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CASE REPORT

PATHOLOGY AND BIOLOGY

William R. Oliver,[1] *M.D., M.S., M.P.A. and Lisa Leone,*[1] *M.A.*

Digital UV/IR Photography for Tattoo Evaluation in Mummified Remains*

ABSTRACT: The presence and location of tattoos can be an important component in the identification of remains in the extended postmortem period if remnants of skin persist. However, when there is significant mummification, visualization of tattoos can be problematic. Multiple methods have been proposed to make tattoos more visible, but all have limitation. In this case report, a mummified body was discovered. The presumptive victim was reported to have a small tattoo on her hand but it was not visible to the naked eye. The hand was photographed using ultraviolet (UV) and infrared (IR) light. A tattoo matching the description was noted in the photographs. In contrast to film-based IR and UV photography, digital UV and IR photography allows rapid visual evaluation of results and optimization of image utility. The ability to quickly modify photographic parameters quickly greatly increases the utility of IR and UV photography in the autopsy suite.

KEYWORDS: forensic science, photography, tattoo, ultraviolet, infrared, mummification

The presence and location of tattoos can be an important component in the identification of remains in the extended postmortem period when remnants of skin persist. However, when there is significant mummification, elucidation of tattoos can be technically difficult because of skin discoloration and dehydration. Many methods have been proposed to increase the visibility of tattoos in the extended postmortem interval, including rehydration, hydrogen peroxide, and exposing subdermal tissue (1,2). All have some, but limited applicability. Rehydration may make the skin more pliable, but not deal with discoloration. Hydrogen peroxide may clean some, but not all, discoloration. Manipulation of friable tissue may distort or destroy a pattern.

The use of ultraviolet (UV) and infrared (IR) photography has been of significant interest in forensic science in general and of cyclical published interest in forensic pathology and odontology (3). A large number of articles were published in the 1990s investigating the use of so-called alternate light methods, including narrow-band illumination, fluorescence, and UV/IR photography for the evaluation of bite marks and trauma (4–7). There has been limited publication in the use of such methods for tattoo evaluation in the extended postmortem interval. One study found utility in evaluating fluorescence of ink using narrow-band illumination. This study noted that IR photographic evaluation, while slightly more useful than hydrogen peroxide, has traditionally been of limited utility because it required photographic skills and was difficult and time-consuming (1). Others have noted that the use of UV photography was difficult because it is impossible to see what is being photographed (7). With the use of film photography, the opportunity for quick feedback and fine-tuning of photographic parameters was not available. The photographs were, literally, taken blind.

[1]Division of Autopsy and Forensic Services, Department of Pathology and Laboratory Medicine, Brody School of Medicine at East Carolina University, 7S10 Brody Medical Sciences Building, Greenville, NC 27858.

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In recent years, relatively affordable cameras sensitive to IR and UV light have been marketed for forensic use. Many low-cost consumer digital cameras are sensitive to the IR or UV spectrum and incorporate blocking filters for standard use. An aftermarket has developed to market these cameras with the filters removed. The availability of these relatively inexpensive cameras has spawned an active hobby market in artistic IR and UV photography (8). In this report, the authors use a commercial forensic camera sensitive in the UV/IR range to visualize a tattoo that was not perceptible in the visible spectrum.

Case Report

The nude body of an adult female was found prone unburied in the woods. A missing person's report had been filed in a nearby city approximately 2 months earlier, and police investigators suspected these were the missing person's remains. At autopsy, the body was largely skeletonized, with mummification of the skin of the back and upper extremities. Anthropological evaluation was consistent with the age, sex, and race of the missing person. Dental evaluation was consistent with the missing person, but was limited because of postmortem loss of teeth, which defied efforts at recovery. By history, the decedent was known to have a small tattoo of a heart on the back of her left hand, though the exact location was uncertain.

Examination of the left hand revealed marked mummification, but the skin of the dorsal surface of the hand was intact. Visual examination of the hand did not reveal any evidence of a tattoo. Attempts to increase visualization by rehydration and washing were unsuccessful. Hydrogen peroxide was not applied because none was on hand.

Materials and Methods

The hand was photographed using a Fujifilm IS Pro digital camera (Valhalla, NY) with Coastal Optics 60 mm 1:4 UV-VIS-IR

Apo Macro Lens (Jenoptik Optical Systems, Jupiter, FL). UV illumination was achieved using a Raytech Raytector Portable Lamp (10-062 R5-FLS-2; Middletown, CT). IR illumination was performed by use of a simple heat lamp (GE IR heat lamp, 250 W; General Electric, Erie, PA).

UV photography was performed in a dark room without the use of filters. The camera was stabilized by placement on a tripod. The camera was set to manual mode to allow setting of f-stop, shutter speed, and ISO; initial estimates of appropriate exposure were achieved using the internal metering system of the camera. As the initial estimate required maximum opening of the aperture, subsequent tuning of exposure was performed primarily by incrementally changing shutter speed after visually evaluating the results of each exposure. The final optimal exposure was f-stop 4, shutter speed 30 sec, ISO 200.

IR photography was performed in room light using an IR longpass filter (#904, step at *c.* 800 nm; Peca Products, Beloit, WI). Again, initial estimates used the internal metering of the camera, with the camera on manual mode and incremental changes using the immediate feedback of the previous image. The final optimal exposure was f-stop 4, shutter speed 1/60 sec, ISO 200. After the initial optimization of exposures, a full survey of the remaining intact skin was performed.

Results

Under both UV and IR photography, a small heart-shaped tattoo was noted between the metacarpals of the thumb and index finger. The detail of the tattoo was visually similar in both spectra, though the UV provided a more subjectively realistic appearance of the texture of the skin. An image of the hand using the visible spectrum is shown in Fig. 1. The IR image is shown in Fig. 2. The UV image is shown in Fig. 3.

The initial setup (placing camera on tripod, sealing the door of the room against light, etc.) and initial optimization of exposure for photography of the hand took *c.* 15 min. After initial optimization, a full survey of the posterior surface of the body (no skin remained on the anterior surface) took approximately 10 min. No other tattoos were noted. By history, the decedent had two other tattoos, but both were in areas of depredation and were not available for photographic analysis.

FIG. 1—*Visible light image of the hand.*

FIG. 2—*Infrared image of hand.*

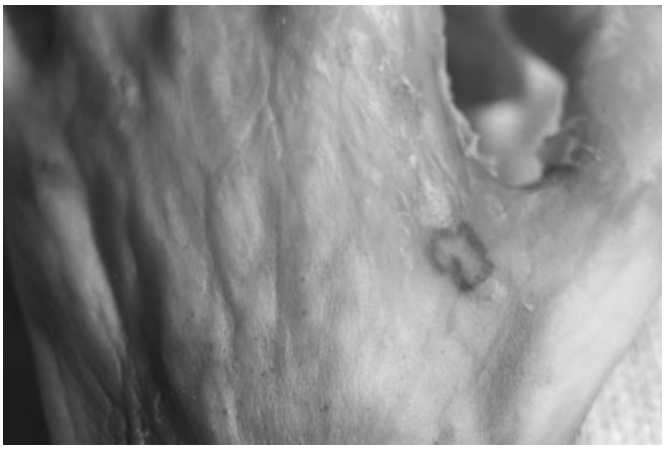

FIG. 3—*Ultraviolet image of the hand.*

Discussion

This case demonstrates that at least with some inks, tattoos are clearly discernible using UV and IR photography. The almost immediate feedback provided by digital photography allowed evaluation of each image as it was taken to allow modification of exposure.

Only one case is described in this case report. The shape and irregularity of this tattoo suggest that this may not be a professional tattoo and may use any of a number of inks. It has been demonstrated that different inks can have very different UV and IR absorption properties (9,10). This has been of great use in the questioned document field, but can be a hindrance in the evaluation of tattoos. Previous attempts to use UV and IR to evaluate tissues in this manner were limited by the fact that these results are not visible to the naked eye and can only be seen in the photographic results. This has led some authors to focus on ink fluorescence, which is often visible. However, in one study, only three of 12 commercial inks tested were noted to fluoresce (1). More recently, tattoo inks that are visible only under near UV light are becoming more popular (11).

Traditionally, forensic photography using alternate light sources has focused on the use of narrow-band illumination with tunable or filtered sources of illumination. Because such light sources are often expensive, as a practical matter the authors decided to take

the opposite approach for absorption photography. We apply inexpensive and rather broad illumination and use filters on the camera for bandwidth limitation. Inexpensive commercial UV sources commonly illuminate preferentially in relatively narrow spectra, but even such inefficient sources can provide significant illumination in wavelengths of less emission using very long exposures.

The development of relatively inexpensive commercial digital UV/IR cameras allows the immediate evaluation and optimization of UV/IR photographs of tattoos in the extended postmortem interval. This, in turn, may make a previously rather esoteric method practical for use in a forensic office.

In this case report, the initial setup and optimization took about 25 min, and an entire body survey took an additional 10 min. Much of that time consisted of sealing the room from light and positioning the camera for UV photography. Light protection could be streamlined by installation of adequate shades over windows and flaps over door edges. The authors estimate that integration of routine UV photography for decomposed remains would add *c.* 10–20 min to autopsy time. IR photography did not require light shielding and involved relatively fast shutter speeds that did not require tripod stabilization. Thus, IR photography alone would add relatively little time to an autopsy and could easily be made routine, adding 5–10 min, depending on how photography is staffed in the autopsy suite.

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Additional information and reprint requests:
William R. Oliver, M.D., M.S., M.P.A.
Division of Autopsy and Forensic Pathology
Department of Pathology and Laboratory Medicine
Brody School of Medicine at East Carolina University
7S10 Brody Medical Sciences Building
Greenville, NC 27858
E-mail: billo@billoblog.com