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Approaches for the Detection of Latent Fingermarks on Deceased Human Bodies

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Abstract

Latent fingermarks are produced when there is contact between the friction ridges of the thick skin and a particular handled surface. This type of evidence is frequently developed at crime scenes, but their detection on human skin, a complex type of surface, has posed a challenge to the forensic science community. A thorough scientific literature review on this topic was conducted. Experimental studies have evaluated the effectiveness of different techniques such as direct transfer method, powder dusting, and chemical techniques, including the application of cyanoacrylate fuming, iodine vapor, and ruthenium tetroxide. Also, a few case reports provided information of such approaches in real case scenarios. Moreover, techniques for detecting blood-contaminated fingermarks on human skin were evaluated. However, the recommendation of a technique with effectiveness to obtain fingermarks with sufficient ridge detail for identification purposes has not yet been achieved. Different factors that may influence experimental results are presented.

Keywords: Latent Fingermarks; Friction Ridge Evidence; Postmortem; Human Skin; Cadaver; Homicide

Introduction

Latent fingermarks are formed from the deposition of secretions and contaminants present in the friction ridge skin onto a substrate [1]. As the morphology of the friction ridges is unique to everyone, experts in the fingerprint identification field use a comparative examination to verify the morphological compatibility between minutiae from a latent fingermark evidence and a known source fingerprint, with the aim of providing technical support for criminal investigations [2]. A wide range of techniques may be applied for the detection of latent fingermarks on surfaces of interest at the crime scene. However, depending on the circumstances of the criminal event and on the type of surface (e.g., porous, semiporous, or nonporous), choosing the ideal technique or sequence of techniques may be challenging.

The skin is a complex surface consisting in a multi-layered organ that acts as a crucial mechanical barrier between the organism and its external environment, enabling temperature regulation, and preventing dehydration [3]. It can be categorized as either thin or thick based on their location, comprising two essential layers of varying thickness: the inner dermis and the outermost epidermis. Thick skin is predominantly present on the volar regions, while thin skin covers the rest of the body where hair follicles are present [4]. Postmortem degradation of skin structures induces modifications in its morphology and histology, and the decomposition of eccrine and sebaceous gland structures, being directly impacted by environmental factors [5].

The detection of latent fingermarks on the skin of deceased victims has the potential to provide crucial evidence in criminal investigations. However, a constrained amount of research has examined techniques relevant for this application. So far, a general agreement concerning this matter has not been achieved for forensic practice. The present study aimed to evaluate the available scientific literature in order to establish guidelines for the detection of latent fingermarks on the skin of deceased human bodies.

Discussion

Detecting latent fingermarks on human skin poses a challenge due to the similarity between the compounds of the latent fingermark residue and those found on the skin surface. The success of this endeavor is affected by variables related to skin as a deposition surface. As described by Sampson and Sampson [6], temperature, humidity, and skin conditions have been identified as critical factors. According to the authors, an ambient relative humidity of 40-60% and temperature of 20-

25°C are considered ideal for developing latent fingermarks on human skin. In addition, other studies have argued that there should be a match between the room and the body temperatures for best results [6,7].

The Home Office Fingerprint Visualizations Manual - FVM [8] empathizes the continuity of the sweat excretion for some minutes after death, hindering the differentiation between secretions from the deceased skin and those transferred during contact from the thick skin from another individual. The FVM states that the presence of hair on the skin surface and its propensity to undergo deformation upon contact also reduces the likelihood of producing identifiable friction ridge detail. Smoother, hairless regions of the body touched after death are considered the most promising sites for the recovery of this type of evidence, although the probability of successful in latent fingermark development remains very low. According to the scientific literature available, both physical and chemical techniques have been explored for the detection of latent fingermarks on this context (Table 1).

When considering the application of powders on human skin, it is recommended to utilize black magnetic powder for dusting procedures on body regions such as shin, ankle, forearm, and feet of deceased individuals [9-11], with the possibility of also using moldable materials like Isomark® for lifting the marks [10]. The effectiveness of the powdering procedure is contingent upon the time interval between the fingermark deposition and the application of the developing technique, with shorter intervals leading to higher probability of developing fingermarks. However, it must be reinforced that despite these considerations, the probability of recovering latent fingermarks with sufficient quality for identification through powdering procedures remains relatively low, at approximately 10% [10,11].

Another physical procedure that should be noted is the direct transfer method. The benefit of utilizing non-toxic materials for direct transfer when collecting latent fingermarks from the dead skin should be considered since posterior forensic toxicological examination may be recommended in the specific case. Following trace collection, the transfer material can be processed in laboratory to unveil fingermarks with other techniques. However, despite the application of direct transfer techniques to human skin, their effectiveness in deceased human bodies remains under investigation [6,12]. Besides other materials, thermal paper was used for retrieving latent fingermarks from the wrist, neck, and forehead of two cadavers, and was posterior treated with a ninhydrin derivate, obtaining a 66% rate of suitable fingermark development [12].

The application of cyanoacrylate (CA) fuming has offered a certain degree of effectiveness in detecting latent fingermarks on human skin [9,13-15], and have been successfully applied in real case scenarios [16,17]. However, condensation produced on the skin of refrigerated cadavers can compromise the detection of the present fingermarks [7]. Improvised chambers were used for the CA processing of the skin, including a plastic tent over the body at the crime scene obtaining relevant evidence for criminal investigations [16,17]. Researchers have also used a casket air tray [13] and a plastic tent to fit the upper and lower limbs [9,15] for CA treatment of the skin. Another study applied CA directly on a dead skin using a neutral filter paper [14]. Despite significant research efforts, the results showed variable effectiveness and were insufficient to support a strong recommendation of the technique for detecting latent fingermarks on human skin.

Table 1: Summary of the main findings available in the literature regarding techniques for developing latent fingermarks on the skin of cadavers and their effectiveness.

Technique	Deposition Surface	Results: Effectiveness
Magnetic Black Powder	Wrist, neck [7], forearm, lower leg, and foot [10]	Identifiable fingermarks: 12% [10]; ?[7]
Swedish Black Powder	Wrist, neck [7], chest, legs, ankle [11], forearm, lower leg, and foot [10]	Identifiable fingermarks: 8% [11]; 6% [10]; ? [7]
Magnetic Silver Powder	Wrist and neck	No fingermark was detected [7]
Silver Special	Wrist and neck	No fingermark detected [7]
Thermal Paper + ThermaNin	Wrist, neck and forehead	Identifiable fingermarks: 66% (up to 5h) [12]
CA fuming + Magnetic Powder and Rhodamine 6G	Not specified	Fingermarks detected, but affected by skin moisture?[13]
CA fuming + Europium dye	Not specified	Fingermarks detected upon exposure to UV light?[15] *
CA + Neutral filter paper	Not specified	Identifiable fingermarks: <90%* [14]
CA fuming + Magnetic Powder	Impressions produced on the neck and wrist of cadavers. The method was also employed in real-life cases.	Identifiable palmprint and footwear impression detected [16, 17] No fingermark detected due to skin moisture [7]

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Iodine Fuming** + Silver plate	Thighs	Identifiable fingermarks detected: 31% (after 10 min) and 2% (after 15 min) [18]
Iodine Fuming** + α-naphthoflavone**	Lower limbs	Identifiable fingermarks: ?[9]
RTX**	Wrist and neck	Identifiable fingermarks: < 90% [7]; ? [9]

*Information on the production of fingermark samples not presented.

**flammability or toxicity concerns.

In addition to chemical methods, two published articles have investigated the potential use of Ruthenium tetroxide (RTX) for the detection of latent fingermarks on the skin of dead human bodies [8,9]. The results of these studies suggest that RTX is a suitable chemical for developing this type of evidence with adequate quality for identification, as demonstrated by Trapecar & Balazic [7]. The authors achieved a 90% rate when applying RTX directly on the human skin. Regardless these positive findings, the application of RTX is not currently recommended due to the limited number of experimental studies and the acute toxicity that may harm forensic examiners [8]. Iodine is a common chemical compound utilized for detecting latent fingermarks on porous and semi-porous surfaces, which was also indicated for detecting impressions on the skin of cadavers [9,18]. The technique showed remarkable decrease in effectiveness as a function of time since deposition: after 15 min, only 2% of the impressions were detectable [18]. Wilkinson et al. [9] examined the employment of iodine vapor with α-naphthoflavone-based fixative solution to produce more stable developed marks. However, Bleay et al. [19] pointed out that this fixative solution is highly flammable and not recommended for forensic routines. Non-flammable alternative fixative formulations have been suggested, but they have not yet been tested on human skin (Table 1).

Detecting patent fingermarks, which are visible to the naked eye, should also be considered crucial in criminal investigations, particularly at violent crime scenes. Petretei & Angyal [20] made some effort in detecting experimentally produced fingermarks contaminated with blood on the skin of cadavers. The authors compared the utilization of Amido Black, Gentian Violet, and Acid Fuchsin for the enhancement of the samples. Treatment with Amido Black and Acid Fuchsin resulted in better development in unrefrigerated bodies, generating sufficient ridge detail for an identification. Another experiment involved the application of Acid Fuchsin in fingermark samples contaminated with varying amounts of blood produced on the lower limbs of the cadaver, followed by refrigeration for 72 hours before treatment. Some enhancements were obtained for impressions containing smaller amounts of blood but insufficient for identification. In a third experiment, the same method was applied to eight cadavers, achieving 28% of enhanced fingermarks with sufficient quality for identifications.

In the case report published by Lawley [21], blood stains were found on the ankle, legs, wrists, and hands of a stabbed corpse. The body was maintained in a 4°C cold storage room and subsequently exposed to room temperature for 2 hours prior to examination. Amido Black was applied for the detection of a fingermark on the inner surface of the right thigh of the victim, but with insufficient quality for an identification. According to the author, the cold storage maintenance may have influenced the results.

Conclusion

Over the past few decades, various techniques have been suggested for the detection of latent fingermarks on the skin of deceased individuals. Although there is no agreement on the optimal method for this purpose, certain factors certain factors are crucial to preserve fingermark evidence on the skin after death. It should be noted that the time since death is a major factor, with better perspectives in recent death cases. Also, implementing strategies for non-contact drying of refrigerated bodies before processing could be crucial, particularly due to condensation on the skin surface. In cases where investigation require latent fingermark evidence from a dead body, examination at the crime scene would be considered ideal. However, if it is not feasible, caution must be exercised in handling the corpse and in the transportation, refrigeration, and preservation of specific body parts, such as wrists, shins, ankles, neck, among others.

Although positive identification has not been obtained in real cases, the efforts to develop fingermark evidence on the skin of deceased individuals at crime scenes [16,17] or in examination rooms [21] have highlighted the necessity for strategies that improve the effectiveness of the existing methods. In this context, the effect of biases in research should be taken into account such as the production of latent fingermarks under optimal conditions with excessive sebaceous content instead of 'natural' fingermarks; the previous selection of body regions with a higher probability of producing high-quality fingermarks; knowledge of the locations where the samples were produced prior to the development procedures; a very short or unrealistic time lapse. Only part of the literature presented quantitative data on the effectiveness of the techniques, even when detection of identifiable fingermarks was achieved.

Conflict of Interest

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