspects about the bioluminescence of tissue, it can be summarized that the alternate light image shows details of the bruise pattern below the level of the epidermis by enhancing the differences between injured and uninjured tissue. Below the epidermis is where most of the blood and blood pigment components of the bite mark bruise are located. This author has found that slightly underexposing the image during ALI at least one

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or two stops will produce better results than capturing the image at normal or overexposed settings. In post-mortem situations the camera must be tripod-mounted for this protocol since exposure times can vary between $\frac{1}{4}$ second to 1 second intervals at mid-range f - stops. The photographer should first illuminate the bite mark with the forensic light source and set the correct exposure through the camera's metering system. Actual exposure time is dependent upon the ISO speed, strength of the forensic light source, the amount of pigmentation in the skin of the subject, and location of the bite mark. The last important item that must be mentioned when shooting ALI is that it should be done in total darkness, where the only light source illuminating the subject is from the forensic light. Focusing can be done through the yellow filter attached to the lens while overhead lights are on, but turn out all other lights for image acquisition. Figures 3 and 4 illustrate the differences between a bite mark image collected in visible and alternate lighting.

INFRARED PHOTOGRAPHY (IR)

Prior to the introduction of UVIR digital cameras, all images were film based. Special IR film is still available for purchase, however there are specific handling, developing, and focusing requirements that must be employed for successful image capture.

Unfortunately most digital cameras are designed for capturing images using visible light only. Their manufacturing process includes software designed for only the visible part of the light spectrum and a special filter in front of the electronic sensor that blocks the UV and IR ends of the spectrum. Therefore in order to acquire IR images with a digital camera, one must either have a camera that has been produced specifically for UV and IR capture, or modified to accomplish the task. Fujifilm of North America® was the first company to produce a digital camera with these capabilities. Sadly, these cameras are no longer being produced. However, there are a few companies that for a fee will modify some digital cameras for UV and IR shooting.⁶ Many a fine art photographer has modified an older, retired digital camera and resurrected it for use specifically for IR imaging. The same modification allows the forensic photographer to shoot images in infra-red and ultraviolet.

Digital infrared photography can be tricky when it comes to recording bite marks in that one must adjust for a focal shift due to the longer wavelength of light reflecting back to the sensor. Focal shift changes can be eliminated with a quartz lens, a subject that will be discussed in the UV section of this paper. An IR filter must also be placed over the lens so that only the IR part of the spectrum is transmitted through the lens to the sensor. There are several types of IR filters to choose from, however a #87 glass or gelatin filter will suffice for this application. Lighting for IR is generally not an issue, as most ambient or room light will be adequate for exposures. In bite mark photography, the IR range of the spectrum shows the viewer the deepest part of the bruise pattern, well into the dermis and underlying vascular tissue. Results are often mixed, with IR photos showing less detail than ALI and visible techniques. However, one very useful area where IR application outperforms visible light techniques is in tattoo documentation when the original tattoo is either occluded or has faded considerably (Fig. 5, 6). IR also has the ability to "see" through blood (Fig 7, 8).

With practice, the forensic photographer should be able to repeatedly get good results using the IR technique.

REFLECTIVE PHOTOGRAPHY (UVA)

ULTRAVIOLET

Purchasing the necessary UV forensic photography equipment can become quite expensive. In order to have the capability to acquire UV images of bite marks, one needs some very specialized components. The digital camera again must be either modified or designed with UV acquisition in mind. Fuji Corporation's most recently produced version of this type of digital camera was designated the IS Pro (Fig.

9). The software was adapted for UV capability and the blocking filter removed. Currently, there are still a few of these cameras for sale if you can find them, however the glass lens that is sold with them is not ideal for UV transmission. In order to maximize the amount of UV light transmission to the sensor, a silicon-based (quartz) lens should be used. Quartz lenses are available for purchase from UKAoptics⁷ and Coastal Optical Systems.⁸ One other necessity

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for capturing ultraviolet images with a digital camera is the Baader UV filter.⁹ Quartz lenses usually sell for about \$4000 U.S, the filter costing about \$275.00.

As for illumination during UV imaging, the more powerful the light source, the better the results. Adequate lighting requires a flash or strobe source with a high rating value, capable of creating an intense burst of light, usually through a UV filter placed in front of the flash window. Quantum Corporation¹⁰ makes such an item specifically for UV imaging. Some of the more expensive Vivitar[®] strobe units also provide adequate light for this technique. Whichever unit is purchased must be matched to the capabilities of the camera. This means the camera must have compatibility and enough power in the electronics to trigger the flash unit and synchronize its activation simultaneously with the exposure sequence. Ultraviolet images unlike IR and ALI depict the surface disruption of the skin when used for bite mark photography. Professional assistance is highly recommended when assembling the components for all of these three advanced photographic techniques.

PHOTOGRAPHIC EVIDENCE MANAGEMENT

Images collected during crime scene documentation, including bite marks, may become part of the legal system and as such, are subject to chain of evidence rules. The photographer becomes accountable for their possession and/or transfer to other involved participants of the investigation. It is very important to maintain the integrity of those images in their original form, and to document any modifications during their reproduction during analysis. Any steps taken during the collection, management, and file reproduction of images should follow the Imaging Guidelines developed by the Scientific Working Group on Imaging Technologies (SWGIT) found at: <http://www.fdiai.org/images/SWGIT%20guidelines.pdf>

CONCLUSIONS

To summarize, biting injuries are complex and the evidence collection, analysis and interpretation should be handled with caution. Acquiring accurate, reproducible images is just one part of the process – albeit an important

one. It should be stated that not all situations will require all of the previously discussed techniques. There will be instances where one advanced non-visible technique will outperform all others in terms of quality of images gained. Sometimes none of the advanced techniques provide any advantage over the tried and true visible light protocol. With practice, the seasoned forensic photographer will be able to predict which protocol will provide the best results before ever opening the camera case. It must also be said that even if none of the advanced techniques prove useful, it does not mean the entire session is a failure. Frequently the evidentiary value of the bite mark is of such low quality that neither advanced nor visible imaging protocol will be of use to the investigator. Sometimes the best option in those inferior cases is to disregard the bite mark evidence completely and rely on the DNA results instead.

Photography is an important tool of forensic dentistry and the demands on the photographer may be great, especially when the bite mark is the sole evidence tying a suspect to the crime. Patience and preparation in advance will ultimately lead to more successful results, albeit frustrating in many instances. The forensic photographer who develops the skills necessary to record these injuries will make a significant contribution to the case. Documenting bite marks in advanced photographic protocols will remain one of forensic dentistry's greatest challenges.

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FIGURE LEGEND



Fig. 1. Orientation photo giving anatomical location of biting injury

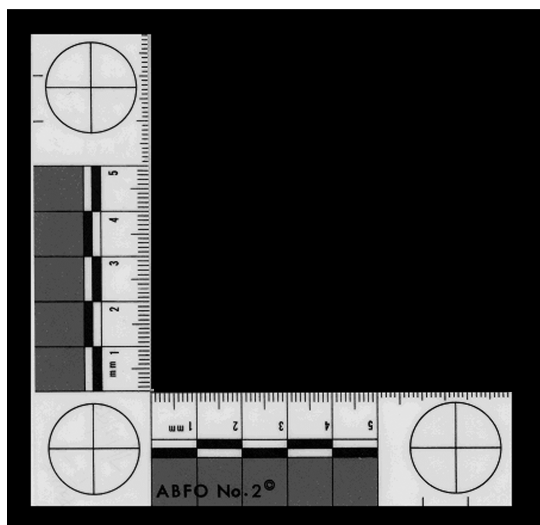


Fig. 2. ABFO #2 scale

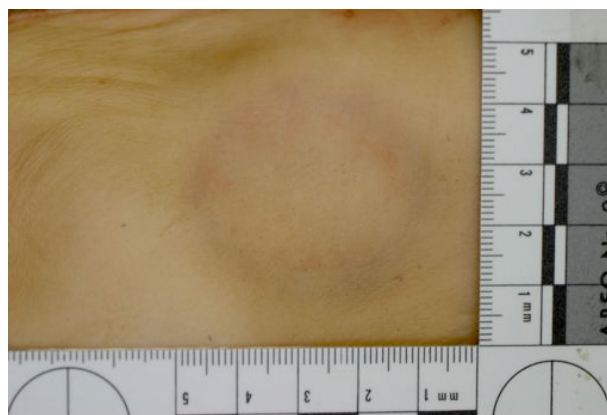


Fig. 3. Visible light image of two-week old bite on arm

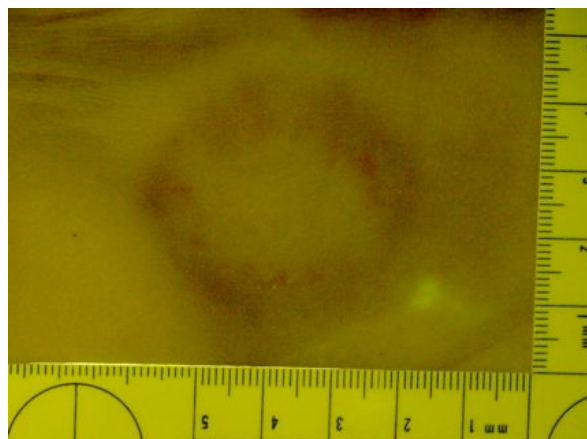


Fig. 4. Alternate light image of same bite as seen in Fig. 5



Fig. 5. Tattoo occluded by hair in scalp of homicide victim



Fig. 7. Facial wounds with blood



Fig. 6. Same tattoo as seen in Figure 9 using Infra-red protocol



Fig. 8. Infra-red image of Fig. 11

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Fig. 9. *Fujifilm ISO Pro UVIR professional grade camera*