Methods to Enhance and Preserve Blood Impressions from the Skin of Decedents During the Early Stages of Decomposition

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Introduction

Blood and other proteinaceous impression evidence have great value in criminal investigations and can be present on human skin due to the nature of contact between people during violent physical encounters, such as bloody fingermarks around the neck of a choked victim or post-mortem activities in relation to moving or handling a decedent. The constant substrate involved in the interaction between people during the commission of violent crimes is human skin. However, skin is one of the least studied substrates in the impression discipline.

This applied research project explored the enhancement and recovery of blood impressions from decedent skin during the early stages of decomposition. A comparative analysis was conducted between two known dye stains: Amido Black and Hungarian Red, and Zar-Pro™ Fluorescent Lifters. Amido Black is a commonly utilized chemical enhancement method for research trials on skin [1, 3, 4, 5, 10, 11, 13, 14, 15] and it has been used on decedent skin in casework [4, 7, 9, 10, 11]. Hungarian Red has also been utilized to enhance blood impressions on human skin [3] and has been recognized as a more effective method over Amido Black [12, 13], and when enhanced impression are lifted onto BVDA Gellifters®, the impressions have fluorescent properties [5, 12, 16] to improve visualization. Zar-Pro™ Fluorescent Lifters are a fairly novel enhancement method used to effectively lift, enhance, and preserve blood [6, 7, 8, 17, 18, 19, 20, 21], semen [20, 21], and some saliva impressions from various substrates [20, 21]. Proteinaceous blood and semen impressions are long lasting and have been recovered from substrates even after being aged in situ for one-year [20, 21]. Zar-Pro™ Fluorescent Lifters have been used to effectively recover latent blood impressions after remaining in situ for five days on living human skin [21].

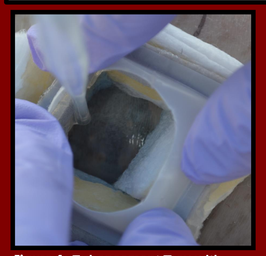

Figure 1: Enhancement Tray with Amido Black dye stain

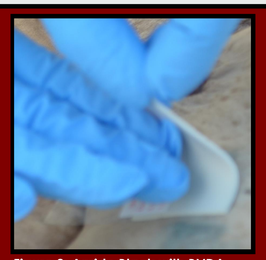

Figure 2: Amido Black with BVDA Gellifter®

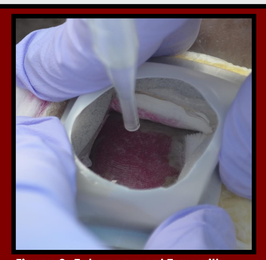

Figure 3: Enhancement Tray with Hungarian Red dye stain

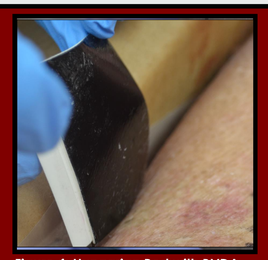

Figure 4: Hungarian Red with BVDA Gellifter®

Figure 5: Zar-Pro™ Fluorescent Lifter

Materials and Methods

Decedents (donors)

This study involved the use of human remains, specifically the skin of deceased human body donors, as a substrate for the fingerprint impressions that are the focus of the research. Two human donors were obtained through the FROST willed body program at Northern Michigan University. The donors were placed on their back (supine position) for the deposition of blood impressions. After the deposition of the impressions onto the skin, the decedents were moved to an open field area where they were placed unclothed in the supine position at a pre-determined site to decompose. A protective cage was placed over the decedents to prevent against large scavengers and a canopy was placed over the caged areas to buffer against direct rainfall. This research is exempt from IRB research as the human subjects are deceased, thus, they do not qualify as human subjects and the donors themselves are not the focus of this research. Madonna University Institutional Review Board reviewed the research project to determine exemption status from Federal Policy for the Protection of Human Subjects of the United States Government. The FROST facilities employ site-specific, proprietary tracking systems for their donors, which are and will remain unknown to all other participants in this study.

Optimal deposition parameters and controlling for deposition variables

The blood used in this study was pre-screened research quality human blood (Innovative Research) stored and refrigerated between uses in pre-aliquoted tubes at 4°C (39.2°F). Before impression depositions, the blood was warmed to 37°C (98.6°F), the average core body temperature, using a mini dry bath and then vortexed to mix the contents. Three trained research assistants deposited optimal quality impressions onto the decedent skin. Prior to the trials, decedent bodies were frozen and then refrigerated with the decedent's body temperatures ranging from 12.8-15.6°C (55-60°F) during depositions. The warmed blood was pipetted directly onto the impression surface (depositor's thumbs) and evenly dispersed to lightly coat the entire surface area. The surface area of the depositor's thumbs ranged from 0.74 to 0.91 in^2. Thumbprints were made with 13-16µL of blood, depending on the depositor's calculated surface area [21]. During the 30 second pre-deposition waiting interval, depositor's thumbs were held horizontally in anatomical position, then applied to the skin using 8-10 lbs of pressure for an 8-10 seconds deposition pressure interval, which is the time that the depositor's thumb remains in contact with the skin while depositing the impression. Impressions were deposited in five pre-determined body locations (neck/upper chest, left and right arms, and left and right legs) by all three depositors to ensure equal variation within the deposited samples. The area of the deposited impressions were then marked with a permanent marker for ease of locating impressions that may not be readily visible throughout the trials. Fingerprints are considered personal identifying information, so the depositor's fingerprint samples were collected with the informed consent of the individuals involved in this research study and in accordance with the institutional standards.

Deposition parameters for optimal-quality blood impressions were set for the decedent skin during the study design phase. Reproducibility of impressions are difficult, making the optimization of deposition parameters essential to help create consistent and comparable impressions for analysis in research trials [21]. Optimal quality impressions with visible proteinaceous material and visible ridge detail, including the overall impression pattern, ridge paths and deviations, such as dots, ridge endings, and bifurcations were deposited on the decedent skin. Using optimal quality impressions in research allows for interpretation of the variables associated with impression degradation and not the numerous variables associated with the deposition of the impression [21].

Impression deposition and recovery from decedents

A total of 90 impressions were deposited on two decedent donors (D1 and D2) resulting in 180 impressions to be recovered throughout five days. The impressions were placed on the neck/upper chest area (LNK), right arm (LRA), left arm (LLA), right leg (LRL), and left leg (LLL). The decedents were then place outdoors at the FROST facility to decompose. The blood impressions were enhanced and lifted using: Amido Black with BVDA Gellifters® (EA), Hungarian Red with BVDA Gellifters® (EB), and Zar-Pro™ Fluorescent Lifters (EC) at the one-hour (BC1-quality control sample), one-day (B01), two-day (B02), three-day (B03), four-day (B04), and five-day (B05) intervals. Non-impression controls were also collected using Zar-Pro™ Lifters (ZP) and white and black BVDA Gellifters® (GL) from the forehead (LFH) of each decedent at the one-hour (NC1), one-day (N01), two-day (N02), three-day (N03), and five-day (N05) interval to determine whether the donor skin has inherent fluorescent properties as a result of decomposition.

Enhancement Methods

The protein dye stains: Hungarian Red and Amido Black, and Zar-Pro™ Fluorescent Lifters were selected for use in these research trials due to enhancement effectiveness, affordability, and the fact that they are easy and safe for crime scene use. Amido Black (TriTech Forensics) and Hungarian Red (TriTech Forensics) were utilized in the trials. The pre-made dye stains have fixative in the solution, which does not require any additional fixative for use in this study. The stains were applied directly to the impression area using a disposable pipette with 2mL for Amido Black and 1.5mL for Hungarian Red, and then rinsed with de-staining solution using 2mL for Amido Black and 1.5mL for Hungarian Red. A plastic enhancement tray was designed for the application of the dye stains for this project to prevent staining outside of the impression area (Figures 1 and 3). After staining, the enhanced impressions were photographed in situ and then lifted from the substrate using white BVDA Gellifters® for Amido Black, and black BVDA Gellifters® for Hungarian Red. The colors were selected to improve visualization of impression details and to preserve the impression for subsequent analysis (Figures 2 and 4). Unlike the dye stains, Zar-Pro™ Fluorescent Lifters (TriTech Forensics) do not require a fixative. The Lifters were activated with Zar-Pro™ Activator (TriTech Forensics) and then applied directly to the impression (Figure 3), lifting the impression onto the white lifter for visualization and preservation for subsequent analysis. The commercially available products purchased for this study were used according to the manufacturer's instructions.

Documentation and Storage

Photographs were taken using a digital camera (Canon EOS T5i digital SLR fitted with an EF 100 mm Macro lens or Nikon D5100 digital SLR fitted with an 18-55mm lens). When photographing under alternate lighting conditions, a handheld Rofin Polilight® Flare Plus II with an orange barrier filter was used to excite and visualize fluorescence. Deposited impressions were photographed after the initial deposition in situ under normal lighting, prior to enhancement in situ under normal lighting, post-enhancement in situ under normal lighting and post enhancement under normal and alternate lighting. Zar-Pro™ lifted impressions and Hungarian Red lifted impressions on the black BVDA Gellifters® were visualized at 505nm with an orange barrier filter.

The lifted impressions (Amido Black on the white BVDA Gellifters®, Hungarian Red on the black BVDA Gellifters®, and Zar-Pro™ Lifters, along with the non-impression controls) were stored individually in clearly labeled dye-free envelopes. At the end of the trials, the recovered impressions and photographs were transported to MUFSRF for the facilitation of subsequent analyses and stored in a locked file cabinet in a controlled access storage room.

Day 2

Figure 13: Decedent 1-Right Arm-Amido Black- In Situ

Figure 14: Decedent 1- Right Arm- Amido Black- Gel Lift

Figure 15: Decedent 1- Neck- Zar-Pro™

Figure 16: Decedent 1-Neck- Zar-Pro™ ALS

Day 3

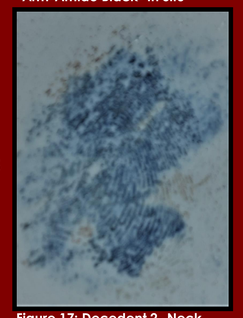

Figure 17: Decedent 2- Neck Area- Amido Black- Gel Lift

Figure 18: Decedent 2- Right Arm- Hungarian Red- In Situ

Figure 19: Decedent 1- Right Leg- Zar-Pro™

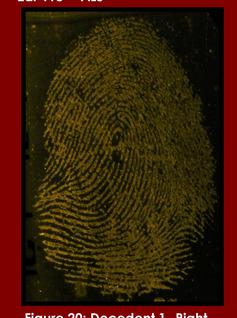

Figure 20: Decedent 1- Right Leg- Zar-Pro™- ALS

Day 4

Figure 21: Decedent 2- Right Leg- Amido Black- In Situ

Figure 22: Decedent 2- Right Arm- Hungarian Red- In Situ

Figure 23: Decedent 2- Left Leg- Zar-Pro™

Figure 24: Decedent 2- Left Leg- Zar-Pro™- ALS

Day 5

Figure 25: Decedent 1- Right Arm- Amido Black- In Situ

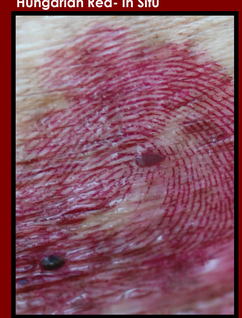

Figure 26: Decedent 2- Right Arm- Hungarian Red- In Situ

Figure 27: Decedent 1- Neck- Zar-Pro™

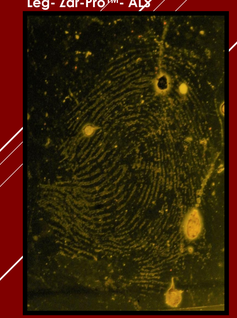

Figure 28: Decedent 1- Neck- Zar-Pro™- ALS

Hour 1

Figure 6: Decedent 1-Right Arm- Amido Black- In Situ

Figure 7: Decedent 1-Right Arm- Amido Black- Gel Lift

Figure 8: Decedent 1-Left Arm- Hungarian Red- In situ

Figure 9: Decedent 2-Left Arm- Zar-Pro™

Day 1

Figure 10: Decedent 1-Right Arm- Amido Black- In Situ

Figure 11: Decedent 1-Left Arm- Hungarian Red- In Situ

Figure 12: Decedent 2-Left Leg- Zar-Pro™

Discussion and Conclusion

The thumbprints deposited for the research trials were optimal quality impressions deposited on the decedent donor skin and enhanced and lifted at various intervals during the early stages of decomposition. All three methods were effective in the enhancement of blood impressions through the five-day interval. Amido Black and Hungarian Red produced best results when visualized in situ after staining in normal lighting (Figures 6, 8, 10, 11, 13, 18, 21, 22, 25, and 26). Amido Black lifted impressions with the white BVDA Gellifters® were effective in lifting impressions with visible ridge detail for analysis under normal lighting conditions (Figures 7, 14, and 17), whereas Hungarian Red lifted impressions with the black BVDA Gellifters® did not produce visible ridge detail under normal lighting or alternate lighting conditions. Zar-Pro™ Fluorescent Lifters were effective in lifting and enhancing impressions with ridge detail visible under normal and alternate lighting (Figures 9, 12, 15, 16, 19, 20, 23, 24, 27, and 28). At the four-day interval, the epidermal layer began separating from the dermal layer, which allowed for the recovery of stained impressions on the epidermal skin to be removed from the decedent. The recovered epidermal skin improved the visualization of the stained impressions in situ, as background interference was mitigated by the skin removal. Digital images from the research trials will be organized in triplicate data sets to be sent electronically to three practicing latent print examiners working on casework in ASCLD (American Society of Crime Lab Directors) accredited forensic science laboratories to conduct a comprehensive comparative assessment of Impression Details and Fluorescence Intensity for each enhancement method. This will reduce any indirect subjectivity of research results while assessing intra- and inter-examiner variation. A Cohen's Kappa statistical analysis of inter- and intra-examiner ratings will be applied to verify the significance of the results obtained.

Acknowledgements

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