TECHNICAL NOTE

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Use of an Alternate Light Source for Tattoo Recognition in the Extended Postmortem Interval*

REFERENCE: Bennett JL, Rockhold LA. Use of an alternate light source for tattoo recognition in the extended postmortem interval. J Forensic Sci 1999;44(1):182–184.

ABSTRACT: With increasing frequency the art of tattooing is permeating Western culture. In the United States, this rise in popularity has been accompanied by the adoption of more personalized and intricate designs; hence tattoos are becoming increasingly useful as tools for personal identification in medicolegal settings. Although pathological examinations indicate tattoos become more distinct given removal, or slippage, of the epidermal layer and/or following saturation with a 3% hydrogen peroxide solution, information on the degenerative change of tattoos during the postmortem interval has not been presented. This technical note provides an assessment of tattoo enhancement methods and presents a new method to enable better recognition of tattoos during the postmortem interval. Our results indicate certain tattoos remain visible and identifiable given extensive soft tissue decomposition. The use of an alternative light source proved most useful in illuminating tattoo inks throughout decomposition.

KEYWORDS: forensic science, forensic pathology, postmortem interval, tattoos, identification, alternative light source

As a form of body ornamentation and decoration the process of injecting dye into the skin plays an important cultural role in many societies. Tattoos (from the Tahitian *tatau,* to mark) are believed to have ritualistic foundations among numerous groups, possessing medicinal, therapeutic and magical powers. In addition to such curative properties, the art of permanently painting the body has been associated with religious dedication, maturation and puberty rites (1,2). Body markings have also been applied as a form of identification or punishment, and among Russian prisoners small tattoos have reportedly been used as a mode of communication (3). Tattooing has also been used for medical and reconstructive purposes to obscure pigment defects such as port-wine stains and vitiligo (4). However, throughout much of the 20th century, sociologically, tattoos have been associated with group membership, including the military, motorcyclists, fraternities and, more recently, gangs. Although once associated primarily with lower socioeconomic status, this form of self-expression has seen resurgence in recent years and is increasingly becoming a sign of rebellion among the middle class. In the United States, this rise in popularity has been accompanied by the development of unique and intricate designs (5). Given that tattoos represent one of the most personal and permanent forms of body modification, they are becoming increasingly useful as tools for personal identification in medicolegal settings.

The appearance of tattoos, both at autopsy and in the immediate postmortem period, have been reported and described by medical examiners. In addition, methods to improve the recognition of artistic details have been presented (6–10). Although conclusive identification of individuals has been made based upon tattoos (see Ref 9), little has been proposed concerning the degenerative changes which occur following death. Owing to the increasing potential of tattoos for identification purposes, investigation of tattoo visibility during the postmortem period can benefit the medicolegal community. This technical note describes the patterns and trends that characterize tattoo degeneration, evaluates current methods of tattoo enhancement, and presents a new technique to facilitate recognition of tattoos during the postmortem interval.

Numerous techniques and materials have been used to inject ink or dye into human skin. In most instances, the appearance of the tattoo reflects the method by which it was applied (2,5,11). Tattoos are generated by the repeated action of a needle or needles that puncture the skin and deposit a small portion of ink/dye into the dermal layer. Most professional tattoo artists in the United States use an electronic tattoo machine consisting of a base, which comprises the bulk of the machine, coils, a steel return spring, and a sanitary tube. The coils are connected to a steel return spring and bar and are powered by a 6 to 12 V current. The flowing current causes the coils to become magnetic, attracting the bar and extending the steel spring. As the bar comes into contact with the coils the circuit breaks and the demagnetized spring and bar return to their original positions. This effectively vibrates the bar and the mounted needle up and down hundreds of times per minute (2) (plus personal communication, D. Hill, 1997). Multiple needles and varied needle configurations are used to generate different line thicknesses for shading and detail.

Ink can be injected into the skin without the use of a mechanical device. A sharp instrument is used to puncture the surface of the skin on which the design has been drawn. This action forces the ink substance into the dermal layer. A needle wrapped with thread that has been dipped in ink can be pushed into the skin to produce

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* Presented at the 49th Annual Meeting. American Academy of Forensic Sciences, New York, NY, Feb. 1997.

Received 5 Feb. 1998; and in revised form 2 June 1998; accepted 8 June 1998.

a tattoo. These tattoos, often referred to as ''homemade,'' are less uniform and colors are poorly defined because the ink is injected deeper and less evenly into the skin than when using an electronic device. Tattoos produced without the use of a mechanical device are traditionally generated with common pen ink or India ink. These types of puncture tattoos, which involve the injection of insoluble pigments, are believed to have been practiced as early as 10 000 years BP (see Ref 12).

In addition to inks, pigments utilized in puncture tattoos have reportedly consisted of a variety of insoluble substances including naturally occurring red and black pigments, carbon and soot dissolved in water, milk or kerosene (1). Inks used in electronic tattoo machines reportedly contain a combination of proteins, pigments, and metallic salts in a suspension. The specific qualities and quantities of these substances are unknown, in part due to the fact that color additives in tattoo inks are not subject to scrutiny by the Food and Drug Administration (13,14). Although ink producers claim inks are not harmful, ingredient lists are regarded as trade secrets and are not subject to public disclosure (personal communication, D. Hill, 1997).

Materials and Methods

To investigate the degeneration of tattoos and to test current methods of enhancement, the following study was conducted at the William M. Bass Anthropological Research Facility in Knoxville, TN. A total of eight tattoos on four subjects were evaluated during the late spring and early summer. Observed tattoos were located on numerous body surfaces, including the chest, forearm, upper arm and back. Overall dimensions range from 3 cm in diameter to over 15 cm in length. The tattoos in this investigation consisted of many colors and represented different levels of detail and application techniques, ranging from single color to intricate multicolor designs with complex shading and line variation.

Throughout the study, tattooed areas were exposed to open air and natural environmental conditions. Specimens were observed and assessed at 48 h intervals. Degenerative changes were evaluated in terms of the four stages of decomposition proposed by Reed (15). Reed designated four stages: fresh, bloating, decay and dry, herein referred to as stages 1, 2, 3, and 4, respectively. These stages are demarcated by visible changes in the appearance and condition of the tissues, and are not defined by specific time periods.

In addition, various methods of tattoo enhancement were evaluated during progressive stages of decomposition. Specimens were rinsed with a 3% hydrogen peroxide solution and photographed using infrared techniques (7,10). Furthermore, at the suggestion of Arthur Bohanan of the Knoxville Police Department, tattoos were viewed using an alternate light source. This portable device, owned by many law enforcement agencies, provides access to various wavelengths in the visible light spectrum. The use of different pass band filters in combination with colored barriers will cause particular substances to emit light, while others will absorb light (16). Specimens were inspected using a variety of filters and color viewing barriers. Additionally, tattoos (both professionally and nonprofessionally applied) on living subjects were investigated using the alternate light source to test the applicability of the technique.

Results

A similar pattern of sequence and degeneration was noted on all tattoos in this study. The immediate postmortem period, stage 1 (ranging from 1 to 10 days), was marked by no change in tattoo appearance. During the initial phase of stage 2 decomposition, a slight darkening of the skin was witnessed and resulted in a decrease in tattoo visibility. This was followed by sloughage of the epidermal layer which resulted in enhanced brightness of colors and increased definition of lines. Following sloughage, marked changes were witnessed as the skin developed an increasingly waxy texture. Stage 3 decomposition was characterized by an increase in skin discoloration. The discoloration and waxy surface further decreased the visibility of tattoos. Gradually, the skin dehydrated and developed a leathery surface. During this phase, tattoos exhibited a leathery appearance and the margins demonstrated fine striations and muted colors. The decrease in visibility during this period is likely due to an increasing discoloration of the skin. Further decomposition, stage 4, resulted in continued obliteration of the tattoo design. Even given extensive decomposition, a slight persistence of color against darkened and desiccated tissue was observed. However, in several instances recognition of tattoos during this phase of decomposition was only possible due to prior knowledge of the tattoo location. Near complete obliteration of the tattoo occurred just prior to desiccation of the tissue, at which point tattoo visibility was dependent on the defining characteristics of certain colored inks (e.g., brightness and non-natural color).

Techniques of tattoo enhancement were investigated at various periods during the extended postmortem interval. Removal of the epidermal layers, by rubbing with a dry cloth, proved useful for tattoo enhancement during early stages of decomposition (i.e., prior to skin desiccation). This brightened the appearance and permitted greater recognition of tattoo details. However, this technique is only useful during the primary stage of decay. The application of a 3% hydrogen peroxide wash (10) was somewhat useful during the early stages of decay. Immediately following the peroxide wash, the skin appeared slightly bleached and tattoo detail was marginally enhanced. Infrared photography (7), though slightly more useful than hydrogen peroxide, required photographic skills and was difficult and time consuming. Peroxide wash and infrared photography somewhat clarify the obscured appearance of tattoos during early and middle stages of decomposition; however, they fail to improve recognition during advanced stages. Moreover, these methods of enhancement rely upon knowledge of the occurrence and location of tattoos.

The application of an alternative light source proved most useful for tattoo enhancement and recognition using a 450 nm band pass filter and an amber-colored barrier. This combination caused certain inks to fluoresce while others absorbed light. This simple method, whereby certain inks appear to glow, proved useful during all stages of decomposition. Tattoos on living subjects exhibited the same qualities, with certain inks appearing fluorescent under the light.

Not all colored inks fluoresce when illuminated by the alternative light source. Given that tattoo inks are not federally regulated, it is not currently possible to state which inks will fluoresce. During the course of our study, we tested a range of inks from a single retail source and found that 3 out of 12 fluoresced when viewed under the alternative light source using the filter and barrier. In addition, standard India ink, used in a homemade tattoo on a living subject, did not fluoresce when viewed with the light source. However, this ink did absorb light, resulting in a darkening of these features of the tattoo, which served to improve the appearance quality of the image.

The alternative light source provides an effective way to assess an individual for the presence of tattoos. This method is especially useful during the extended postmortem interval when the application of current techniques of enhancement are not successful. Several tattoos in our study were not readily recognizable prior to application of the alternative light source. The light improved the visible detail of much of the tattoo and facilitated recognition of the image. The alternative light source technique illuminates details, yet provides a simple and accelerated method for assessment of the entire body, especially crucial if the existence and placement of tattoos are unknown.

Discussion and Conclusion

Clearly, degenerative changes to tattoos are dictated by the decomposition of the soft tissue. Our observations point to the longevity of certain tattoo inks in the postmortem interval. Although tattoos may not be readily recognizable given the discoloration of external tissue that occurs during decomposition, the application of an alternative light source to desiccated and decomposed tissue permits recognition of certain tattoos in the extended postmortem period. This technique can potentially facilitate positive identification as it illustrates fine detail and enables a simple and accurate method for assessment of the entire body. The alternative light source, which causes certain inks to fluoresce, is a useful method for tattoo enhancement, thereby improving the ability to use tattoos for establishing identification.

Acknowledgments

We would like to thank Arthur Bohanan of the Knoxville Police Department for providing us with insight and use of an alternative light source. Special thanks to Dusty Hill of Biotech Tattoo, who generously told us everything we needed to know about tattoos. We particularly appreciate everyone who kindly bared their skin.

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