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THE IMPACT OF PACKAGING AND TRANSPORTATION ON THE ANALYSIS OF LEVEL TWO DETAILS IN LATENT PRINTS

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SYDNEY BABER
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THE IMPACT OF PACKAGING AND TRANSPORTATION ON THE RECOVERY OF LATENT PRINTS

A THESIS APPROVED FOR THE
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BY

Dr. Mark McCoy Committee Chair

Ms. Caitlin Porterfield Committee Member

Mr. Craig Gravel Committee Member

Ms. Mia White Committee Member

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Abstract

This study was conducted to determine if packaging and transportation of small items of evidence impacts the ability to preserve and process latent friction ridge impressions deposited on those items. Similar research has been completed with DNA evidence and researchers found that packaging and transportation did impact the quality of the DNA evidence when it was analyzed (Goray et al., 2012). As latent prints are fragile, assessing current practices and determining the best protocols for latent print recovery is essential.

This study focused on best methods for preserving and processing latent friction ridge impressions. Aluminum cans and ceramic white tiles were used as items of evidence. Fingerprints were deposited on the items and left for two hours to represent time between the crime being committed and the same crime being investigated. The evidence was then divided into two groups – one group processed without being transported and one group processed after being packaged in paper bags and driven in the car. These two groups represented evidence processed on scene and evidence processed after being packaged and taken to the lab. Time of transport was 30 minutes. Latent impressions were then processed with black powder and the prints were lifted with tape. Latent impressions were analyzed for level 1 detail (cores, deltas, pattern type) and level 2 detail (ending ridges, bifurcations, dots, etc.). The value of the friction ridge detail was then compared between the items processed on scene and those items of evidence that were transported.

The goal of this study was to establish best practices and guidelines for preserving and processing latent friction ridge impressions in an effort to maintain the highest possible level of detail and provide more value during the analysis phase. It was determined that the substrate the fingerprints are deposited on heavily influences how the fingerprints will be affected by the packaging. The fingerprints on the ceramic tiles had less frequent contact with the inside of the packaging, but were more affected when contact did occur. The aluminum cans had more frequent contact with the inside of the packaging, but were less affected.

Key Words: Latent Fingerprints, Packaging, Transportation

Introduction

Fingerprint evidence is an important form of evidence in many criminal investigations. It is imperative that fingerprints, whether patent, plastic, or latent, are maintained in the best possible condition for processing, lifting, and using as evidence. Understanding the effect standard packaging procedures and transportation methods have on the ability to recover latent impressions and observe level one and level two details is important for protecting the integrity of the evidence and determining the best approach for preserving this type of evidence.

Though research has been done on the effect of packaging and transportation on other types of evidence, such as DNA evidence and charred bones, no research to date has been done regarding how packaging and transportation impacts the recovery of latent fingerprint evidence (Lewis & Christensen, 2016; Goray et al., 2012).

Fingerprint evidence is an important discipline in forensic science because DNA and fingerprint evidence are the only forms of evidence that are unique to each person and can be used to make an identification to an individual. A good quality fingerprint can identify someone to the exclusion of all others. Therefore, it’s critically important to keep fingerprint evidence in the best possible condition for comparison. When fingerprints are preserved in their original condition, it is more likely that they can be used for identification purposes. This study focuses on the need to preserve latent print evidence and compares fingerprint evidence that is processed at the crime scene to fingerprint evidence that is processed after being packaged and transported back to the lab.

Review of Literature

Latent Fingerprints

A fingerprint is an impression of the friction ridge skin found on the first joint of the finger that is deposited on a surface (Schimel, 2017). All fingerprints left on a surface are categorized as plastic, patent, or latent (Schimel, 2017). Plastic fingerprints are those that are deposited in substrates that take the shape of the friction ridge skin that comes into contact with the surface, such as wax (Schimel, 2017). Because of this, plastic fingerprints are three-dimensional impressions (Schimel, 2017). Patent fingerprints are two-dimensional and deposited in a substance, such as ink or blood (Schimel, 2017). Latent fingerprints are those that are deposited in sweat from a person's skin and are not visible to the naked eye (Schimel, 2017). They can often be seen with the use of alternate light sources or physical and chemical processing methods (Schimel, 2017).

Fingerprints are often used in forensic investigations because they are found at many crime scenes (Cadd et al., 2015). Cadd et al. (2015) wrote that fingerprints are "the most commonly used form of evidence worldwide" (p. 219). The reason that fingerprints are such effective forms of evidence is that they are unique to each person and permanent (Maceo, 2012). Unique in that no two people have ever been found to have the same friction ridge detail (Maceo, 2012). This is based on ridge arrangements and spatial relationships (Vanderkolk, 2012). As for permanence, fingerprints remain unchanged throughout one's entire life, except if affected by accidental injury or intentional mutilation (Hutchins, 2012). This makes fingerprints an effective means of identification (Krishan, 2012).

Locard's principle of exchange states that when two things come into contact with each other, whether they are people or objects, material is transferred between them (Roncace &

Nicosia, 2016). This principle also applies to forensic evidence at crime scenes. Locard's exchange principle explains that, when a person enters a crime scene, they will both leave evidence behind and take evidence with them (Mistek et al., 2018). This includes fingerprints that are left behind at crime scenes. Fingerprints have been, and will continue to be, an extremely important part of forensic investigations.

Fingerprint Evidence in Court

Since fingerprint evidence is a commonly found and widely accepted form of evidence, it is often testified on in court. It is important to understand the best ways to present fingerprint evidence to judges and juries. Garrett and Mitchell (2013) found that there is widespread understanding among jurors that fingerprints are reliable forms of evidence because they are unique to each person. However, the study found that jurors are not impacted by hearing fingerprint terminology specific to the discipline (Garrett & Mitchell, 2013). Researchers also discovered that fingerprint analysts explaining the possibility of error reduced the weight that jurors gave to fingerprint evidence (Garrett & Mitchell, 2013). This confidence was restored in situations where the analysts explained the methodology they used to conclude whether fingerprints did or did not match a source (Garrett & Mitchell, 2013). It is essential that fingerprint experts know the best ways to present fingerprint evidence in jury trials to achieve maximum understanding from the jury.

Analysis of Friction Ridge Skin

As fingerprint evidence is a common form of forensic evidence and often testified to in court, it is important that the methodology associated with analysis of latent prints reduces subjectivity and provides for reliable, valid, and consistent results. The standard methodology used in fingerprint examination is ACE-V (Vanderkolk, 2012). ACE-V stands for analysis, comparison, evaluation, and verification (Vanderkolk, 2012). These are the steps that fingerprint analysts complete when comparing a known print to an unknown print from a crime scene. In the analysis phase, the examiner determines if a fingerprint is of quality and can be used in the comparison phase (Vanderkolk, 2012). To determine if a fingerprint is of quality, the analyst takes into consideration the matrix, substrate, and deposition pressure (Forensic Science Regulators, 2013). The matrix is the substance that the fingerprint is deposited in or made of, for example, a fingerprint may be deposited in sweat or blood (Forensic Science Regulators, 2013). The substrate is the surface on which the fingerprint was deposited, for example a bottle or tabletop (Forensic Science Regulators, 2013). Finally, deposition pressure is the pressure that was exerted at the time that the fingerprint was deposited (Forensic Science Regulators, 2013). Fingerprints with a higher deposition pressure usually have thicker ridges and can become distorted if the pressure of the depositing finger was too great (Forensic Science Regulators, 2013). If the examiner finds that the print is sufficient for comparison, they move to the next step (Vanderkolk, 2012). The unknown print is always analyzed before proceeding to the analysis of the known print to reduce confirmation bias. Level one detail consists of the direction of ridge flow in a print. The analyst determines the pattern type – if a fingerprint has an arch, a loop, or a whorl pattern (Figure 1). There are two types of arches (plain arches and tented arches), two types of loops (right loops and left loops), and four types of whorls (double loops whorls, central pocket loop whorls, plain whorls, and accidental whorls) (Vanderkolk, 2012). In the comparison phase, the examiner looks at the known print and the unknown print side by side and searches for similarities and differences in level one, two, and three details (Vanderkolk, 2012).

Figure 1 – Fingerprint Pattern Types

(PBS Editors, 2007)

From there, the analyst will look for deltas, cores, and scars (Vanderkolk, 2012). If the analyst determines a fingerprint is a whorl, they will complete a whorl tracing if possible (Vanderkolk, 2012). If the analyst determines the fingerprint is a loop, they will complete a ridge count if possible (Vanderkolk, 2012). Individualizations cannot be made when examining only level one detail. Exclusions, however, can be made at this stage. If, for example, the known fingerprint is a loop, and the unknown fingerprint is a whorl, it can be determined that the fingerprints did not come from the same source. Level two detail consists of individual characteristics, called Galton details. These include ending ridges, bifurcations, dots, and islands (Figure 2).

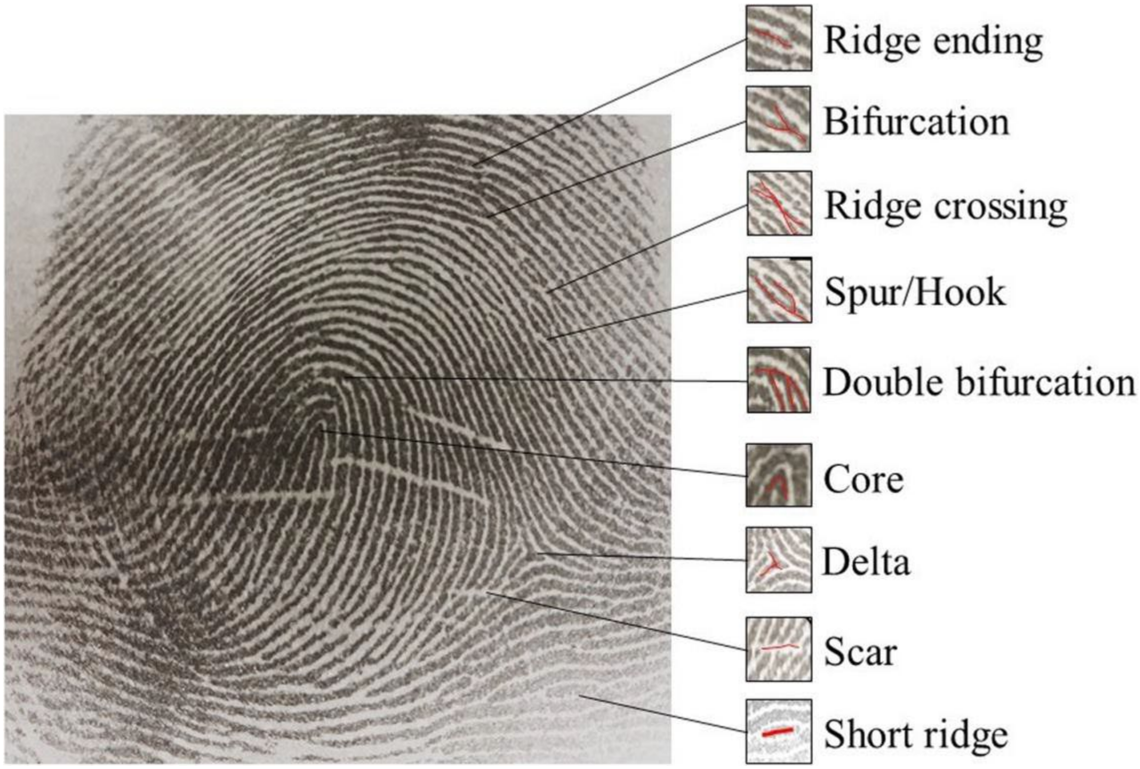

Figure 2 – Level Two Details in Fingerprint Analysis (Azman et al., 2019)

Individualizations and exclusions can be made at this stage (Vanderkolk, 2012). Level three detail takes a closer look at fingerprint ridges. Pore shapes, sizes, and locations are noted as are the edge shapes and end shapes of the ridges (Vanderkolk, 2012). In the evaluation stage of ACE-V, the fingerprint examiner formulates a conclusion as to whether the known and unknown prints originated from the same source (Vanderkolk, 2012). There are three possible conclusions: identification, exclusion, and inconclusive (Vanderkolk, 2012). For an identification, the examiner concludes that the known fingerprint and the unknown fingerprint originated from the same source (Vanderkolk, 2012). In an exclusion, the examiner concludes that the known fingerprint and the unknown fingerprint did not come from the same source (Vanderkolk, 2012). If an examiner comes to an inconclusive result, there was not sufficient quality or quantity of detail to make a determination (Vanderkolk, 2012). In the verification stage, the first three steps are repeated by another qualified fingerprint examiner who comes to their own conclusion (Vanderkolk, 2012). In a blind verification, the second examiner is unaware of the first examiner's conclusion (Vanderkolk, 2012). The verification step is used to increase quality assurance (Vanderkolk, 2012).

Error Rates

Several studies have focused on fingerprint analysis and associated error rates. Thompson et al. (2014) compared how practicing fingerprint experts, intermediate trainees, new trainees, and novices performed in fingerprint matching when compared to each other. They found that experts and intermediate trainees were correct more often than new trainees and novices (Thompson et al., 2014). Experts tended to err on the side of caution in cases of uncertainty (Thompson et al., 2014). When unsure, experts made more errors that would let a guilty person go free, rather than falsely incriminating an innocent person (Thompson et al., 2014). Reducing the amount of false positive identifications helps fingerprint analysts stay credible in their work and in court (Thompson et al., 2014). Credibility is one of the most important factors in latent print analysis, particularly when concerning testimony in criminal cases (Thompson et al., 2014).

When fingerprint analysts present their findings in court, they are providing their expert opinion as to whether a known and unknown fingerprint came from the same source. Ulery et al. (2014) found that "the predominant factor differentiating annotations associated with individualization and inconclusive determinations is the count of corresponding minutiae" (p. 1). To maximize the number of minutiae visible, items of evidence must be handled with the utmost care from the time they are discovered to the time that fingerprints are processed and lifted (Ulery et al., 2014). If care is not taken, latent fingerprints can be easily damaged and may become unusable for comparison (Ulery et al., 2014).

Fingerprint Processing

Various methods can be used to develop high quality fingerprints to use for comparison purposes. Physical processing methods include chemicals, like cyanoacrylate, or powders to make a fingerprint more visible to the naked eye (Yamashita et al., 2012). These methods are best for latent prints deposited on nonporous surfaces (Yamashita et al., 2012). When items of evidence are processed with powders, it is essential that the color of the powder contrasts with the color of the substrate that the fingerprint is deposited on (Yamashita et al., 2012). Fingerprint powders are fine powders gently dusted over latent prints with brushes. They develop fingerprints because of their ability to adhere to sweat left behind when a person deposits a print (Yamashita et al., 2012). Cyanoacrylate fuming is used to plasticize fingerprints to make them more durable and, therefore, less likely to be damaged or lost (Yamashita et al., 2012). Cyanoacrylate is placed in a fuming hood and when heated, the cyanoacrylate volatilizes and adheres to latent fingerprints deposited on items in the fuming chamber (Yamashita et al., 2012). After this process, the fingerprints are plasticized and can be seen with the naked eye (Yamashita et al., 2012). They can then be powdered and lifted multiple times without damage to or loss of the fingerprint and can also be treated with fluorescent dye (Yamashita et al., 2012). Lifting tape is most commonly used to lift fingerprints. For this method, after fingerprints are processed with cyanoacrylate fuming and/or powders, transparent tape is placed onto the print and smoothed out (Hutchins, 2012). It is then lifted and deposited on a clean notecard (Hutchins, 2012). Investigators then write important administrative information on the card like where the print was in the crime scene, the substrate the print was deposited on, the time and date, who lifted the print, and the case number (Hutchins, 2012). Maintaining the integrity of fingerprint evidence throughout processing is imperative.

Many investigations are unsuccessful because of inadequate police work and forensic evidence collection (Lambert et al., 2007). It is important that every person involved in an investigation is knowledgeable about standard operating procedures, proper handling of evidence, and what not to do in a crime scene. Lambert at al. (2007) asked multiple agencies in Michigan what disciplines they felt were most important for police and forensic work. Latent and fingerprint evidence, “interviewing techniques, and “crime scene documentation” were considered “very important” (Lambert et al., 2007, p. 423). Departments also said the areas that make applicants the most competitive, and that recruits must learn, included evidence collection, latent evidence collection and preservation (latent evidence other than fingerprints), and fingerprint evidence collection and preservation (Lambert et al., 2007). It is evident that latent fingerprint evidence is essential to forensic science and investigations. Clearly, it is important that research is done to determine the best methods of evidence processing and preservation for fingerprint evidence.

Destruction and Usability of Evidence

Latent fingerprint evidence is fragile and can easily be lost or destroyed in the process of extracting or analyzing other forms of evidence (Horsman et al., 2018). An example of this is the damage or loss of fingerprint evidence on mobile device screens in the process of extracting digital evidence. Horsman et al. (2018) did a study to establish which method of digital information extraction was least damaging to fingerprint evidence deposited on the screen, with the options being bare finger, latex glove, cotton glove, and stylus. It was found that the use of a stylus caused the least amount of damage to latent fingerprints on screens (Horsman et al., 2018).

In another study, King et al. (2013) examined to what extent the recovery of latent fingerprints affects the recovery of explosive residue and vice versa. Authors found that when performing fingerprint evidence recovery, the explosive residue evidence was easily lost and, similarly, fingerprint evidence was easily lost when recovering explosive residue (King et al., 2013). They went on to discuss the need for recovery methods to be applied that protect both forms of evidence (King et al., 2013). These two studies highlight the vulnerability of fingerprint evidence, and further prove the need for careful and methodical procedures when handling items of evidence that may have latent prints deposited on them.

Fingerprints and Time

Latent print details can be obscured and damaged over time due to factors including oxygen saturation and exposure to elemental conditions such as rain, humidity, and temperature (Cadd et al., 2015). This is supported by the article written by Cadd et al. (2015) which highlights the fact that fingerprints degrade in quality as time passes. The authors of this article call for future research into the effects of oxygen exposure on fingerprints, as well as the development of methods to estimate how much time has passed since a fingerprint was deposited (Cadd et al., 2015). Other studies have found that the widths of the ridges in fingerprints change with the passage of time, with ridge width growing slightly as time passes (De Alcaraz-Fossoul et al., 2018). Additional studies have also noted that the chemical composition of fingerprints changes significantly over time because of sebum composition, specifically the lipid content that a fingerprint is made up of will decrease over time because of the volatility of free fatty acids (Antoine et al., 2010). As multiple studies have found that time has an effect on fingerprints, future research into fingerprint evidence must control for time. When researching fingerprints and their recoverability, it is important to understand what factors change the ability to recover level one and level two details.

Evidence Transfer

Another thing to consider when trying to preserve the integrity of evidence is evidence transfer. Though there is no specific research on how packaging and transportation of fingerprint evidence effects latent print recovery, there are several articles concerning the effects of evidence transfer on other types of evidence. Two of these research articles focused on plastic bags. Belchior & Andrews (2016) discuss that in many countries, particularly in Europe, nylon bags are used to collect fire debris evidence. Researchers soaked items of evidence in gasoline and automotive paint thinner to represent fire debris soaked with accelerants (Belchior & Andrews, 2016). To test how much evidence would be lost in transportation and over time, researchers packaged the fire debris evidence as they normally would in nylon bags, transported it back to the laboratory, and stored it for up to eight weeks (Belchior & Andrews, 2016). Each bag with fire debris was in contact with eight empty bags to determine if evidence of accelerants would transfer to the empty bags (Belchior & Andrews, 2016). Researchers tested two types of nylon bags and found cross contamination with both the gasoline and the paint thinner in both types of bags (Belchior & Andrews, 2016). Both accelerants were detected in the empty bags that were in contact with the bags containing the evidence (Belchior & Andrews, 2016). The contamination was detected at times varying from two days to two weeks (Belchior & Andrews, 2016). This research study indicates the need to determine if packaging procedures result in cross-contamination issues, which could negatively impact analysis and results. Skewed results could greatly complicate investigations and lead the case in the wrong direction. Belchior and Andrews (2016) highlight the importance of carrying out research on evidence packaging, transportation, and contamination so that best practices can be determined and standardized.

In a second study on evidence and packaging, researchers examined polyethylene bags used to collect fire debris (Borusiewicz & Kowalski, 2016). They note that polyethylene bags are not ideal for collecting this type of evidence because they are known to absorb volatile organic compounds, but state that these bags are still used in some countries (Borusiewicz & Kowalski, 2016). Authors indicated that fifty percent of fires are started as acts of arson and that the integrity of fire debris evidence is essential for completing chemical analyses and solving arson crimes (Borusiewicz & Kowalski, 2016). Note that in the chemical analysis of fire debris, fire debris is tested for the presence of volatile organic compounds – common components of accelerants used in arsons (Borusiewicz & Kowalski, 2016). Researchers analyzed 28 unused polyethylene bags with a chromatograph mass spectrometer and found that volatile organic compounds were present in every single bag (Borusiewicz & Kowalski, 2016). It is important that investigators be aware of false positive issues – that the packaging itself could be responsible for the compounds they are detecting in the forensic evidence. Without investigators knowing this, as in the case with the nylon bags, it could easily lead to a misinterpretation of the evidence. Though these studies focus on arson evidence, protecting the integrity of evidence, avoiding cross contamination, and identifying the best method for preserving evidence are critically important to all forensic disciplines to include fingerprint evidence.

Another area that sees transfer or loss of evidence is DNA analysis. Goray et al. (2019) found that investigators were unknowingly transferring DNA between items of evidence because they failed to change gloves often enough (Goray et al., 2019). Authors discuss that DNA profiles were found on the outer surfaces of most of the gloves they examined for the study, and that this causes a high risk of contamination if personnel are not changing gloves before touching other items of evidence (Goray et al., 2019). These cases highlight the need for standardized guidelines to be developed and followed for the processing and packaging of evidence. As mentioned, no specific studies could be found concerning the packaging or transportation of fingerprint evidence.

Evidence Guidelines in Other Disciplines

Evaluating and studying actual cases indicates the importance of following standard operating procedures when handling evidence. For example, in a case from 2014, a fingerprint was recovered from the trigger of a nine-millimeter handgun in a case where no other evidence was available (Amata, 2015). The gun had been examined with both white light and ultraviolet light with no visible fingerprints being discovered (Amata, 2015). After sitting in a controlled storage environment for eight months, the gun was put into a cyanoacrylate fuming chamber, and a fingerprint became visible on the trigger of the gun (Amata, 2015). Investigators lifted the fingerprint, compared it to ten-print cards, and identified who it belonged to (Amata, 2015). The authors wrote that an important consideration in this case was that standard operating procedures were closely followed, which allowed the fingerprint to remain on the gun, and later be discovered and processed (Amata, 2015).

As previously discussed, it is important to preserve as much evidence as possible when attempting to process and analyze all types of forensic evidence. For example, as previously mentioned in the Horsman et al. (2018) study, it is important to preserve latent fingerprints while extracting digital evidence from mobile devices. Touroo & Fitch (2016) discuss the importance of preserving evidence as it relates to veterinary forensic pathologists. A veterinary forensic pathologist's job is to examine the bodies of deceased animals (Touroo & Fitch, 2016). Often, an animal's body is only a small part of a larger crime scene, as is the case in human deaths (Touroo & Fitch, 2016). Because of this, veterinary forensic pathologists must understand basic crime scene processing procedures and actively try to protect the integrity of the crime scene and other forms of evidence within it (Touroo & Fitch, 2016). Accordingly, veterinary forensic pathologists follow guidelines not only for their own area of expertise in properly handling deceased animals, but also in general crime scene investigation (Touroo & Fitch, 2016). To make this as easy as possible, many veterinary pathologists follow standardized rules and guidelines (Touroo & Fitch, 2016). Similar guidelines should be provided for all forensic disciplines.

Another area in which strict guidelines should be developed and adhered to is the collection and preservation of DNA evidence. Magalhães et al. (2015) propose guidelines for healthcare workers and law enforcement to follow when handling cases with DNA evidence. Authors point out that cases of sexual assault have low rates of reporting, prosecution, and conviction, and that biological evidence is often the only evidence left behind, heightening its importance (Magalhães et al., 2015). Authors set forth guidelines on avoiding contamination, degradation of evidence, and loss of evidence (Magalhães et al., 2015). They also focus on proper procedures for selecting, collecting, packaging, and transporting evidence (Magalhães et al., 2015). They write, "knowing and respecting the best practices of evidence management is essential to ensure that evidence (sometimes found in low quantities) is not lost, destroyed, or contaminated, and to guarantee reliable results and the admissibility of evidence in the court of law" (Magalhães et al., 2015, p. 7). Having a well-structured set of guidelines is possibly one of the best tools for professionals working with forensic evidence.

In another study, authors suggested the need for standardized guidelines for crime scene investigators in the collection of digital forensic evidence (Bulbul et al., 2013). Authors included information for crime scene investigators on how to best identify and secure digital evidence at a crime scene, document the location of the evidence, and collect, label, and preserve the evidence properly (Bulbul et al., 2013). Specific guidelines such as these are invaluable tools that help preserve the integrity of the physical evidence and ensure that it will be admissible in court. Though some guidelines are followed in fingerprint collection, packaging, transportation, and analysis (such as typically packaging evidence in paper bags and following ACE-V methodology when analyzing prints), the discipline is lacking a robust set of packaging and transportation standards that have been validated through research and that minimize the damage to fingerprint evidence. Standard packaging techniques and transportation methods may damage fingerprint evidence, suggesting the need for updated guidelines for investigators to follow regarding the collection, preservation, and transportation of fingerprint evidence.

Impacts of Packing and Transportation on Evidence

Gorav et al. (2012) completed a research study on how packaging and transportation impacts DNA evidence. Researchers found that the loss of DNA evidence during packaging and transportation is not only a possibility, but in some conditions, a “very likely occurrence” (Goray et al., 2012, p. 165). They deposited saliva on plastic and cotton, packaged the items using paper bags, and transported them to the lab for testing (Goray et al., 2012). Their findings showed that packaging and transporting the plastic and cotton resulted in a 44% loss of the DNA on average (Goray et al., 2012). Authors call for updated packaging and transportation procedures, but do not indicate what procedures work best to minimize the transfer or loss of DNA evidence (Goray et al., 2012).

In another study, the effects of aluminum foil packaging on charred bone was analyzed (Lewis and Christensen, 2016). Authors point out that burned bones are sometimes wrapped in aluminum foil before being transported to reduce the risk of the bones fragmenting (Lewis & Christensen, 2016). Researchers hypothesized that aluminum foil may leech aluminum into bones when used to package bone evidence (Lewis & Christensen, 2016). This was based on the discovery that aluminum foil leaches aluminum into food under certain conditions (Lewis & Christensen, 2016). Surprisingly, researchers found no evidence that aluminum foil deposits material into bone, even at high temperatures (Lewis & Christensen, 2016). Because of this, researchers say that aluminum foil can continue to be used in the packaging of burned bones (Lewis & Christensen, 2016).

The best practices for the packaging and transportation of evidence to preserve fingerprints needs to be established. Jones et al. (2001) described how the heaviness of a fingerprint deposit, the print donor, and fingerprint age affect a fingerprint's ability to be developed (Jones et al., 2001). These things were considered when completing this research study and assessing the best methods for packaging and transporting items with latent print evidence.

Jasuja et al. (2009) found that the conditions under which latent fingerprints are deposited have a great effect on the ability to recover them. The article listed some of these conditions as, "… environmental conditions, the type of surface on which latent prints are deposited, the ability of the donor to deposit fingerprints, contact time, force of contact with the object, etc." (Jasuja et al., 2009, p. 8). These factors were also taken into consideration when completing this research study on packaging and transportation of fingerprint evidence. Interestingly, researchers found that better fingerprints are deposited by sweaty hands with force, but after reaching a certain level of sweat and force, these factors have the opposite effect, decreasing the quality of fingerprints (Jasuja, 2009).

After reviewing the literature surrounding latent fingerprint evidence, its value in court, the effects of packaging and transportation, and guidelines for packaging in other disciplines, it is evident that research is needed to increase the information and literature in the field of latent fingerprints. It is vital that current practices of packaging and transporting fingerprint evidence are tested and either confirmed as best practices or revised to ensure evidence is optimally preserved. The goal of researching whether standard packaging and transportation of small items of evidence affect latent fingerprints was to determine if it is more beneficial for items of evidence to be processed on scene or taken back to the lab.

Methodology

For this research study aluminum cans and white ceramic tiles were used as simulated items of evidence. There were two groups of items – (1) processed on scene and (2) processed after being packaged and transported to the laboratory. The first group represented cases where evidence is processed for fingerprints at the crime scene and the second group represented cases where evidence is collected, packaged, transported, and then processed in the laboratory. Note that each group included aluminum cans and white ceramic tiles. Fingerprints were deposited on all items of evidence and then were allowed to sit for two hours, after which the latent fingerprints in the "processed on scene" group were processed indoors. For the items of evidence that represented evidence driven to the crime laboratory, they were packaged using paper bags, placed in the car, and driven for 30 minutes to represent an average amount of time between a crime scene and evidence lab.

Note, that a study on processing fingerprints with vacuum metal deposition was very important in the development of methods for this research project. Though researchers in the study developed fingerprints with vacuum metal deposition and this study developed fingerprints with fingerprint powder, the authors' findings that fingerprint age, donor, and the heaviness of the fingerprint deposit all affect the ability to recover the fingerprint were relevant to this research (Jones et al., 2001). Because of these factors, only the researcher deposited the fingerprints on the items of evidence. This included the "on scene" group and the "driven to the laboratory" group.

The research article by Jasuja et al. (2009) found that the conditions under which latent fingerprints are deposited have a great impact on the ability to recover them. Based on suggestions from Jasuja et al., fingerprints in this study were deposited on the same day in an indoor environment, using identical items of evidence in both groups, and attempting a consistent length of time the finger was held on the item of evidence to deposit the fingerprint.

Two hours after fingerprints were deposited on the items of evidence in each group, and after packaging and driving the "driven to the laboratory" group evidence, black fingerprint powder was used to develop prints on all items of evidence. Prints were lifted with clear tape and deposited onto white notecards. All fingerprints were examined for level one and level two detail to determine if packaging and transportation had any effect on the processing and analysis of the latent fingerprints.

For the level one detail analysis, the fingerprints were examined for pattern type, direction of flow, cores, and deltas. For level two detail analysis, the fingerprints were examined for Galton details such as bifurcations, ending ridges, and short ridges. Fingerprints were grouped by size – larger prints from group one paired with larger prints from group two, and smaller prints from group one paired with smaller prints from group two. After being roughly grouped by size, the two fingerprints were overlaid and a blue circle was placed on the slightly larger print to act as the perimeter for identifying details. This can be seen in Figure 3 below. Each fingerprint was divided into four quadrants and each quadrant was examined for Galton details. When identified, each detail was labeled as shown in Figure 3. In the comparison stage, percent of detail lost was measured by the average percent difference between the number of details from each group. The two groups are represented in Table 1.

The percentage of detail lost was calculated using the percent change formula: ((final – initial) / |initial |) x 100 = percent change. “Initial” refers to the number of details identified in the Group 1 print, and “final” refers to the number of details identified in the Group 2 print. For example, for the fifth ceramic tile fingerprint comparison in Table 2 below, the percent change formula was used as follows: ((15 – 26) / 26) x 100 = 42.3% detail loss where there were 15 Galton details in the Group 2 print and 26 Galton details identified in the Group 1 print.

	Tiles	Cans	Treatment
Group One – On Scene	1A left, 1A right; 1B left, 1B right; 1C left, 1C right	2A left, 2A right; 2B left, 2B right; 2C left, 2C right	Deposited Processed 2 hours
Group Two – At Lab	4A left, 4A right; 4B left, 4B right; 4C left, 4C right	5A left, 5A right; 5B left, 5B right; 5C left, 5C right	Deposited Packaged 2 hours Transported 30 minutes Shelf 7 days
# of Prints	12	12	

Table 1 – Experimental Groups

Results

This research focused on how fingerprint evidence deposited on ceramic tiles and aluminum cans is affected by packaging and transportation When the paper bags containing the ceramic tiles in Group 2 were turned on each side, only one tile shifted and fell on the surface where the fingerprints were deposited. Of the six tiles tested, the tile that fell on its surface was the only one that had a fingerprint affected. The aluminum cans had considerably more contact than the tiles due to how much lighter in weight they are. Consequently, their position inside of the bags was more likely to shift during transport, causing contact between the paper bags and the aluminum surface the fingerprints were deposited on.

The fingerprint details identified were bifurcations, ending ridges, and short ridges. These have been labeled as B, E, and S in the figures below. Figure 3 shows a group one fingerprint compared to a group two fingerprint that was on a white ceramic tile whose surface did not have any contact with the inside of the bag. As a result, there was a 0% detail loss.

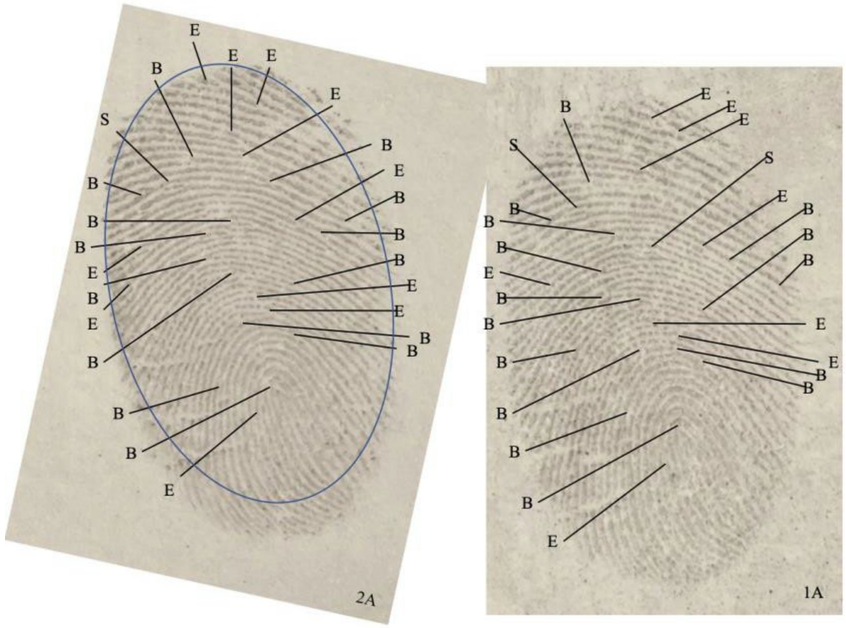

Figure 3 – Least Detail Loss, White Ceramic Tiles

Figure 4 shows a group one fingerprint compared to a group two fingerprint that was on the tile whose surface did have contact with the inside of the bag. As a result, there was a 42.3% detail loss.

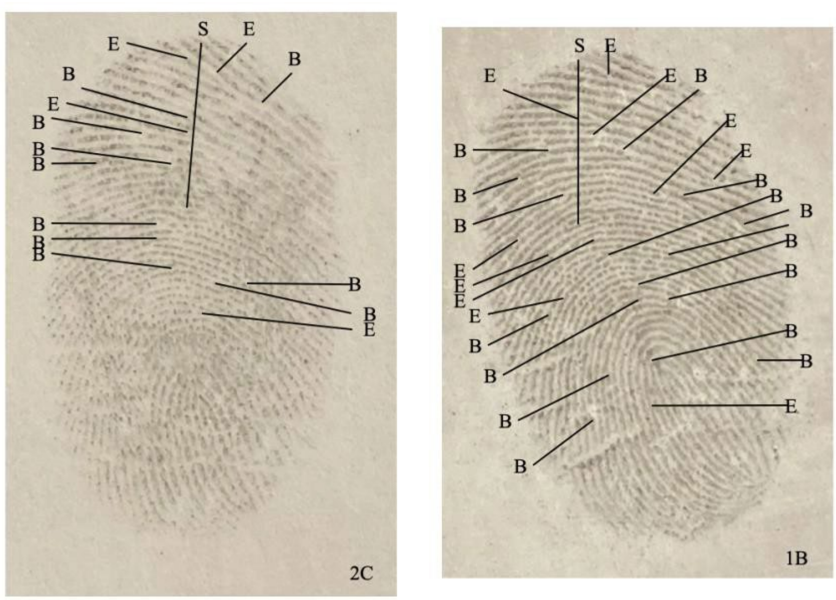

Figure 4 – Most Detail Loss, White Ceramic Tiles

Figure 5 shows a group one fingerprint compared to a group two fingerprint from an aluminum can. This group two print was the least affected of any of the prints from aluminum cans. It had a 4.5% detail loss.

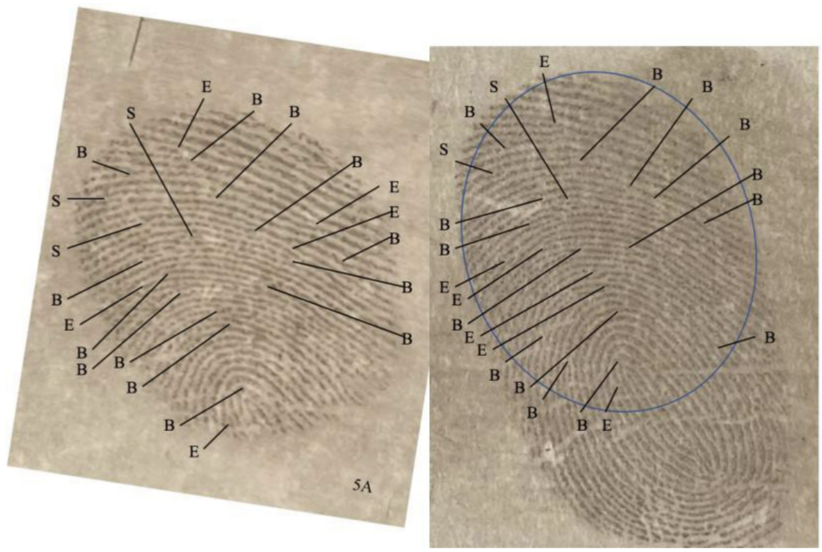

Figure 5 – Least Detail Loss, Aluminum Cans

Figure 6 shows a group one fingerprint compared to a group two fingerprint from an aluminum can. This group two print was the most affected of any of the prints from aluminum cans. It had a 34.4% detail loss.

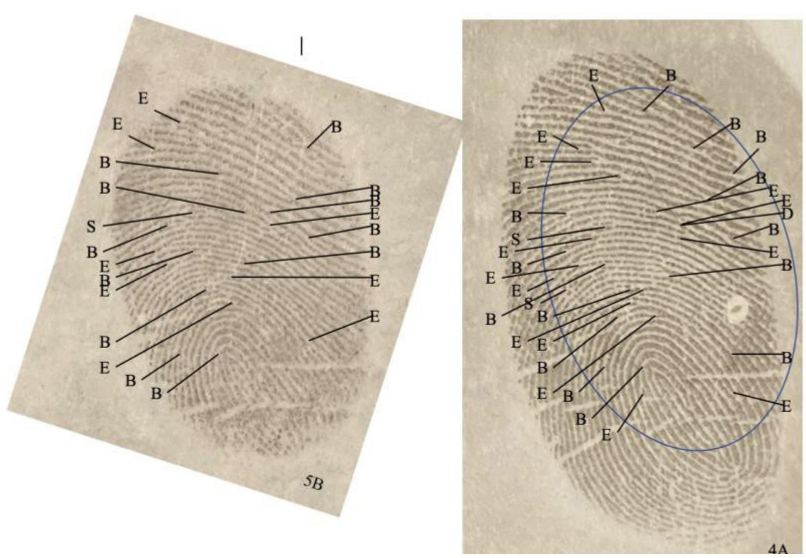

Figure 6 – Most Detail Loss, Aluminum Cans

The fingerprints on the white ceramic tiles, except for the one that fell, had a percent change from 0% to 3.7%, as shown in Figure 3. The fingerprint from the one tile that was affected had a 42.3% detail loss as shown above in Figure 4. The aluminum can fingerprints had a higher number of fingerprints affected, with the lowest detail loss being 4.5% and the highest detail loss being 34.4%, as shown in Figures 5 and 6. Although more of the aluminum can fingerprints were affected, the one ceramic tile fingerprint that was affected had more detail loss than even the most affected aluminum can fingerprint – 42.3% and 34.4%, respectively. The percent of detail loss is shown below in Tables 2 and 3.

Table 2 – Percent of Detail Loss, White Ceramic Tiles

Percent of Detail Loss – Ceramic Tiles						
Details Identified in Group One	25	26	28	26	15	31
Details Identified in Group Two	25	26	27	27	26	32
Percent of Detail Lost	0%	0%	3.6%	3.7%	42.3%	3.1%

Table 3 – Percent of Detail Loss, Aluminum Cans

Percent of Detail Loss – Aluminum Cans						
Details Identified in Group One	38	22	30	34	32	27
Details Identified in Group Two	29	21	28	29	21	22
Percent of Detail Lost	23.7%	4.5%	6.6%	14.7%	34.4%	18.5%

Conclusion

Based on these results, deciding whether to take an evidence item back to the lab depends heavily on the characteristics of the item. If an item is heavy and fingerprints are on a surface that is unlikely to come into contact with the inside of the bag, as was the case with the ceramic tiles, it may be more beneficial to transport the item back to the lab where processing can be done in standardized conditions, potentially by someone with more skills in fingerprint processing. With the ceramic tiles in this research study, all but one of the fingerprints were preserved in the same condition they were deposited in. In this case, there was no difference made to the fingerprint evidence whether the tiles were processed on scene or transported back to the lab. Although most fingerprints from tiles had no detail loss, the one tile that had contact with the inside of the bag had significant detail loss. Handling these items extremely carefully so that the tile surface did not have direct contact with the bag may have resulted in all fingerprints being preserved in their original condition.

If an item is lightweight and able to move around freely inside the bag, as was the case with the aluminum cans, it may be more beneficial to process fingerprints on scene instead of packaging the item and transporting it back to the lab, risking the loss of details. The aluminum cans in this research study all had contact with the inside of the packaging because of their lightweight nature, and they all had loss of detail to varying degrees. Based on these findings, it seems more beneficial to process lightweight items for fingerprint evidence on scene instead of packaging them and transporting them back to the lab for processing. The shape of the evidence item should also be taken into consideration, with flat items like the tiles more likely to not move around and contact the packaging than three-dimensional shapes like the cans. Minimizing the surface area that contacts the packaging seems to be the most important component in preserving details.

The results of these tests showed that heavier, flatter items had less of a chance of moving within the packaging, while the lighter three-dimensional items were more likely to have contact with the bags. These findings are important because items of evidence must be kept as close as possible to their original condition to retain their evidentiary value. This research helped fill a gap in the literature that exists surrounding what methods are ideal to preserve fingerprint evidence.

Limitations

This study had several limitations. First, the fingerprints were not uniform in size. This prevented a comparison of all fingerprints in Group 1 to all fingerprints in Group 2 for each substrate. Ideally, the prints would have been uniform in size and this comparison would have been possible, allowing for an average percent change to be calculated for each print. To account for this, prints were grouped by size and overlaid to add a perimeter, but future research should ensure that all prints are uniform in size.

Additional limitations are that only one drive time of 30 minutes was tested, and that is not representative of the drive time between all crime scenes and laboratories. Furthermore, the fingerprints only set for two hours between deposition and processing or packaging. Fingerprints at crime scenes can sit for minutes to years before they are processed or packaged and transported. Two hours is not representative of all situations. The weather conditions on the day that the fingerprints were deposited, transported, and processed were also not representative of all possibilities. This study had a small sample size of fingerprints, which were only deposited on two surfaces, ceramic and aluminum. It also only looked at latent fingerprints, as opposed to patent or plastic.

This research originally included a third group that went through the same treatment as group two, except that group three sat on a shelf for 169 days instead of seven because 169 days is the average amount of time for fingerprint evidence to sit in a lab before being processed (Hayes, 2010). Upon being analyzed, it was discovered that a different area of the fingerprint was deposited for the group three prints, therefore the fingerprints from group three were not deposited similarly enough to the other two groups for comparison purposes. As a result, group three prints were not compared to groups one and two.

Future Studies

Since it has been proven that packaging and transportation negatively impact the recovery of fingerprint evidence, more research must be done to identify best practices for handling, transporting, and processing items of evidence for fingerprints. This study found that heavy flat items like tiles are less likely to have fingerprint details obscured than three-dimensional lightweight items like cans. Future studies should include more simulated items of evidence to see if these results are repeated, and to determine how fingerprints on other items of evidence are affected by packaging and transportation. Future studies should also include varying time intervals, both before being processed and in drive time, to be more representative of different possible scenarios. Future research should also examine how packaging evidence and having it sit on a shelf for 169 days (average turnaround time for fingerprint evidence) impacts recovery. In addition, future studies should make sure that all the prints deposited are uniform in size so that calculations can include the average percent loss across all the fingerprints examined.

Though this study focused on how fingerprint details are affected by packaging and transportation, it is important to note that the goal is to move towards the best practices to keep fingerprints in their original condition. For this to be achieved, studies must be done comparing packaging and transportation methods to each other. For example, comparing standard paper bag packaging of evidence to packaging in which evidence items are suspended with zip ties.

It is important to forensic science that best methods are identified and implemented so evidence – fingerprint evidence and other forms – is kept in the best possible condition for analysis and interpretation.

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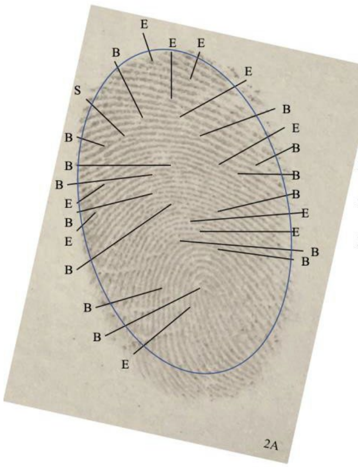
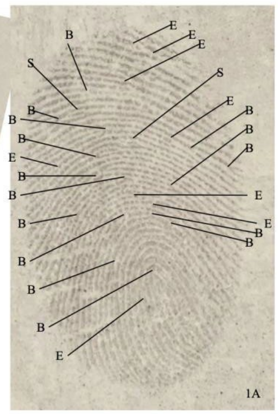
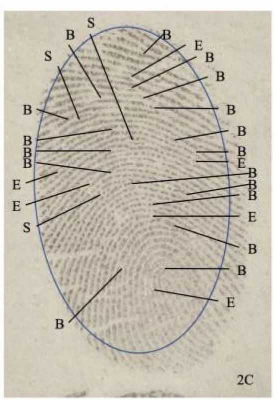
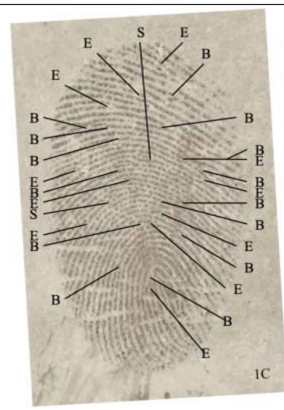
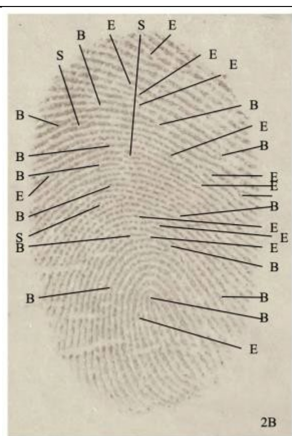
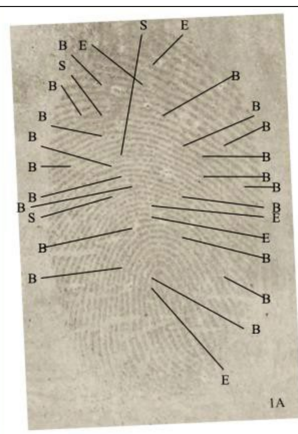
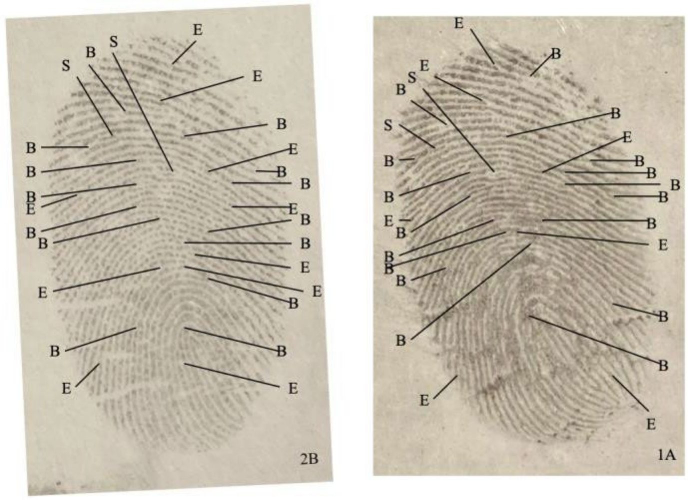
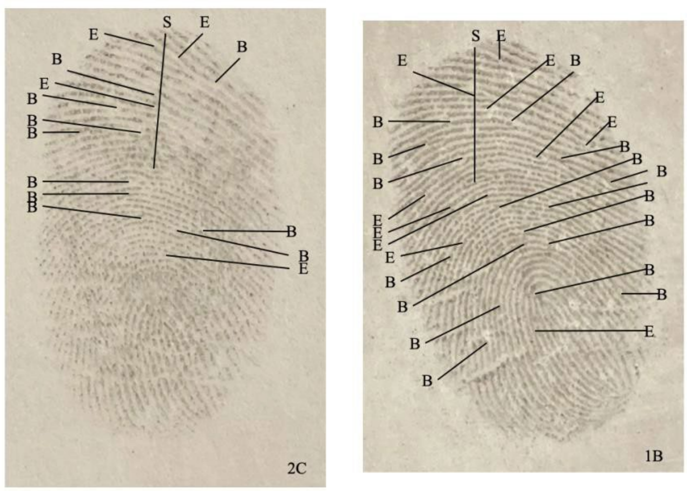
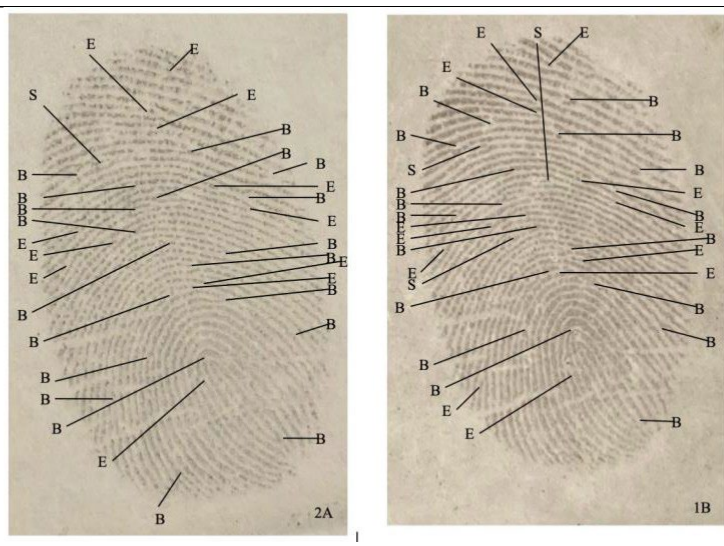
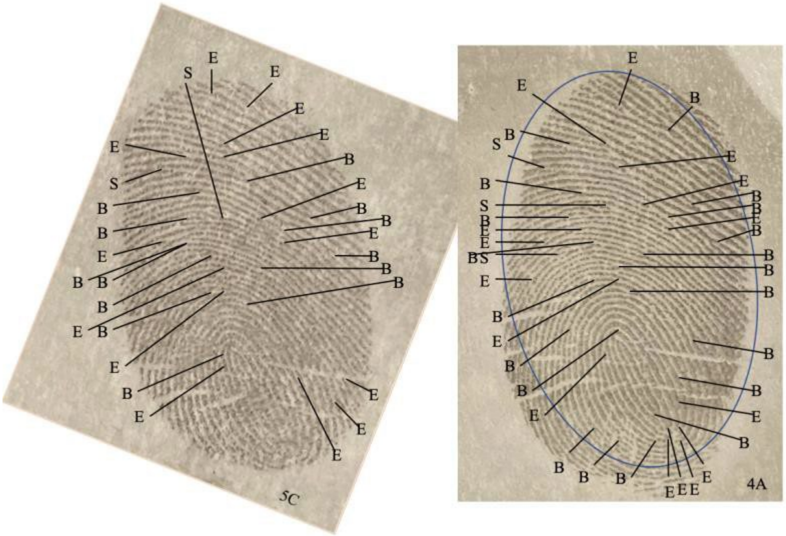
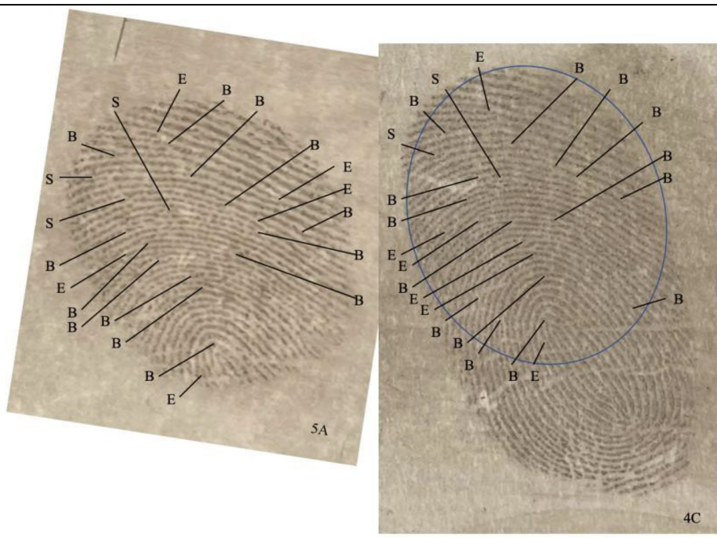
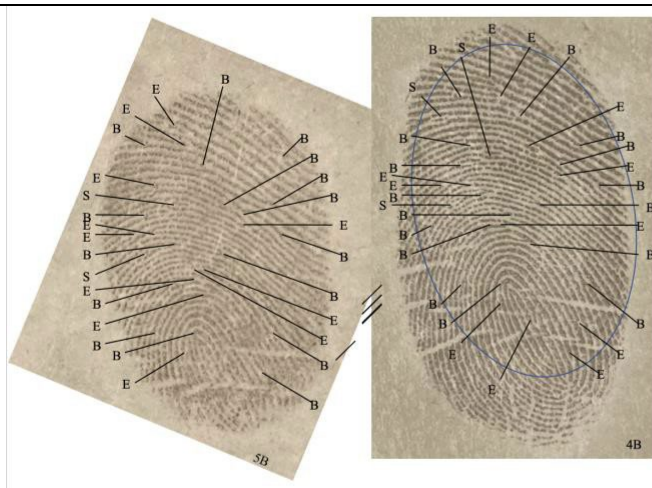
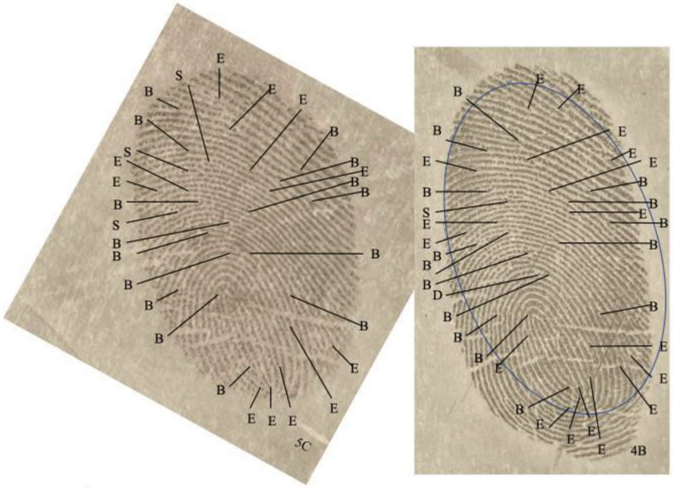
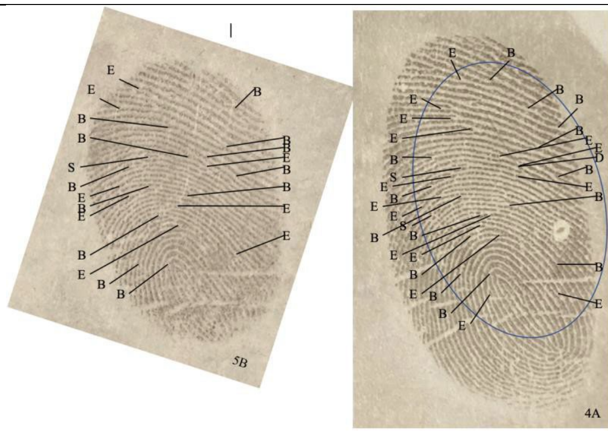
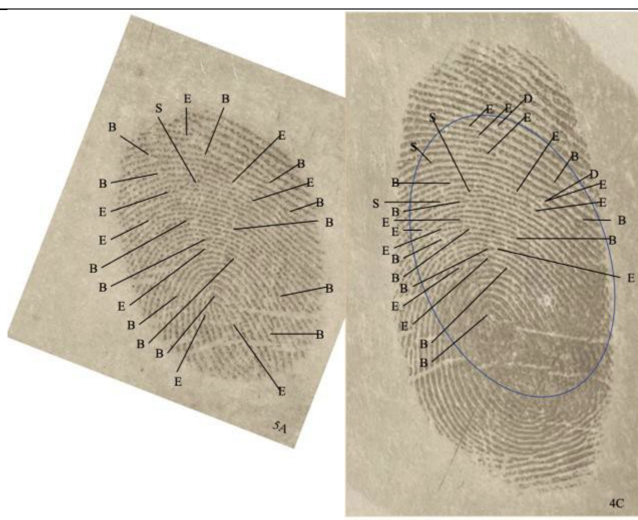
Appendix

Analysis	Details Initial, Details Final	Percent Loss Calculation
 	25, 25	((25 – 25) / 25) x 100 = 0%
 	26, 26	((26 – 26) / 26) x 100 = 0%
 	28, 27	((27 – 28) / 27) x 100 = 3.6%

	26, 27	((26 – 27) / 27) x 100 = 3.7%
	15, 26	((15 – 26) / 26) x 100 = 42.3%
	31, 32	((31 – 32) / 31) x 100 = 3.1%

	29, 38	((29 – 38) / 29) x 100 = 23.7%
	21, 22	((21 – 22) / 21) x 100 = 4.5%
	28, 30	((28 – 30) / 30) x 100 = 6.6%

	29, 34	((29 – 34) / 34) x 100 = 14.7%
	21, 32	((21 – 32) / 32) x 100 = 34.4%
	22, 27	((22 – 27) / 27) x 100 = 18.5%