PLASTI DIP® AS A TOOL FOR LIFTING CELLULAR MATERIAL FROM COARSE SURFACES

By

Michael John Cahill

A thesis submitted in fulfilment of the requirements for the degree of

Master of Forensic Science (Professional Practice)

in

The School of Veterinary and Life Sciences

Murdoch University

Supervisor:

Brendan Chapman (Murdoch University)

Semester 2, 2019

MURDOCH UNIVERSITY

PERTH, WESTERN AUSTRALIA
Declaration

I declare that this manuscript does not contain any material submitted previously for the award of any other degree or diploma at any university or other tertiary institution. Furthermore, to the best of my knowledge, it does not contain any material previously published or written by another individual, except where due references have been made in the text. Finally, I declare that all reported experimentations performed in this research were carried out by myself, except that any contribution by others, with whom I have worked is explicitly acknowledged.

Signed: Michael John Cahill               Date: 13/12/2019
Acknowledgements

I’d like to acknowledge Murdoch University for providing the funding and facilities required to complete this study. I’d like to thank my supervisor, Brendan Chapman, for providing support and guidance throughout this project, both in the lab and during the writing process. Finally, I’d like to thank my partner, Amber, for emotional support during this study and assisting with the writing and analysis.
Table of Contents

Title Page ......................................................................................................................... i
Declaration ......................................................................................................................... ii
Acknowledgements ............................................................................................................. iii

Part One

Literature Review ............................................................................................................. 6-37

Part Two

Manuscript ........................................................................................................................ 39-56
Part One

Literature Review

PLASTI DIP® AS A TOOL FOR LIFTING CELLULAR MATERIAL FROM COARSE SURFACES
Abstract

Fingerprints have been used as a tool to identify persons of interest since the twentieth century. After the successful generation of DNA profiles from a single fingerprint, the value they possess in a criminal investigation has increased. Unfortunately, due to the destructive nature of the methods employed to obtain fingerprints, it is very difficult to preserve the fingerprint ridge patterns and collect the deposited cellular material. Furthermore, although fingerprints can be digitally captured, this technique may not possible on textured or curved surfaces. To overcome this, a variety of techniques have been developed to lift fingerprints from surfaces. Currently, three different types of fingerprints lifts exist; adhesive tape, gelatine lifts, and silicone casting. Each lift has demonstrated the successful recovery of fingerprints and DNA on a range of non-porous surfaces; however, no one type of lift has proven to be the overall superior method. To date, the recovery of cellular material from coarse surfaces, such as bricks, has remained a challenge with only silicone casting demonstrating limited success. Branded as a ‘multi-purpose rubber coating’, Plasti dip® is a peel-off rubber coating that can be applied to surfaces from an aerosol can. Preliminary research demonstrated that Plasti dip® could successfully recover similar quantities of DNA as foam swabs from blood deposited onto bricks. Further investigation also indicated that small concentrations of male Y amplicon DNA could be recovered from bricks, suggesting the Plasti dip® can be used to recover touch DNA. This review aims to discuss the ability of current fingerprints lifts to successfully recover ridge patterns and cellular material. We also discuss the potential Plasti dip® possesses as a tool for the recovery of cellular material from coarse surfaces.
# Table of Contents

Abstract ........................................................................................................................................ 7

Table of Contents .......................................................................................................................... 8

List of figures .................................................................................................................................. 9

1.0 Introduction ............................................................................................................................ 10

2.0 Current fingerprint lifting techniques ....................................................................................... 12

  2.1 Enhancement methods preceding fingerprint lifting ................................................................. 12

  2.2 Adhesive tape lifts .................................................................................................................... 13

  2.3 Gelatine lifts ........................................................................................................................... 15

  2.4 Silicone casting ......................................................................................................................... 19

  2.5 Recovery of fingerprints from coarse surfaces ......................................................................... 22

3.0 DNA recovery from fingerprint lifts .......................................................................................... 23

  3.1 Effect of fingerprint powder on DNA recovery ......................................................................... 24

  3.2 The recovery of DNA from adhesive tape fingerprint lifts ....................................................... 26

  3.3 The recovery of DNA from gelatine fingerprint lifts ................................................................ 27

  3.4 The recovery of DNA from silicone casting fingerprint lifts ................................................... 28

4.0 Does Plasti dip® have a role to play in advancing DNA recovery from coarse surfaces? ........ 29

  4.1 Project aims ............................................................................................................................ 29

  4.2 Experimental design ............................................................................................................... 30

5.0 Conclusion .................................................................................................................................. 30

6.0 References ................................................................................................................................ 30
List of Figures

**Figure 1.** Diagram demonstrating how gelatine lifts can lift loose particles and reproduce surface contours (adapted from Bleay et al. 2017).

**Figure 2.** Fingerprint lifted from human skin with silicone casting (adapted from Trapecar 2009).

**Figure 3.** Finger marks on limestone developed with green fluorescent fingerprint powder and lifted with silicone casting (adapted from Davis & Fisher 2015).
1.0 Introduction

The use of fingerprints as a means to identify persons of interest at a crime scene has been employed by the United States since the start of the twentieth century (1). Fingerprints are copies of individuals' fingertip patterns, which are ridges separated by furrows and are made of friction ridge skin, creating a unique pattern. The uniqueness comes from their arrangement and the arrangement of ridge features known as minutiae (2). Combined, these patterns can be used for identification and individualisation of persons of interest at a crime scene. Additionally, fingerprint patterns cannot be altered except by mutilation, skin diseases or an accident that affects the deep layers of the skin (2). Consequently, when an individual touches a surface, they can leave behind copies of their unique ridge patterns on the touched surface. Material, such as sweat and sebum, present on the fingertips can form fingerprints that are copies of the individuals' ridge patterns. Fingerprints comprised of sweat or sebum are known as latent prints and are generally invisible to the naked eye and make up the majority of fingerprints discovered at crime scenes (3). Once discovered, fingerprints left at a scene can allow forensic investigators to match the impressions to the individual who left them. Furthermore, contact with a surface can leave trace amounts of epithelial cells and free DNA that can be collected and used to create a DNA profile (4). This provides investigators with two methods to match fingerprints to the individuals who left them.

Current methods of DNA collection from fingerprints involve the use of swabs. These swabs are destructive to the ridge pattern on the deposited fingerprint rendering them useless for identifying persons of interest (5). As fingerprints provide valuable information in an investigation, the preservation of both the ridge detail and cellular material is of the utmost importance as it provides the maximum opportunity to
identify persons of interest. Ideally, non-destructive techniques would be applied to the impression. This involves capturing the print digitally with a camera. However, these techniques may not always be suitable for fingerprints as an impression left on a curved or uneven surface may not be captured accurately due to the image distortion. Fingerprints on textured or patterned surfaces may also be difficult to visualise and capture, making them difficult to analyse (6). A common method to overcome this is to “lift” the fingerprint, which involves applying an adhesive layer to the impression that traps the ridge detail as well as any material left on the surface. This material can range from cellular material to exogenous material (7). Once lifted, the fingerprint can be transported, visualised and analysed under more suitable conditions. The advantage of lifting techniques is that fingerprints on surfaces that are difficult to image or chemically enhance can be recovered and analysed in a more suitable environment (6). Current lifting techniques are rapid and allow the lift to be easily transported from the scene. This also allows the fingerprint to be removed from the environment it was enhanced in, which can help to overcome any background interference.

Plasti dip® is a multi-purpose rubber coating that can be easily applied to a surface with an aerosol can and subsequently peeled off if required (8). Plasti dip® can be applied to a range of porous and non-porous surfaces, such as wood, fabric, metal, and glass, and can prevent weathering, wearing, tearing, shattering and corrosion. At the time of this review, no published research has examined Plasti dip as a tool for the recovery of cellular material deposited by fingerprints. It is believed that Plasti dip® would be most advantageous for the recovery of touch DNA from porous surfaces as the liquid state would be able to penetrate the pores and successfully recover material trapped within. This would be highly beneficial in burglary and
assault cases where the only piece of evidence may be an object with a coarse surface, such as a brick or stone (9). In this review, we seek to (i) evaluate the state of knowledge surrounding current types of fingerprint lifts and their limitations (ii) assess the ability of fingerprints lifts to successfully recovery DNA from lifted prints (iii) identify future areas of research, including the use of Plasti dip® as a tool for DNA recovery.

2.0 Current fingerprint lifting techniques

Currently, there are three common types of fingerprint lifts; adhesive tape, gelatine lifts, and silicone casting (6). The following section discusses initial enhancement techniques for the visualisation of fingerprints, the application of current fingerprint lifting methods, as well as the ability to recover fingerprints from coarse surfaces.

2.1 Enhancement techniques preceding fingerprint lifting

All lifting methods require some form of optical, physical or chemical enhancement in order to be visualised (3). Some examples of optical, physical and chemical enhancement methods include alternative light sources, powdering and cyanoacrylate fuming respectively. Following physical and chemical enhancement, fingerprints can be lifted with one of the above-mentioned forms of lift. The advantage of lifting fingerprints treated with powder is that it allows the impression to be rapidly collected and easily transported from the scene. This is advantageous when enhancing prints on surfaces that can be challenging to photograph or analyse, such as curved or patterned surfaces (10). Lifts also remove the print from the environment it was enhanced in, and thus any background powder that may be present and infer with visualising the print. This can especially beneficial for fluorescent fingerprint powders as some surfaces can produce background
fluorescence that makes the fingerprints difficult to visualise under alternative light sources (11). It should be noted that lifting granular and magnetic powders may cause greater degradation of ridge detail as these powders are less compatible for lifting than flake powders (6). These flake powders are reflective under oblique lighting and provide the greatest contrast for imaging. As both powdering and lifting cannot be repeated for a fingerprint, careful consideration needs to be taken when applying fingerprint powder as excessive physical contact may cause distortion to the ridge detail (10). This also applies to the removal of the lift as quality can potentially be lost due to powder adhering to the lift and traces of the powder staying on the surface (6). For fingerprints that have been enhanced with cyanoacrylate fuming, loose surface layer superglue can be lifted using gelatine lifts and the use of black gelatine lifts can provide excellent contrast against the white superglue. However, the lifting of cyanoacrylate enhanced fingerprints can be difficult to achieve with non-gelatine lifts due to their high adhesive ability (6).

2.2 Adhesive tape lifts

The use of adhesive lifts is common practice for lifting fingerprints in forensic investigations. However, as this method requires additional enhancement techniques to visualise the fingerprint, the quality of the print is not guaranteed. Adhesive lifts involve the use of conventional sticky tape to recover fingerprints that have been previously enhanced with techniques such as powdering and cyanoacrylate fuming. However, as there are limited lifting tapes available specifically for forensic purposes it is difficult to guarantee the performance of every roll of generic tape produced (6). A study by Sundar & Rowell (2013) attempted the recovery of cyanoacrylate enhanced fingerprints but contact with the impression resulted in a very poor transfer of ridge detail (12). It was only after modifications to the fuming process that
fingerprints could be successfully lifted whilst still retaining ridge detail. The drawback of this method, however, is that there is a risk of losing the impression due to the stripping of the treated fingerprint from the surface caused by the additional solvent treatments. Another study by Jaroensuk et al. (2009) demonstrated that fingerprints on non-porous surfaces could be enhanced with techniques such as powdering and cyanoacrylate fuming post tape lifting with water-soluble tape (13). Lifted latent prints were enhanced with black powder, cyanoacrylate fuming and black powder, or cyanoacrylate fuming and rhodamine 6G, and then compared to fingerprints that were enhanced without lifting. Although both methods generated high-quality fingerprints, fewer minutiae were identified on the prints enhanced after lifting (13). This difference was not significant but was observed across all fingerprints used in the study, which suggests that there is some damage that occurs to the ridge detail during lifting. Adhesive tape can also be applied for the collection of fingerprints from deceased individuals for identification purposes. Traditionally, it was recommended that fingerprint powder should be applied to fingertip followed by lifting with white adhesive lifters (14). However, the use of fingerprint ink followed by lifting with clear tape also proved sufficient in the recovery of quality fingerprints (15).

For investigations involving the use of tape for binding, fingerprints may be deposited onto these tapes and enhanced to allow visualisation and identification. For fingerprints deposited onto a number of adhesive tapes, including duct tape, masking tape, and clear packing tape, the use of Wetwop™ powder consistently demonstrated quality impressions with well-defined ridge detail. Wetwop™ is a wet powder that is used to develop fingerprints on the adhesive side of tapes. Aged fingerprints can also be enhanced with the powder. After deposition onto duct tape, the tape was adhered to the non-adhesive side of the second piece of duct tape and
stored for 18 months. Upon recovery, the deposited fingerprint was enhanced with Wetwop™. Generated fingerprints showed high-quality ridge detail, demonstrating the powders’ ability to enhance aged fingerprints (16). However, caution should be taken as heavy staining can result if allowed to remain on the impression for too long (17). Another method that can be applied to fingerprints on adhesive tape is the use of fluorescent carbon nanoparticles that allow for visualisation under ultraviolet (UV) light (18). Following treatment with a nanoparticle solution and UV light, fingerprints were successfully visualised with high-quality ridge detail. When comparing aged and fresh fingerprints, both generated similar results with the aged producing slightly lower quality ridge detail as expected (19). Additionally, following the application and removal of adhesive tape onto the deposited surface, quality ridge detail was still observed after numerous removals. This demonstrates that the procedure can generate successful results for deposited fingerprints with reduced residues.

2.3 Gelatine lifts

Gelatine lifts provide an alternative lifting method to the traditional tape lift, by collecting forensic samples without disrupting porous and non-porous surfaces (20). They are typically comprised of gelatine, provide moderate adhesion, and are flexible in nature (6). This makes them better suited for textured surfaces as they can be compressed to the surface and will retain some of the surface contours, which provides an excellent contrast to the impression when the lifted fingerprint is digitally captured (Figure 1). Lifted fingerprints can also undergo further enhancement, such as cyanoacrylate fuming and powdering, but the results generated vary depending on the variety of lift used (21).
Currently, a number of gelatine lifts are available; however, the majority of research is conducted with BVDA Gellifters® and Instant lifters. The Gellifters® come in black and white, with the black lifter recommend as the optimal method for latent fingerprint recovery. This is due to the contrast provided by the dark surface, as well as the uneven surface reflection created by the white lift, which created bright areas during reflected light illumination that masked ridge detail (22). Instant lifters are transparent and come with a resealable backing. They are noted as being an alternative for adhesive tape and not a substitute for Gellifters®, with lower quality lifts observed from human skin when compared to Gellifters® (20, 23). As the lift is designed to recover impressions without affecting the fingerprint, user application has less effect on the ridge detail than adhesive tape lifts (24). The moderate adhesive nature is also less destructive and makes the lift more appropriate for fragile surfaces. When comparing adhesive tape to gelatine lift on a number of surfaces, it was observed that gelatine lifts were the least destructive method (24). On smooth porous surfaces such as metal and glass, tape lifts were significantly destructive to the fingerprint that resulted in unidentifiable ridge details. This was
also observed on fingerprints deposited onto paper, which is to be expected. This destructive nature was only observed on glass surfaces when lifting fingerprints with gelatine lifts, suggesting that gelatine is the more appropriate method when additional processing of the fingerprint may be required. It was also demonstrated that fingerprints enhanced with black powder on human skin could be recovered with gelatine lifts. Although the black lift required slanted lighting to visualise the powdered fingerprints, both black and white lifts produced collected impressions with sufficient detail and quality for identification purposes (23). Compared to adhesive and instant lifters, Gellifters® produced a lower number of fingerprint lifts where no identifiable or eliminating ridge details could be observed (23).

Gelatine lifts are capable of lifting and visualising latent fingerprints from a non-porous surface without any physical or chemical enhancement. Given the nature of latex and vinyl gloves, successful enhancement of fingerprints on disposable gloves has proven challenging with methods such as ninhydrin and cyanoacrylate fuming generating poor results (25). Using gelatine lifters, the inside of gloves were ‘rolled’ in an attempt to recover latent fingerprints. The gelatine lift was able to recover latent fingerprints with high-quality ridge detail and were visualised without any physical or chemical enhancement (26). These results were consistent for both powdered vinyl gloves and powder-free latex gloves, with subsequent lifts also generating multiple high-quality fingerprints. Compared to powdered fingerprints, less detail was observed in non-enhanced fingerprints deposited on various surfaces such as metal and glass (21). This result was observed in both fresh and aged fingerprints. As the gelatine lift shows moderate adhesion, following fingerprint lifting there was some residue left behind on the surface. Powdering the lifted area produced impressions that resembled similar detail to the lifted prints. Additionally, powdered aged prints
showed greater detail than lifted impressions due to the hardening of the residues, which resulted in less transfer onto the gelatine (21). A major limitation of gelatine lifts is lifted latent impressions steadily degrade over time, with the application of cover materials accelerating this process (6). Although research suggested that short periods of reattachment (1 hour) resulted in minimal impact, extended storage (several hours) can have a significant effect (22). This effect is due to the residues present on the fingerprint diffusing into the gelatine membrane, as well as some of these residues transferring to the plastic film when applied. This creates additional challenges as the uncovered impression can be difficult to protect during transportation. It is therefore imperative that lifted impressions are photographed as soon as possible. For true gelatine lifts, another limitation is the inability to lift impressions from surfaces above 40°C (6). At this temperature, there is a chance that the gelatine lift may melt to the surface, however, this issue is not of major concern for lifts composed of other materials such as silicone.

Gelatine lifters are primarily used for the recovery of fingerprints on non-porous surfaces but have also shown promising results for semi-porous surfaces such as polymer banknotes (27). A number of fingerprints were deposited onto banknotes and enhanced with various physical and chemical techniques, such as powdering and ninhydrin. Fingerprints were then lifted with gelatine lift or visualised under reflected infrared imaging and compared to determine which method produced a greater number of observable ridge patterns. It was demonstrated that gelatine lifts were able to produce more fingerprint lifts with more than 1/3 of the ridge detail present (11). Additionally, it was observed that treatment with gelatine lifts creased the number of previously observable fingerprints. This observation was the most significant in fingerprints treated with multimetal deposition and cyanoacrylate
fuming, with both treatments showing over a 30% increase in the number of observable fingerprints. These observations were seen in precursor notes, however, which are a slight variation of mass-produced banknotes. Subsequent lifting of mass-produced banknotes generated the greatest increase, of approximately 70%, in fingerprints enhanced with wet powder-white suspension. Most other methods generated an increase of less than 40% (11). These results were only observed in fingerprints previously enhanced with a form of physical or chemical method. When attempting to recover fingerprints without any prior enhancement, gelatine lifters on their own produced the lowest number of fingerprints with over 1/3 of ridge detail visible (11). Davis et al. (2016) also demonstrated that fingerprints treated with copper vacuum metal deposition were able to be lifted from polymer banknotes (28). The maximum contact time between the gelatine lift and fingerprint was two minutes, as longer time periods resulted in poor quality lifts. As the copper molecules within the fingerprint residue are less tightly packed than the molecules between the residue, it is hypothesised that there is less adhesion to the surface and hence can be lifted. An advantage this method has is that the quality of the lifted fingerprint was unaffected by the thickness of copper deposited onto the latent print (28). This is especially useful as it reduces the risk of overdeveloping fingerprints. Lifted fingerprints can then be sprayed in rubeanic acid, resulting in a bright green impression with the background unaffected, which provides excellent contrast for visualisation and analysis. Staining of the gelatine can, however, occur over time, and so prolonged contact with the acid is not recommended.

2.4 Silicone casting

Casting compounds involve the application of fast curing silicone to a latent fingerprint located on difficult surfaces. Traditionally used on impression evidence
such as tool marks and shoe prints, the silicone can also recover fingerprints from surfaces that other methods may fail to. Currently, two methods have shown promise, with one method involving the use of a gun dispenser to apply liquid silicone to a card (29). A study by Brennan et al. (2001) applied the silicone directly to the fingerprint and allowed the liquid to flow over the impression (30), however, this may not always be applicable to the surface. It is therefore recommended that the silicone be applied to a card, subsequently applied to the impression and enhanced with cyanoacrylate fuming for easier visualisation (29). A study by Shalhoub et al. (2008) demonstrated that following lifting with silicone, the original impression can be chemically enhanced with cyanoacrylate fuming (31). When compared to the original impression treated with cyanoacrylate, the silicone generated similar quality fingerprints with both methods failing on semi-porous surfaces. This demonstrates the potential liquid silicone casting possesses, as two enhancement methods can be applied to the same fingerprint without sacrificing quality. The second method involves powdering the latent fingerprint and applying a rubber silicone to the enhanced fingerprint (20). Once again the silicone is allowed to harden before being removed from the original surface, along with the powdered fingerprint. Silicone casting has demonstrated excellent results when compared to adhesive and gelatine lifting techniques for the recovery of fingerprints from human skin (Figure 2). It was determined that 15% of fingerprints lifted with silicone casting were suitable for individual elimination and identification, whereas only 10% of fingerprints lifted with gelatine foil produced the same results (32). Additionally, when compared to adhesive tape and instant lifter, silicone casting generated a larger proportion of fingerprint lifts that were capable of producing a full and partial profile
from the observed ridge detail (23). It should also be noted that silicone casting struggles to lift fingerprints on the skin above 48°C and over 40 hours old, but this is most likely due to the fingerprint deteriorating rather than a limitation of silicone (33). For surfaces covered in water, gelatine lifts and adhesive tapes are unable to lift fingerprints due to its inability to make direct contact with the surface and the loss of adhesion caused by water (34). Using a silicone-based gel polymer, enhanced fingerprints were successfully recovered from wet metal. Similar results were also seen when compared to cyanoacrylate fuming, with the silicone cast generating higher quality fingerprints (31). This demonstrates the advantage silicone castings
can have over conventional adhesive tapes and gelatine lifts. Silicone lifts can also be constructed by applying a silicone layer to a Teflon® sheet and allowing to cure in high temperatures. These lifts have demonstrated the successful recovery of powdered fingerprints and matching to electronic databases (35). An advantage these lifts have over the gelatine and adhesive tapes is that they are stable at high temperatures, meaning that they can also be used for other forms of chemical analysis such as drug detection.

2.4 Recovery of fingerprints from coarse surfaces

In some burglary and assault cases, the only available piece of evidence may be an object with a coarse surface, such as bricks and stones. In such instances, the ability to successfully recover an identifiable fingerprint would be highly advantageous. The difficulty arises with the porous nature of these objects, attempts to enhance fingerprints on various types of rocks and stones proving difficult, with only fingerprint powder generating fingerprints that could be compared to a fingerprint database 50% of the time (9). Davis & Fisher (2015) attempted to visualise fingerprints deposited onto bricks, limestone and sandstone using various physical and chemical enhancement methods and then lift the prints with tape or silicone (36). Successful visualisation was achieved less than 50% of the time for each treatment time, and the only method that was successfully able to lift fingerprints was powdering combined with liquid silicone (Figure 3). Although the study focused on fresh fingerprints, the potential for successful recovery has been made apparent. Preliminary research indicated that Plasti dip® can recover fingerprints deposited onto glass, suggesting there is potential for use as a fingerprint lift. Additionally, the highly adhesive nature is similar to silicone casting suggesting that Plasti dip® could produce identifiable fingerprints from coarse surfaces.
Figure 3. Finger marks on limestone developed with green fluorescent fingerprint powder and lifted with silicone casting (adapted from Davis & Fisher 2015).

3.0 DNA recovery from fingerprint lifts

Although there are numerous studies attempting the successful recovery of DNA from latent fingerprint lifts, a number of challenges prevent the generation of DNA profiles. The amount of cellular material deposited onto a surface is highly variable and dependent on a number of uncontrrollable factors (37). It was demonstrated that individuals deposit varying amounts of DNA onto handled objects and can be classed as good or bad ‘shedders’, with good shedders depositing larger quantities of DNA than bad ones (38). Further studies discovered that this rate of deposition was also affected by the frequency of handwashing and the use of the dominant or non-dominant hand (39). Additional factors affecting deposition include the contact time, environmental conditions and the nature of the surface that is being handled (37). The following section discusses the effect of fingerprinting techniques on DNA
recovery, as well as assesses the ability of fingerprint lifts to successfully recover DNA.

3.1 Effect of fingerprint powder on DNA recovery

With the development of DNA profiling technology, the successful recovery of DNA from fingerprints has become highly advantageous in an investigation as it can provide multiple opportunities to identify persons of interest. Fingerprint lifts can achieve the recovery of both fingerprint ridge detail and deposited cellular material (4). It was hypothesised that the viability of DNA recovery could be improved by addressing the collection methods applied at the crime scene. As fingerprint lifts are unable to lift 100% of residues left on a surface after contact (40), DNA profiles were attempted to be recovered from surfaces following tape lift. The surface was single or double swabbed post tape lift, and DNA extraction and profiling were attempted from recovered swabs. It was concluded that high-quality DNA could be extracted from both swabbing methods, but no full DNA profiles could be generated from the extracted DNA (41). This was due to the low concentration of DNA extracted, which was well below the standard 0.5 ng required by most commercial kits (42). As the majority of fingerprints lifted with adhesive tape have been enhanced with some form of powder, the effect of specific powders on DNA recovery has been assessed extensively. Initial studies demonstrated that the presence of black or white powder in the amplification mix resulted in inhibition (43). However, current methods of DNA extraction separate the powder from the recovered DNA before amplification and therefore do not cause inhibition. This was also observed when generating DNA profiles from fingerprints enhanced with black or white powder, which showed no significant difference (43). Similar results were generated by Subhani et al. (2019), who researched which combination of fingerprint powder and lift resulted in the
greatest percentage of recovered alleles in DNA profiles (44). By comparing aluminium, black, magnetic and magenta powder, and gelatine, tape and silicone lifts, it was determined that statistically no combination of powder and lift resulted in the greatest number of recovered alleles (44). Additionally, no significant difference was observed between lifted fingerprints that were enhanced with powder and those that were not, suggesting that powders do not affect the recovery of DNA profiles. These findings contradict other studies that suggest magnetic powder does affect the recovery of DNA. It was demonstrated that fingerprints deposited onto glass slides and enhanced with black powder generated higher quality profiles than fingerprints enhanced with magnetic powder (45). For the black powder fingerprints, 66% of alleles were recovered whereas only 33% of alleles were recovered from the magnetic powder fingerprints. However, it has been suggested these negative effects are only observed in specific brands of magnetic powder. Inconsistent DNA yields were obtained from fingerprints enhanced with various types of magnetic powder when using Promega DNA IQ™ kits. It was shown that MAGNA™ Jet Black had negative effects on the recovery of DNA extracted with Promega DNA IQ™ by mechanisms that could not be determined (46). However, upon removal of the powder prior to DNA extraction, high-quality DNA profiles were generated. This demonstrates that although DNA extraction may be affected by magnetic powder, subsequent DNA profiling can still be achieved. Fluorescent fingerprint powders are commonly used as a method to enhance latent fingerprints. When comparing different fluorescent and infrared fingerprint powders, it was determined that the use of these powders did not show any significant effect on the number of loci generated (47, 48). Although a colour change was observed in the DNA samples as a result of the powder, this only affected spectrophotometric measurements that had used clear
solutions as the blank. A major issue with fingerprint powders stems from the application of reusable brushes to enhance latent impressions. This creates a challenge for DNA recovery as these brushes are stored in a non-sterile environment and can transfer cellular material between crime scenes (49). By applying DNA profiling techniques to brushes used to apply fingerprint powder brushes, partial and full DNA profiles were able to be generated (50). This creates a significant issue as these transferred profiles can interfere with investigations and create false positives. However, this issue can also be easily overcome by using disposable brushes or subjecting reusable brushes to sterilisation techniques to prevent contamination.

### 3.2 The recovery of DNA from adhesive tape fingerprint lifts

When extracting DNA from adhesive tapes, consideration should be taken as to what method is applied. A study demonstrated that when using the Promega DNA IQ™ extraction kit on DNA recovered with particular types of Scotch® tape, none or low DNA yields were recovered. Further to this, quantification with real-time PCR demonstrated that no PCR inhibition occurred (46). Similar results were observed when using the Qiagen GmbH kit (51), suggesting that the adhesive tapes interfere with the extraction process. This issue can be easily overcome however through the application of a different type or brand of adhesive tape. Recovery of DNA from tape can be challenging due to the strong adhesion preventing the recovery of cellular material. One technique to overcome this is the application of a solvent to the tape that is able to neutralise the adhesive surface and allow the material to be retrieved (52). Using the solvents chloroform or Un-Du®, cellular material was successfully collected from aged fingerprints deposited onto duct tape. Full DNA profiles were generated from the recovered material, which suggests that the solvents don’t affect downstream DNA profiling methods (16). However, multiple samples showed DNA
profiles not consistent with the donor, suggesting contamination at some point during the process.

Lifted fingerprints that have been affixed to a backing card and stored are known as archived fingerprints. Although this process can result in possible loss of DNA, successful profiling can still be achieved from extracted DNA (40). Following fingerprint lifting with adhesive tape and storage for two years, the successful recovery of DNA profiles was attempted. For all fingerprints that underwent extraction and profiling methods, only 30% yielded a partial DNA profile and one sample yielded a full profile (53). For fingerprints archived for over 10 years, the average number of alleles detected was five with 15.3% of lifts generating 10 or more detectable alleles. Similar results were observed when comparing sampling techniques and visualisation techniques. Direct cutting, single and double swabbing yielded an average DNA concentration of 0.45 ng, 0.12 ng, and 0.17 ng respectively (54). Partial profiles were also more likely to generate from direct cutting than both swab methods, which suggests that it is the most appropriate method to use for sampling from archived fingerprints. Sampling methods, however, resulted in the destruction of the ridge details preserved within the lift, which is a major limitation of the current DNA sampling methods of lifted fingerprints. For this reason, it is not recommended that DNA be collected from archived fingerprints, as the chance at a DNA profile may not be worth the destruction of the ridge details.

3.3 The recovery of DNA from gelatine fingerprint lifts

Following deposition onto glass, painted drywall and 100% cotton, fingerprints were lifted with Gellifters® or instant lifters and profiled. Both lift types were able to generate DNA profiles from all surfaces, however, the quality of profile varied
between surfaces. Profiles generated from fingerprints deposited on glass were high quality for both lift types and were generated from 100% of samples deposited. On painted drywall, instant lifters generated profiles of a higher quality than Gellifters® and at a higher frequency. The opposite was seen with 100% cotton, with Gellifters® generating significantly higher quality profiles than instant lifters and for 100% of samples compared to less than 50% for the instant lifters (55). An alternative method for the recovery of DNA from gelatine lifts is direct proteolytic digestion of the lift and the fingerprint. Compared to direct swabbing of the gelatine lift and post lift surface swabbing, direct digestion frequently generated higher concentrations of extracted DNA from powdered fingerprints (56). However, this was only observed in clear lifters as quality DNA was unable to be successfully extracted from both black and white gelatine lifters. This may be due to the presence of metal compounds in the gelatine lifters that provide colour but may also act as PCR inhibitors.

3.4 The recovery of DNA from silicone casting fingerprint lifts

Silicone casting has been demonstrated as an efficient way to recover cellular material from fingerprints. Compared to swabbing, it was observed that liquid silicone was able to recover higher concentrations of DNA from greater than 65% of the tested objects, with a light bulb and mobile recovering significantly larger concentrations (31). As these fingerprints were deposited in a controlled method, additional fingerprints were deposited onto drinking objects by asking the volunteers to handle them as they naturally would. Once again the silicone was able to outperform the swabs on greater than 65% of the objects. For fingerprints deposited onto human skin, the ability for silicone casting and gelatine lifts to create DNA profiles was compared (32). Fingerprints lifted with liquid silicone were able to generate successful profiles in 17 profiles, compared to the gelatine lifts only
generating three. These results demonstrate the potential silicone casting possess as a method for the recovery of DNA from a range of surfaces.

4.0 Does Plasti dip® have a role to play in advancing DNA recovery from coarse surfaces?

Porous surfaces pose a real challenge for the recovery of DNA as the pores trap cellular material but prevent swabs and tape from collecting it (57). Currently there is very limited research on successful recovery of fingerprints and DNA from coarse surfaces such as bricks and stones. Plasti dip® is a peel-off rubber coating, typically used on surfaces to protect from weathering, wearing, corrosion and tearing. Easily applied with an aerosol can to a range of porous and non-porous surfaces, Plasti dip® starts as a liquid and quickly dries. This is a major advantage when working with porous surfaces as the liquid is able to penetrate the pores of the surface and recover the cellular material trapped within. Previous analysis by Nguyen (unpublished) indicated that Plasti dip® can successfully recover DNA from blood deposited onto bricks (58). This was promising as similar concentrations of DNA were observed when recovering blood with foam swabs from bricks. Further studies by Rylands (unpublished) also demonstrated that low concentrations of male Y amplicon DNA could be recovered from buccal cells deposited onto bricks (59). However, less than 30% of replicates produced observable concentrations suggesting that alterations to methods are required.

4.1 Project aims

The aim of this research is to attempt the successful recovery of DNA from cellular material deposited onto bricks using Plasti dip®.
4.2 Experimental design

A mouthwash containing buccal cells will be deposited onto brick pieces (10 replicates) and attempted to be recovered with Plasti dip®. For comparison, three different concentrations will be used and cellular material will also be recovered with rayon, foam and nylon swabs. Recovered DNA will be extracted using QIAamp® DNA Investigator Kit (Qiagen) and then quantified using Quantifiler™ HP kit.

5.0 Conclusion

Since their application in the justice system, fingerprints have proven to be a useful and highly accepted form of evidence. Following the successful generation of DNA profiles from deposited fingerprints, their evidential value increased exponentially as it provides investigators with two opportunities to successfully identify persons of interest. Preservation of both the fingerprint and the deposited DNA is of the upmost importance and can be achieved with fingerprint lifts. Currently, three types of lifts exist and have all shown successful recovery of fingerprints and DNA from various substrates. However, very little research has been conducted into the recovery from coarse surfaces such as bricks. Following the success of Plasti dip® as a tool to recover cellular material from bricks, further research will be conducted to determine if its application has potential to be used a tool for future investigations.

6.0 References


10. Askarin MM, Wong K, Phan RCW, editors. Reduced contact lifting of latent fingerprint2017: IEEE.


53. Cruz TD, Robb SE. Methods for obtaining STR quality touch DNA from archived fingerprints. 2018.


Part Two

Manuscript

PLASTI DIP® AS A TOOL FOR LIFTING CELLULAR MATERIAL FROM COARSE SURFACES
Abstract

Currently, forensic investigators utilise various types of swabs and tape lifts to recover cellular material from coarse surfaces located during a criminal investigation. However, a number of challenges prevent successful recovery and therefore warrants the need for an alternative method. Plasti dip® is peel-off rubber coating that can be applied to most surfaces and may have an application in the recovery of DNA from coarse surfaces. Thus, the aim of this study was to determine the effectiveness of Plasti dip® to recover DNA from coarse brick surfaces and assess how this method compares to current practice. Cellular material was deposited onto brick pieces at varying concentrations, recovered with either flocked, foam or rayon swabs, or Plasti dip®, and subject DNA was then extracted and quantified. At low and medium cell concentrations, no statistical difference was observed between the swabbing methods and Plasti dip® but at high cell concentrations Plasti dip® was able to recover a significantly larger DNA concentration than swabbing. Quantitation results indicated no degradation of DNA was present, however, further research into the quality of DNA profiles generated from DNA recovered with Plasti dip® is required. Additional steps may be taken to increase the concentration of DNA recovered, however, this demonstrates the potential Plasti dip® has in future forensic investigations.

Keywords

Plasti dip®, bricks, DNA, swabs, cellular material
Table of Contents

Abstract and keywords...........................................................................................................40
Table of Contents....................................................................................................................41
List of Figures..........................................................................................................................42
List of Abbreviations...............................................................................................................42
1.0 Introduction.......................................................................................................................43

2.0 Materials and methods ....................................................................................................45
   2.1 Collection of cellular material.......................................................................................45
   2.2 Recovery of cellular material with flocked, foam and rayon swabs.........................45
   2.3 Recovery of cellular material with Plasti dip®.............................................................46
   2.4 Quantitation of extracted DNA....................................................................................47
   2.5 Statistical analysis .......................................................................................................47

3.0 Results ..............................................................................................................................48

4.0 Discussion..........................................................................................................................50

5.0 Conclusion.........................................................................................................................53

6.0 References........................................................................................................................53
List of Figures

Figure 1. The pattern followed when recovering deposited DNA with swabs.
Swabbing started at the centre of the brick, following the red path, then the green path, then the blue path, and finally the purple path back to the centre.

Figure 2. Quantified DNA concentration recovered with flocked, foam and rayon swabs, and Plasti dip®. Cellular deposit concentration of 1,000 cells (A: large autosomal target, B: small autosomal target), 10,000 cells (C: large autosomal target, D: small autosomal target), and 20,000 cells (E: large autosomal target, F: small autosomal target). Different letters above boxplots indicate significant differences between mean DNA concentrations across DNA recovery methods but within cellular deposit concentrations. P values indicate the relationship between DNA recovery methods. Statistical significance levels: * = P ≤ 0.005.

List of Abbreviations

DNA: Deoxyribonucleic acid
IPC: Internal PCR control
DI: Degradation index
1.0 Introduction

The collection of cellular material at crime scenes has become standard practice for forensic investigations, particularly from surfaces that persons of interest may have come into contact with. Upon contact, cellular material known as touch DNA is deposited onto the surface and can be used to generate a DNA profile for identification purposes (1). The most common methods of collection utilised by forensic investigators are swabs and tape, though their effectiveness to lift cellular material is highly dependent on the nature of the surface that the cellular material has been deposited onto. With various swab types available for purchase, successful DNA recovery can be achieved from most surfaces whilst tape lifts are used for cellular recovery from textiles such as clothing (2, 3). However, both swabs and tape lifts fail to efficiently recover cellular material from coarse surfaces such as rocks, stones, and bricks. For cases involving bricks, rocks, and stones, it may be the only significant piece of evidence and can provide investigators with a direct lead to persons of interest. For example, in 2005, a combined total of 489 assaults and robberies occurred in New South Wales where the type of weapon used was a rock, brick or other missiles (4). Further to this, 304 residential burglaries were reported in Victoria in 2018 that involved the use of rocks, bricks or other missiles (5). Overall, there is a demand in forensic investigations for further research into the development of an effective method to recover cellular DNA from coarse materials such as bricks.

There are a number of challenges surrounding the recovery of cellular material from coarse surfaces that contributes to the ineffectiveness of swabs and tapes. Firstly, due to the porous nature of coarse surfaces, cellular material is trapped within the pores and cannot be successfully recovered with swabs or tape lifts (6). Although it has been hypothesised that these pores protect trapped material from degradation
compared to non-porous surfaces, this has yet to be successfully tested as a result of low concentrations of recovered DNA (6). Additionally, upon contact with the coarse surface, swabs tend to fray and tape lifts rapidly lose their adhesive ability suggesting they are not suitable for recovery from bricks (7). Attempts have been made to recover cellular material with the M-Vac® wet-vacuum system, however, the system is currently unable to recover cell-free DNA and uses a buffer solution that can cause cell lysis over time due to its hypotonic nature (8). As the M-Vac® system may also not be available for some laboratories, the need for a simple and readily accessible method to recover cellular material from bricks is apparent.

To overcome the challenges preventing the successful recovery of cellular material from coarse surfaces, a product known as Plasti dip® may be a feasible alternative to swabs and tapes. Plasti dip® is a multi-purpose rubber coating that can be applied to a range of surfaces to act as a protective barrier against moisture, acids, abrasions, weathering and corrosion (9). Available in an aerosol can for a “convenient spray for those hard to reach places”, Plasti dip® is readily available and low cost (9). In aerosol form, Plasti dip® starts as a liquid and becomes rubber in nature once dry, allowing it to be easily peeled off surfaces. Given this property, it was hypothesised that Plasti dip® in the liquid state could penetrate the pores of coarse surfaces and recover cellular material trapped within that may have been deposited during handling. Previous studies by Nguyen (unpublished) attempted to extract DNA from blood deposited onto brick surfaces and recovered with Plasti dip® (10). Recovered DNA was then quantified and it was demonstrated that when compared to foam swabs, Plasti dip® could recover similar concentrations of DNA. It was also demonstrated that buccal cells could also be recovered with Plasti dip® from brick pieces (10). Rylands (unpublished) successfully recovered low
concentrations of male amplicon Y DNA from buccal cells deposited onto brick pieces. However, further analysis into the recovery of genomic DNA is required to assess its potential application in the generation of DNA profiles (11). Therefore, this study aims to assess the use of Plasti dip® as a tool to effectively recover different concentrations of DNA from brick surfaces compared to flocked, foam and rayon swabs. DNA will be extracted from recovered material, quantified and compared to determine the effectiveness of Plasti dip® as a tool for DNA recovery.

2.0 Materials and methods

2.1 Collection of cellular material

A male volunteer was instructed to perform a mouth rinse with approximately 20 mL of 0.9% saline solution and deposited into two 10 mL tubes. This process was repeated over a period of seven days until eight mouth rinses were performed. Recovered cells were counted on a Boeco Blood Counting Chamber, Neubauer improved (Boeco, Germany) and concentrated to 150 cells/µL.

2.2 Recovery of cellular material with flocked, foam and rayon swabs

Brick pieces were sterilised by soaking in a 5% bleach solution for 30 minutes. Approximately 1,000 cells were randomly deposited onto ten brick pieces (approximately 7×7 cm) by a volunteer, avoiding a one cm border around the edge of the brick. This was then repeated with a cellular concentration of 10,000 and 20,000 cells. Brick pieces were incubated for approximately 90 minutes before the entire brick surface was swabbed in a circular pattern (Figure 1.) with a regular flocked FLOQSwab® (COPAN Brescia, ITA). The swab head was excised into a microfuge tube and DNA extraction was performed with a QIAamp® DNA Investigator Kit
Figure 1. The pattern followed when recovering deposited DNA with swabs. Swabbing started at the centre of the brick, following the red path, then the green path, then the blue path, and finally the purple path back to the centre.

(QIAGEN Hilden, DEU) as per the operation handbook for a nonejectable swab with the following modifications; swab heads were incubated in a thermomixer at 56°C with shaking at 900 rpm for 90 min. Extracted DNA was eluted into a final volume of 40 µL in buffer ATE and stored at -20°C. This method was then repeated with foam Catch-All™ Sample Collection Swabs (EPICENTRE Wisconsin, USA) and COPAN® rayon plastic shaft swabs (Interpath Services Vic, Australia).

2.3 Recovery of cellular material with Plasti dip®

Cellular material was recovered using the following methods; cells were deposited onto brick pieces, six coats of Plasti dip® was applied to the entire brick faces, allowing for each coat to dry for approximately 15 min before applying a new coat.
Once the final coat was dry, Plasti dip® was peeled away from the brick and excised with scissors into a sterile petri dish. DNA extraction was then completed using the QIAGEN kit as per the operating instructions with the following modifications; excised Plasti dip® was separated into three 2 mL microfuge tubes per piece and 1 mL of buffer ATL was added to each tube to fully submerge Plasti dip® pieces. Tubes were then incubated in a thermomixer at 56°C with shaking at 900 rpm for 90 min. Following the second incubation at 72°C, three tubes containing a single piece of Plasti dip® were centrifuged through a single column, 700 µL at a time. Tubes remained at 72°C until ready to be spun through the column to prevent the reformation of white precipitate. Extracted DNA was eluted into a final volume of 40 µL in buffer ATE and stored at -20°C.

2.4 Quantitation of extracted DNA

Extracted DNA was thawed and quantified using a Quantifiler™ HP DNA Quantification Kit (Thermo Fisher Scientific California, USA), following the manufacturer’s protocols. All reactions were conducted in a 384 well plate, with the addition of four negative controls and duplicate standards. Reactions were run and analysed on a QuantStudio6 Flex system (Applied Biosystems California, USA).

2.5 Statistical analysis

The total quantity of DNA retrieved from brick surfaces was assessed across the independent variables (DNA concentration, swab type, DNA autosomal target). All analyses were performed with R statistical software version 3.1.4 (12). The data was checked for normality using the shapiro test using the rcompanion package before an ANOVA was undertaken to determine differences between the various treatments (13). Differences in dependent variables across DNA concentration swab
type were then analysed using Tukey’s honest significant difference test employed for post-hoc analysis using the *agricolae* package (14).

### 3.0 Results

For DNA recovered with all methods, no inhibition was observed as per the IPC. For bricks treated with 1,000 cells, flocked, foam and rayon swabs recovered DNA concentrations ranging from 0.002–0.015 ng/µL, 0.001–0.056 ng/µL and 0.006–0.0001 ng/µL respectively with one replicate from each swab producing a negative result due to an undetected DNA concentration. Plasti dip® recovered DNA concentrations ranging from 0.034–0.001 ng/µL. For bricks treated with 10,000 cells, flocked, foam, and rayon swabs, and Plasti dip® recovered DNA concentrations ranging from 0.031–0.008 ng/µL, 0.020–0.002 ng/µL, 0.027–0.007 ng/µL, and 0.245–0.030 ng/µL respectively. For bricks treated with 20,000 cells, flocked, foam, and rayon swabs, and Plasti dip® recovered DNA concentrations ranging from 0.027–0.003 ng/µL, 0.038–0.015 ng/µL, 0.028–0.013 ng/µL, and 0.222–0.030 ng/µL respectively. Across all cellular deposit concentrations, flocked swabs produced the lowest average Degradation Index (DI) of 0.81, Plasti dip® and foam produced a DI of 0.97 and 1.3 respectively, and rayon swabs produced the highest DI of 1.8.

When assessing the total amount of DNA retrieved there was no statistical significance between the different recovery methods in the brick pieces treated with 1,000 cells or 10,000 cells in both the large and small autosomal target DNA concentration (Figure 2A, B, C, D). However, there was a statistically significant relationship for brick pieces treated with 20,000 cells (*P* = 0.0123* at long autosomal DNA target and *P* = 0.0139* at small autosomal DNA target; Figure 2E, F). In the higher DNA concentration, quantified DNA concentration recovered with Plasti dip®
Figure 2. Quantified DNA concentration recovered with flocked, foam and rayon swabs, and Plasti dip®. Cellular deposit concentration of 1,000 cells (A: large autosomal target, B: small autosomal target), 10,000 cells (C: large autosomal target, D: small autosomal target), and 20,000 cells (E: large autosomal target, F: small autosomal target). Different letters above boxplots indicate significant differences between mean DNA concentrations across DNA recovery methods but within cellular deposit concentrations. $P$ values indicate the relationship between DNA recovery methods. Statistical significance levels: * $= P \leq 0.005$. 
was significantly higher than flocked, foam and rayon swabs for both the large and small autosomal targets (Figure 2E, F).

4.0 Discussion

As to be expected, all methods recovered the lowest DNA concentration from bricks treated with 1,000 cells and as the cell number increased so did the recovered DNA concentration. For bricks treated with 10,000 cells, no statistically significant difference was observed between all swab types and Plasti dip®, while Plasti dip® recovered a significantly higher DNA concentration than all swab types from bricks treated with 20,000 cells. Previous studies have indicated that the amount of DNA that is deposited onto a surface during contact ranges between 0 ng and 170 ng (15). Given that the amount of DNA deposited in the present study is within this range, these results suggest that Plasti dip® may be a superior method to swabbing when recovering DNA from bricks. Additionally, these results indicate that Plasti dip® may have an application as a tool used in future forensic investigations. Given the uniqueness of brick surfaces, further studies need to be conducted into its ability to recover DNA from other coarse surfaces such as stones and rocks. However, as rocks and stones display varying attributes such as compositions, texture, and porosity, a large sample size would be required (16). Additionally, alterations to methodology would also be necessary due to the irregular shaping observed in rocks and stones that may make Plasti dip® application and removal difficult.

Although not an intended component of the study, it was found that bricks that had previously been treated with Plasti dip® before undergoing this experiment showed increased levels of recovery compared to untreated brick pieces (data not shown). For this reason, previously treated bricks were removed from analysis. Although
previous traces of Plasti dip® were removed, it was noted that upon deposition of the cellular suspension that previously untreated brick pieces absorbed the suspension faster compared to the previously treated brick pieces. This suggests that Plasti dip® may have still been present within the pores of brick, thus keeping the cellular material closer to the surface and preventing it from being trapped. A similar variation was also observed during quantitation, with some recovery methods producing a 6 ng/µL difference between previously treated and untreated brick pieces. In future applications and research, consideration should be taken as these results suggest that Plasti dip® can only be applied once to a surface and that any further methods may be affected.

Flocked swabs and Plasti dip® both generated an average DI less than one, suggesting that no degradation has occurred. Rayon and foam swabs both generated an average DI above one but below 10, suggesting that slight DNA degradation has occurred. Although this is an acceptable indication of DNA quality, further analysis is still be required to determine the quality of DNA profiles that will be generated and identify if contamination occurred during extraction. Previous studies have determined that although large concentrations of DNA can be recovered, this does not guarantee the generation of high-quality DNA profiles (2, 6, 8). For example, flocked swabs were able to recover larger concentrations of DNA than foam swabs from brick pavers but were unable to generate any full DNA profiles (2). Similar results were observed when analysing the integrity of DNA collected with flocked swabs, which became significantly degraded after six months of storage compared to other swab types (17). In addition, a study by Hogan et al. (2018) demonstrated that DNA recovered from brick surfaces degraded over 20% more than DNA recovered from other surfaces such as carpet, wood, and tile (6). For this
reason, future research into Plasti dip® should look at the effect it may have on the generation of DNA profiles, which will increase the credibility of Plasti dip® as a tool that forensic investigators can use to recover DNA.

All swab types generated a consistently low concentration of DNA, with no replicate recovering more than 0.1 ng/µL of DNA regardless of DNA concentration. Aside from the swabs' inability to penetrate the pores of the brick surfaces, this low concentration may be attributed to the absorptive nature of the swabs that can result in a reduced extraction and recovery efficiency. Bruijns et al. (2018) observed an extraction and recovery efficiency less than 50% for rayon, cotton, foam and flocked swabs, suggesting that a large concentration of DNA remains on the swab head (18). These results were largely affected by the model of swab applied, with flocked swabs generating up to a 40% difference between same branded varieties (19). Similar results were observed when recovering touch DNA from brick pavers with a range of swab types (2). Verdon et al. (2014) reported that two different varieties of Puritan foam swabs generated two very different extraction and recovery efficiencies (2). This suggests that the concentration of recovered DNA could be increased simply by changing the brand or variety of swab applied. Additional steps could also be taken during DNA extraction to improve the concentration of recovered DNA. For example, following the transfer of the lysate to a spin column, the QIAamp® DNA Investigator Handbook recommends the application of a QIAshredder™ spin column to the swab head to collect any lysate that may remain within (20). Similar recommendations are provided for COPAN® flocked swabs, with the company recommending the use of a NAO™ Basket to assist in the recovery of all lysate from the swab head (21). Although this method was not utilised in this study, research suggests that when comparing the concentration of DNA recovered with and without
the use of the QIAshredder™ and NAO™ Basket, in most instances the additional step lead to greater concentrations of recovered DNA (22, 23). This suggests that its application in the present study may lead to an increased DNA recovery for all swab types.

5.0 Conclusion

The recovery of cellular material from touched surfaces can provide forensic investigators with valuable information about persons of interest involved with crimes. However, a number of challenges prevent the recovery of material from coarse surfaces such as bricks and stones. In the current study, Plasti dip® was applied to brick surfaces in an attempt to overcome these challenges and successfully recover quantifiable DNA. Although low and medium cellular deposit concentrations resulted in no significant difference, Plasti dip® recovered significantly more DNA at a high cellular deposit concentration compared to the three currently used swab types. However, this study also found that surfaces previously treated with Plasti dip® may be unable to undertake further recovery methods as traces of Plasti dip® may remain. Although further studies are required to determine the quality of DNA profiles that are generated from extracted DNA, this research demonstrates the application Plasti dip® may have for the recovery of cellular material from brick surfaces in future forensic investigations.

6.0 References

1. van Oorschot RAH, Jones MK. DNA fingerprints from fingerprints. Nature. 1997;387(6635):767-.


