Development of a Method to Recover Fingerprints from Textured Surfaces

By

Jane Purtell

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

Master of Forensic Science (Professional Practice)

in

College of Science, Health, Engineering and Education

Murdoch University

Associate Professor James Speers (Murdoch University)

Elliot Cottrill (WA Police)

Semester 1, 2021

Declaration

I declare that this thesis 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 reference has 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:

Jane Purtell

20/07/2021

Acknowledgements

I would like to acknowledge and express my thanks to my supervisors Associate Professor James Speers and Elliot Cottrill for their guidance and support through out the completion of the project.

Table of Contents

Blank Page – not numbered

Part One

Literature Review

Development of a Method to Recover Fingerprints from Textured Surfaces

Abstract

Latent fingerprints have a high evidentiary value but are currently being underutilized from textured surfaces like dashboards. There is no current method to lift latent fingerprints from a textured surface. Dashboards are the principal surfaces for several crime types, and being able to lift fingerprints from their surfaces would help investigators. The problem with dashboards is the textured nature of their surface prevents the current methods from working. Enhancement methods looked at is the powder type used for initial enhancement. A lifter or casting material could be used to detach the print from the surface without texture affecting the fingerprint. It was noted that after lifting, the fingerprint would not have high contrast with the surface, so cyanoacrylate fuming and dyed with rhodamine 6G would happen to increase contrast, both cyanoacrylate fuming and rhodamine 6G both works used extensively for current methods to enhance contrast. Lifters and casting materials were neither research in there use for and results on textured surfaces and should be researched more extensively.

Contents

List of Tables

List of Figures

List of abbreviations

FRS - Friction Ridge Skin

CA - Cyanoacrylate

R6G – Rhodamine 6G

BY40 – Basic Yellow 40

1.0 Introduction

Fingerprints are commonly found at crime scenes and are held in high regard due to their high discriminatory value [3,5,6,8] and they can be used to identify a person and provide an idea of event sequences to a crime scene [1,4,5,6]. A fingerprint has a high evidentiary value because of the uniqueness of each person, and fingerprints can be used to collect other types of evidence such as DNA and environmental data to give information on where a person has been [1,4,5,6]. Latent fingerprints are the most common type of fingerprints found at crime scenes [4,5,6,8,9]. The development of latent fingerprints is a process that begins with the least destructive method and moves through to the most destructive methods for analysis to maintain the integrity of the print but also to preserve any other evidence collection like DNA [9,10,11,12]. Analysis of fingerprints is done through three methods: Optical, physical, and chemical methods [6,9,11]. Optical methods include using different lights on different wavelengths to expose the fingerprint. The optical methods are non-destructive unless high UV light is used as the DNA can degrade [6,9,11]. The use of the physical and chemical happens after the optical methods as these methods are more destructive and rely on the type of surface the fingerprint has been deposited on [6,9,11]. The surfaces fingerprints can be deposited on are porous, non-porous surfaces and semi-porous surfaces. Numerous crimes involve cars like theft, motor vehicle accidents, getaway cars, and abductions. Therefore, a vehicle's dashboard can hold a history of who has been in the vehicle, providing that latent fingerprints can be lifted from its textured surface. A car's dashboard is a non-porous surface generally made of plastic [7].

The enhancement of a non-porous surface using physical and chemical techniques begins with the most common technique: powdering. There are three main types of powders fluorescent, non-fluorescent and magnetic [5,9,10,12,11,15,16]. The powder used depends on the surface texture and colour as the goal is to get maximum contrast between surface and fingerprint [5,10,15,16]. Due to the textured nature of a dashboard after the powder is used to expose a latent print, another method must be used to separate the fingerprint from the surface to identify the ridge details and individual characteristics of the print, as the texture of the surface makes it hard to see the fingerprint detail on the surface of deposition [9,16]. There are fingerprint lifters and limited casting methods to remove a fingerprint from the surface and maintain the integrity of the fingerprint [17,18,19,20,21]. After being lifted from their original non-porous surface, latent fingerprints may not have a high level of contrast, so cyanoacrylate fuming and rhodamine 6G dye staining can be used to enhance the contrast to see the print in more detail [23,24,25]. To address the research gap of there being no technique to lift latent fingerprints from dashboards or highly textured surfaces, the whole enhancement process is being considered from the best powder to use to what type of lifter and casting material as fingerprint evidence research does not mention many casting materials that can be used.

2.0 Discussion

2.1 Fingerprint Background

2.1.1 Fingerprint Formation

The anatomy of the skin allows fingerprints to form and maintain their integrity throughout an individual's life despite continued use of the skin and the sloughing of the skin cells [1,2]. The skin comprises the epidermis, dermis, and underlying subcutaneous tissue[2][3]. The epidermis layer of the skin protects the body by creating a barrier between the outside and the inner functions of the body, the friction ridge skin (FRS) on the epidermis consists of ridges and furrows and is found on the finger, palms, and soles of the feet [1,3]. FRS is formed around the tenth week of embryonic development and remains unchanged until death [1]. The FRS is maintained due to the nature of the epidermis as the skin is constantly replacing the cells that slough off due to use or death; the attachment of the epidermis to the dermis helps to maintain the integrity of the FRS during the constant state of change over through providing nourishment for the epidermis by holding all the blood vessels and providing a secure attachment bridge through keratinocytes [3]. Keratinocytes reinforce the skin to prevent skin breakage at the first sign of physical stress to the skin and form a layer of cell interaction between the epidermis. Dermis layers of the skin where the primary and secondary ridges are attached at the stratum basal, the primary and secondary ridges form the ridges and farrows seen on the fingerprint [3]. Due to the reparative nature of the epidermal layer and the keratinocytes, it is tough to change the unique pattern of an individual's friction ridges. It can only occur when there is severe damage between the dermis and epidermis at the connective sites [3].

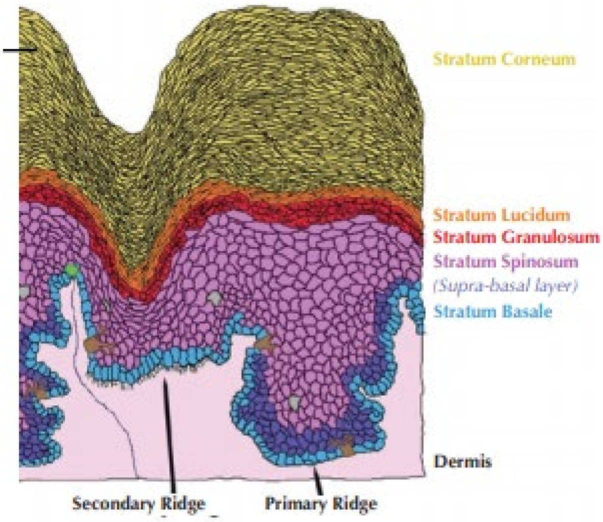

Figure 1: Structure of the skin showing the connective layer of keratinocytes at the Stratum Basale [3]

2.1.2 Latent Fingerprints

There are three types of fingerprints found at crime scenes: plastic, patent, and latent [6]. Plastic prints are fingerprints that have been deposited onto surfaces that can conform around the finger to form a 3D print like plasticine and chewing gum [6]. Patent prints occur when residue on the finger-like blood, oil, or dirt is transferred to a surface upon deposition of the fingerprint [6]. Latent fingerprints are invisible to the naked eye and require enhancement by optical, physical, or chemical means to be seen [1,6,9]. Latent fingerprints are the most common fingerprint found at crime scenes and are the fingerprint type found on dashboards in cars [1].

Latent fingerprints are composed of natural secretions from the glands around the body. They are mainly comprised of eccrine and sebaceous secretions transferred onto a substrate resulting in the impression of the FRS onto the surface [3,4,6]. Latent fingerprints can contain a mix of substances that can be either natural or foreign contaminants [4]. The most common type of latent print is an eccrine fingerprint. Eccrine glands are the only glands present on the FRS and produce sweat which is why eccrine fingerprints comprise about 98% water and 2% other varying organic and inorganic compounds (table 1) [4]. A latent sebaceous fingerprint is composed of a majority of lipids, including fatty acids, glycerides, and squalene (table 1); sebaceous glands are present all around the body except for on the FRS [2,4]. Apocrine glands are present in the armpits, breast, and groin and secrete water and iron [2,4]. Latent fingerprints will not always have just one source as touching the face can combine eccrine and sebaceous on the one latent print. There are contaminants on the skin and the deposition surface that can alter the composition of a latent fingerprint [4].

Table 1: Constituents of gland secretions [4]

Source\constituents	Inorganic	Organic
Eccrine glands	Chlorides Metal ions Ammonia Sulphate Phosphate	Amino acids Urea Lactic acids Sugars Creatinine Choline Uric acid
Sebaceous glands	–	Glycerides Fatty acids Wax esters Sterol esters Sterols Squalene Hydrocarbons Alcohols
Apocrine glands	Iron	Proteins Carbohydrates Cholesterol

2.2 Fingerprint Deposition Surfaces

There are many surfaces that fingerprints can be deposited onto; these surfaces can be broken up into three types: non-porous, semi-porous, and porous surfaces. The higher the porosity of the surface, the further a fingerprint residue will be absorbed into the surface changing enhancement method that can be used on the surface to make the fingerprint visible [(3)]. The surfaces of a car dashboard in modern cars are one of four types of plastic: Polypropylene, polyvinyl chloride, polycarbonate, and acrylonitrile butadiene styrene [(7)]. In older cars, the dashboard is covered in a vinyl top; all of the dashboard materials used in vehicles are non-porous surfaces [(7)]. Although the surface of a dashboard is non-porous, some of the casting techniques that will be mentioned have been tried on porous and semi-porous surfaces to varying degrees of success.

2.2.1 Non-porous surface

Non-porous surfaces are surfaces that will not absorb moisture. Thus the latent fingerprint will stay on the surface of the deposition material but will be more susceptible to damage as the fingerprint residue is easier to remove as it can be wiped off. The environment around the print can contain contaminants and temperature and can evaporate some components of the fingerprint residue (3). To enhance fingerprints on non-porous surfaces, powders, light sources, and CA in conjunction with a dye are often used (3). Textured substrates provide a problem as there is incomplete contact between the substrate and the FRS, resulting in the fingerprint being segmented and lacking in third-level detail (3).

2.2.2 Porous surface

Porous surfaces are absorbent surfaces and not made from dense materials; porous surfaces include paper, cardboard, wood, and bricks (3). Fingerprints deposited onto porous surfaces absorb the water-soluble components of the fingerprint, such as the amino acids, into the surface while the water-insoluble components get evaporate. These factors make fingerprints in porous surfaces more durable than fingerprints deposited onto non-porous surfaces (3). Amino acid techniques are best for porous surfaces as ninhydrin, as once absorbed, the amino acids remain stationary and do not migrate (3).

2.2.3 Semi-porous surface

semi-porous surfaces can absorb or repel fingerprint residue, thus need to be treated with enhancement processes for both porous and non-porous surfaces (3). semi-porous surfaces include glossy cardboard, glossy magazines, and finishes that create a non-porous barrier over a porous surface like on some wood finishes (3).

2.3 Powdering

Powdering a fingerprint impression is one of the most common ways to enhance an impression, by powdering the impression first allows other techniques to be used on the impression afterward as lifting, casting, and chemical methods can be layered on top of powdered fingerprints [8]. Fingerprint powdering works by a brush being used to spread the powder across a surface to reveal a fingerprint ridge detail; the powder adheres by resinous polymer to the secretions of FRS deposits left on the surface [8,9,14]. The particle size of a particular fingerprint powder is vital as the finer particles can better enhance a print due to more of the finer characteristic detail of the print being enhanced somewhat bigger coarser particles that adhere less to a print [5,10,11].

2.3.1 Carbon black powder

Carbon black powder is one of the most widely used fingerprint powders for developing latent fingerprints [5]. Carbon black powder is widely used due to the versatility of the powder as it can be used on many surfaces and produces good contrast results. The powder is not effective on darker surfaces as there is no contrast between the surface and developed print [5,10]. The versatility of the carbon black powder is that it can be mixed with other powders to change the colour slightly to a grey if combined with white titanium-based powders [12]. Carbon black powder is a carbon-based powder with a particle size of around 80nm to 800nm [10,11]. Due to the relatively small nature of the particle carbon black powder, it is easier to spread across a surface and obtain highly detailed prints as the smaller particles have higher adherence to the fingerprint residue than a bigger particle allowing for more second and third level detail to be seen [10,11]. Limitations to the carbon black powder are that it is applied to a surface using a fingerprint brush and can damage the fragile prints by smudging the print if there is too much pressure applied to the brush [9,10].

2.3.2 Magnetic powder

Magnetic fingerprint powders work in much the same way as the carbon black powders and come in a range of colours as fluorescent dyes have been added to the magnetic powder to enable both black and colour options for the powder [15]. Magnetic fingerprint powders hold an advantage over regular fingerprint powders as magnetic powders have a larger optimum diameter and have lower background powder staining. The excess powder can be removed with a magnetic applicator without brushing over the surface [15]. Magnetic powders are made with a high iron flake content and have an average particle size of 0.5 nm but are composed of both finer and more coarse particles for a higher visualization of the latent print [10,11,15].

2.3.3 Fluorescent Powders

Fluorescent fingerprint powders have had an added dye to enable the powder to fluoresce under different wavelengths of light to increase the contrast between deposited surface and enhanced fingerprint [1,8,9,16]. Fluorescent fingerprinting powders come in a range of colours, with the most frequently used ones being in redescent and greenescent; the average particle size for fluorescent powders is 0.125nm [12,16]. The significantly finer nature of the particles in fluorescent powders allows for the easy spread of the powder. Still, it can also cause problems as the powder is so fine excess powder can collate around the fingerprint, increasing the background staining to the degree that the fingerprint is not as legible [1,12,15,16]. The fluorescent powder has a similar problem to that of the carbon black powder. The application method for both powders is with a fingerprinting brush, which can damage the print and limit the ability to remove the excess powder from the print [9,12,15]. Perhaps one of the most significant limitations to fluorescent powder is the finer particle that makes it a great powder also increases the risk of contamination to the area surround the powders as the powder is so fine if the environmental conditions are windy, the powder will blow everywhere. It can be moved from human breath making contamination an issue [9,12,15,16].

The finer nature of the magnetic and fluorescent powder particles makes them a better choice for powdering the textured surface of a dashboard as more second and third-level characteristics would increase the validity of the fingerprint evidence value [10,11,12,15,16]. Florescent dyed powders are suitable for their fine particles. Still, studies have had the problem of causing contamination to the area and through the application technique of using a brush-damaged fingerprint [9,15]. A study [9] used fluorescent dyed powder to enhance fingerprints on the textured surface of bricks and limestone, and the powder was found to spread well across the surface of the fingerprint. Still, the powder became packed into the rough areas of the brick and limestone, making the print illegible [9]. The study [9] shows that using a brush to apply the powders does not work, and it was suggested that a magnetic applicator could work better as it could help control the amount of powder added. As magnetic powder has yet to be tried to enhance fingerprints on textured surfaces but, has been suggested by multiple studies [9,12] that it might work better at getting complete coverage of the fingerprint without the effect of packing too much powder into the textured crevices as the magnetic applicator could work to pull out excess powder [8,9,12].

2.4 Fingerprint Lifters

Fingerprint lifters are used to lift powdered fingerprints off of the original surface of deposition; to identified and record in a greater value than the been left on the original deposition surface [8,9,17,18]. Fingerprints are often lifted from curved surfaces or reflective surfaces. The lifter adhesive portion is partially removed from the acetate backing and used as a hinged lifter [8,17]. To lift a powdered fingerprint, the correct lifter needs to be chosen to achieve optimum contrast; fingerprint lifters often come in three colours: white, transparent, and black [9]. The adhesive sheet used to lift the fingerprint is ridged and has a sticky adhesive on one side. To lift the print, the sheet is cut to size, and the adhesive is placed over the fingerprint and gently pressed down to remove air bubbles and cover the entire print [9,17,18]. The lifter is then removed and adhered down onto the acetate backing for storage and visualization. The adhesive composition of lifters is not known as it is proprietary information but, it is known to some degree the composition of certain lifters [18]. The BVDA instant lifter is a low tack adhesive designed to lift the fingerprint powdered fingerprint but not lift heavier contaminants surrounding the fingerprint; alternatively, the SceneSafe FAST tape is an adhesive lifter intended for practical use and has a strong adhesive than the BVDA instant lifter [18]. A limitation of adhesive lifters is that the lifter is made of stiff plastic back to the adhesive section and thus doesn't work as well on textured surfaces as lifters will lift the fingerprint but also transfer the pattern of the textured surface to the lifter as well, this makes this type of lifter not suitable for lifting on textured surfaces [17,18].

Gel lifters have different adhesive to standard lifters; the adhesive is made from low-adhesive gelatin material and flexible enabling gel lifters to conform more easily to the surface; the lift is being taken from making gel lifters better for taking fingerprint lifts from textured surfaces [18]. The BVDA gel lifters can lift a fingerprint with visible ridge detail from non-porous surfaces; the prints lifted showed the ridges being lighter than the furrows, which was implied that the powder was reacting with the adhesive gel [9,18]. The BVDA gel lifter was also tested on lifting fingerprints from porous surfaces – this did not work, and no fingerprint was successfully lifted [9]. DNA was able to be collected off of the lifted fingerprint from the non-porous surface [9]. As the studies did not test the ability of the BVDA gel lifter on textured surfaces is unclear as to whether the gel lifter will be able to lift a detailed fingerprint from a textured surface without facing the same problems as the ordinary adhesive fingerprint lifter.

2.5 Casting Techniques

The use of casting techniques is more prevalent in the recovery of footwear impression evidence than in the recovery of latent fingerprints. Some of the casting methods used for footwear casting that could be used to cast a latent print on a textured surface have not been tried (19,20,21). Latent fingerprint casting has some casting materials that are not used for footwear casting, such as silicone and latex (22). Forensic service manufacturers have developed silicone and latex materials to recover latent fingerprints (22). One of the products, isomark, is a fast-curing casting silicone made initially to recover mechanical marks (22). Isomark silicone has been tested to recover fingerprints on non-porous surfaces with metal and plastic materials; the latent fingerprints were lifted from these surfaces and had a high level of detail, and were given scores of 4 on the bandey scoring scale (22,26). The same study tested the silicone on a £ coin with a textured surface; the latent print lifted with the silicone was rated to only be two on the bandey scoring scale and was not of great quality (22,26). A significant limitation for this method is because the silicone is spread thin, the lifted print is not on a stable surface as the silicone was noted to tear easily and could not be packed with an acetate sheet as with lifters as the latent fingerprint would get damage, the way to store and preserve the fingerprint was to CA straight after the fingerprint had to be recovered (22).

Dental stone and dental alginate are both casting materials used for footwear impression; dental stone is the only of the two used to cast fingerprints (19,20,21). Dental stone and dental alginate are casting materials that dentists use to make a cast of teeth and bite marks (20,21). The fingerprints cast with dental stone were lifted from non-porous smooth and some slightly dimpled surfaces such as a keyboard [20]. The latent fingerprints on the surfaces were first powdered with a magnetic powder, then lifted with a lifter and cast with dental stone [20]. The results showed that using the lifter, the fingerprints obtained were of bad quality, but using the dental stone to cast the lifted prints had visible ridge detail [20]. A problem found in the study was that the dental stone got stuck to the surface around the print as well as the print and made removal of the dental stone harder, these results contradict a study [19] done that found that powdered fingerprints and footwear impressions required a fixative like hairspray to fix the powder in place as casting materials would disturb the powder and the prints would lose detail [19,20]. Dental alginate is similar to dental stone but has successfully lifted footwear impressions from more surfaces than dental stone and thus might work over dental stone to lift a latent print from textured dashboard; a limitation with the alginate is that the cast shrinks after it is fully dried so the latent fingerprint would need to be photographed immediately to preserve the fingerprint [21].

2.6 Cyanoacrylate Fuming

CA fuming is a chemical enhancement method used for latent fingerprints, CA fuming is a widespread method to enhance a latent fingerprint further. It can be used in conjunction has been used in conjunction with isomark silicone casting to preserve a print [9,10,20,22,23]. CA fuming works by interacting with the eccrine components of a fingerprint; the CA esters polymerise in the ambient temperature and is helped by a weak base such as water [23]. The presence of water in the fuming chamber increases the humidity; if there is not enough water in the chamber, the low humidity can cause a weakly developed fingerprint as there is not enough water to re-hydrate the fingerprint [23]. A reaction occurs, allowing the polycyanoacrylate molecules to bind to the FRS, creating a hard white polymer [23].

Contaminants in the fingerprint residue like sodium lactate and NaCl can inhibit the CA reaction [23]. Limitations involved with CA fuming included the lack of contrast on lighter coloured substrates and the development of aged fingerprints as the CA transparency on the ridges occur.

There is a one-step CA process where a luminescent dye is incorporated with the CA to minimize handling time [24]. The one-step fuming process produces better results for aged fingerprints than regular CA. Due to the dye being added, the fingerprints are developed slowly over 60 minutes but found that the fluorescent dye added to the CA lost some of their intensity, making it. Hence, the two-step process had better contrast in the end [24].

2.6.1 Rhodamine 6G

Dyes are used to enhance further the contrast between the CA fingerprint and deposited substrate on non-porous and semi-porous surfaces, and different dyes can be used with CA [23,25]. R6G is a dye often used in conjunction with CA as R6G being an anion, has a strong affinity for CA as CA is a cation [23]. R6G fluoresces under 532nm light [23]. Alternatively, countries like the UK use BY40 dye as it is ethanol-based instead of methanol-based like R6G because of suspected health risks. BY40 stains CA green-yellow; for surfaces that are not compatible with ethanol, the UK uses basic red 14 [25].

2.9 Qualitative assessment

The qualitative assessments are used to determine the quality of the developed fingerprint based on the amount of first through third level detail that can be seen.

2.9.1 Level one detail

The first level detail consist of the class of the fingerprint and direction of flow [3,6,27]. The classes of fingerprints are Loops, Whorls, and arches. Loops are the most common class of print, with 65% of the population having them; loops contain a delta and core [3,6,27]. A delta is a triangle shape within the print, and the core is the centre of the pattern. There are two types of loops radial loops and ulnar loops [3,6,27]. Radial loops flow downward towards the radius, and ulnar loops flow toward the ulnar [3,6,27].

Whorls occur in about ~35% of the population and consist of four different patterns: central pocket whorl, double loop whorl, accidental whorl and plain whorl [3,6,27]. A whorl consists of two deltas with a central core and a core. Plain whorls have a core surrounded by concentric circles [3,6,27]. Central pocket loop whorls have a loop with a whorl at the end or middle [3,6,27]. Double loop whorls occur when two loops form together producing an S shaped pattern. Accidental whorls is an irregular pattern [3,6,27].

Arches are the least common type of fingerprint occurring in ~5% of the population and do not have a delta or core [3,6,27]. Arches can be plain arches which have a gentle middle rise or tented arches that have a steep arch [3,6,27].

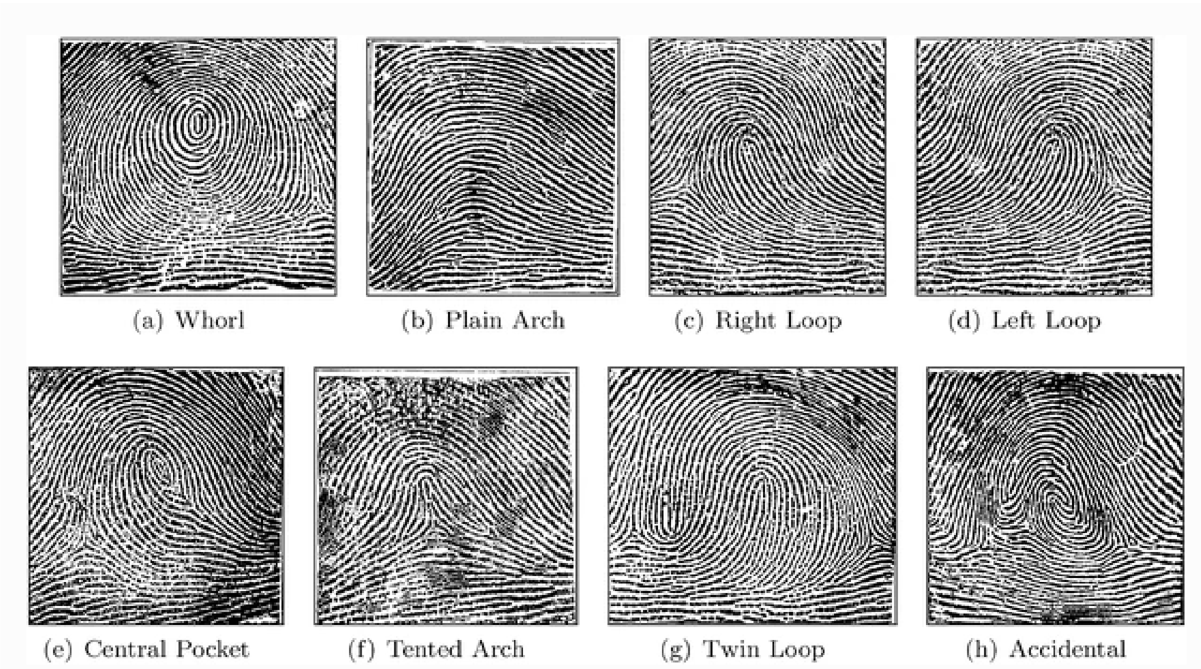

Figure 2: Different fingerprint patterns that make up level one details [27]

2.9.2 Level two detail

Level two detail looks at the minutiae of the fingerprint which are known as the discontinuation of the friction ridges [3,6]. The type of minutiae and location is important as it is different in everyone and is what makes each fingerprint unique [3,6]. Seven types of minutiae can occur in a fingerprint; they are: Bridges – small ridge joining two longer adjacent ridges, spurs- a notch protruding from a ridge, short ridge- small, isolate segment of ridge, dot or island – tiny round ridges, enclosure (lakes) – ridge that forks and forms complete circle and then becomes a single ridge again, bifurcations – ridges that split into two ridges, trifurcations can also occur a ridge splitting in three, ending ridge – a simple straight ridge [3,6].

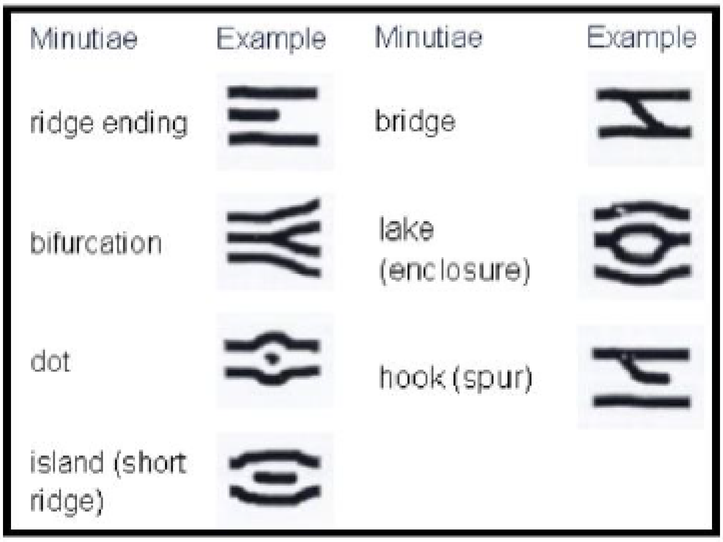

Figure 3: Different types of minutiae [27]

2.9.3 Leve three detail

The level three details are details associated with unique individuals [3,6]. Fingerprints consisting of any imperfections (scars and cuts), there location, position, and direction as well as starting and ending [3,6]. The ridge shape, width, size and distribution of pores is noted as it is different in every person thus contributes to uniqueness [3,6].

2.9.4 ACE-V

The ACE-V method is a way to analyse fingerprints and verify the results for comparative purposes. The steps of the process are: Analysis, Comparison, evaluation and verification (3,6). Analysis is the assessment of the print as it is on the substrate and looking for any distortion and what level of details are present in print (3,6). Comparison is direct or side-by-side comparison of the friction ridge detail to determine if the prints match; in this stage the examiner takes note of details size and location (3,6). Evaluation is a statement of the findings and how much the fingerprints match/don't match to the other (3,6). The verification stage an independent examiner does the entire process and reaches a conclusion that is compared to the previous conclusion (3,6). This method is mainly used in the field and is not see as a way to determine fingerprint clarity in studies.

2.9.5 Bandey five Point Scoring System

The bandey point scoring system is a five-point system developed by the UK Home Office and is used as a means of evaluating the quality of fingerprints for research (26). As it is used for research it is not as conclusive as the ACE-V method and the method is not used in real world cases (26). The method scores 0-1 for really bad fingerprints, 2 for average fingerprints and 3 and 4 for full fingerprint development (26).

Table 2: Bandey Five Point Scoring Scale (26)

Grade	Description
0	No development
1	No continuous ridges; all discontinuous or dotty
2	One third of the mark comprised of continuous ridges; remainder either show no development or dotty
3	Two thirds of the mark comprised of continuous ridges; remainder either show no development or dotty
4	Full development; whole mark comprised of continuous ridges

3.0 Aims and Hypothesis

From the research in the literature review, there has been minimal t research in the development of latent fingerprints from textured surfaces, particularly car dashboards. Thus, the aim of the experiment is to develop a method to lift latent fingerprints from dashboards.

Hypothesis 1:

H_1: Detailed fingerprints can be collected from the textured surface dashboard

H_0: Detailed fingerprints can not be retrieved from the textured surface dashboard

Hypothesis 2:

H_1: Fingerprints can be collected using casting method in small targeted areas

H_0: Casting methods will not work in small targeted areas

Hypothesis 3:

H_1: A dilution series of fingerprints lifted and DNA taken from the series to determine a cut-off point where the fingerprint can no longer be detailed.

H_0 : A dilution series of fingerprints lifted from the series to will not be able to determine a cut-off point where the fingerprint can no longer be detailed

4.0 Conclusion

Latent fingerprint enchantment methods depend on the type of surface the fingerprint is on and the features of the surface. The literature examined showed that for enhancement of a latent fingerprint on a textured non-porous surface, there has not been that much research contacted but, what was gathered was that powdering with a magnetic powder is best for a textured surface as the pressure applied can be modulated and the excess powder can be lifted from the background of the print. For lifting the fingerprint from the surface, the literature is pretty sparse, showing that both silicone and dental stone have been able to lift latent fingerprints in detail from smooth to lightly textured non-porous surfaces but no research into highly textured surfaces and the use of other casting materials for fingerprints. Footwear impression evidence was looked at to get ideas for different casting materials as the level of detail in footwear impression prints to fingerprints is similar. Fingerprint lifters were shown to lift non-detailed fingerprints from textured surfaces with gel lifters producing detailed fingerprints off of non-porous surfaces but there was no research into gel lifters on textured surfaces.

5.0 References

1. Kücken M, Champod C. Merkel cells and the individuality of friction ridge skin. J Theor Biol. 2013;317:229–37.
2. Kabashima K, Honda T, Ginhoux F, Egawa G. The immunological anatomy of the skin. Nat Rev Immunol. 2019;19(1):19–30.
3. Holder EH. U.S. Department of Justice Office of Justice Programs. Office.
4. Cadd S, Islam M, Manson P, Bleay S. Fingerprint composition and aging: A literature review. Sci Justice [Internet]. 2015;55(4):219–38. Available from: http://dx.doi.org/10.1016/j.scijus.2015.02.004
5. Weston-Ford KA, Moseley ML, Hall LJ, Marsh NP, Morgan RM, Barron LP. The retrieval of fingerprint friction ridge detail from elephant ivory using reduced-scale magnetic and non-magnetic powdering materials. Sci Justice [Internet]. 2016;56(1):1–8. Available from: http://dx.doi.org/10.1016/j.scijus.2015.10.003
6. Kasper SP. Latent Print Processing Guide. San Diego: Elsevier Science & Technology; 2016.

7. A&C Plastics. 4 Types of Plastic Used in Cars and Car Parts [Internet]. A&C plastics; 2021[cited 2021 April 25]. Available from: https://www.acplasticsinc.com/informationcenter/r/plastic-used-in-cars#:~:text=PVC%20is%20another%20common%20plastic,dashboards%20and%20automotive%20body%20parts.

8. Subhani Z, Daniel B, Frascione N. DNA Profiles from Fingerprint Lifts—Enhancing the Evidential Value of Fingermarks Through Successful DNA Typing. J Forensic Sci. 2019;64(1):201–6.

9. Davis L, Fisher R. Fingermark recovery from riot debris: Bricks and stones. Sci Justice [Internet]. 2015;55(2):97–102. Available from: http://dx.doi.org/10.1016/j.scijus.2015.01.006

10. Badiye A, Kapoor N. Efficacy of Robin® powder blue for latent fingerprint development on various surfaces. Egypt J Forensic Sci [Internet]. 2015;5(4):166–73. Available from: http://dx.doi.org/10.1016/j.ejfs.2015.01.001

11. Choi MJ, McDonagh AM, Maynard PJ, Wuhrer R, Lennard C, Roux C. Preparation and evaluation of metal nanopowders for the detection of fingermarks on non-porous surfaces. J Forensic Identif. 2006;56(5):756–68.

12. Sari SA, Ningsih H, Jasmidi, Kembaren A, Mahat NA. Development of gambir powder as a cheap and green fingerprint powder for forensic applications. AIP Conf Proc. 2019;2155(September).

14. Sodhi GS, Kaur J, Garg RK. Fingerprint Powder Formulations Based on Organic, Fluorescent Dyes. J Forensic Identif. 2004;54(1):4–8.

15. Gürbüz S, Özmen Monkul B, Ipeksaç T, Gürtekin Seden M, Erol M. A Systematic Study to Understand the Effects of Particle Size Distribution of Magnetic Fingerprint Powders on Surfaces with Various Porosities. J

Forensic Sci. 2015;60(3):727–36.

16. King RSP, Hallett PM, Foster D. Seeing into the infrared: A novel IR fluorescent fingerprint powder. Forensic Sci Int [Internet]. 2015;249:e21–6. Available from: http://dx.doi.org/10.1016/j.forsciint.2015.01.020

17. West MJ, Went MJ. The spectroscopic detection of drugs of abuse in fingerprints after development with powders and recovery with adhesive lifters. Spectrochim Acta - Part A Mol Biomol Spectrosc. 2009;71(5):1984–8.

18. Plaza DT, Mealy JL, Lane JN, Parsons MN, Bathrick AS, Slack DP. Non-destructive Biological Evidence Collection with Alternative Swabs and Adhesive Lifters. J Forensic Sci. 2016;61(2):485–8.

19. Sabolich AR. A Comparison of Hydrophobic Barriers for Casting Footwear Impressions in Water-Soluble Food Products. Journal of Forensic Identification 2018 Apr;68(2):207-221.

20. Knaap W, Adach E. The Knaap process: Lifting two-dimensional footwear and fingerprint impressions using dental stone. J Forensic Identif. 2002;52(5):561–71.

21. Farrugia KJ, NicDaéid N, Savage KA, Bandey H. Chemical enhancement of footwear impressions in blood deposited on fabric - Evaluating the use of alginate casting materials followed by chemical enhancement. Sci Justice [Internet]. 2010;50(4):200–4. Available from: http://dx.doi.org/10.1016/j.scijus.2010.06.006

22. Shalhoub R, Quinones I, Ames C, Multaney B, Curtis S, Seeboruth H, et al. The recovery of latent fingermarks and DNA using a silicone-based casting material. Forensic Sci Int. 2008;178(2–3):199–203.

23. Tapps M, Mcmullen L, Gagné M, Beaudoin A. Revealing a decades-old fi ngermark with cyanoacrylate fuming and rhodamine 6G. Forensic Sci Int [Internet]. 2019;300:e9–12. Available from: https://doi.org/10.1016/j.forsciint.2019.04.025

24. Khuu A, Chadwick S, Spindler X, Lam R, Moret S, Roux C. Evaluation of one-step luminescent cyanoacrylate fuming. Forensic Sci Int. 2016;263:126–31.
25. Farrugia KJ, Fraser J, Friel L, Adams D, Attard-Montalto N, Deacon P. A comparison between atmospheric/humidity and vacuum cyanoacrylate fuming of latent fingermarks. Forensic Science International (Online) 2015 Dec 01;257:54-70.
26. Brown RM, Hillman AR. Experimental Procedures. Traditional visualisation methods.
27. Yager N, Amin A. Fingerprint verification based on minutiae features: A review. Pattern Anal Appl. 2004;7(1):94–113.

Blank Page – not numbered

Part Two

Manuscript

Development of a Method to Recover Fingerprints from Dashboards

Abstract

The development of a method to recover latent fingerprints from textured surfaces by trying multiple lifting techniques – BVDA gel lifter, Dental stone, and dental alginate to determine their ability to lift the fingerprint and the sensitivity of the lifters. The BVDA gel lifters did not yield identifiable fingerprints scored on the bandey scale. The dental alginate and dental stone both yielded identifiable fingerprints but the disadvantages of the dental alginate outweigh the advantages in a practical setting making dental stone the better lifting material for the three textures tested: a vinyl dashboard, a plastic dashboard, and a plastic dashboard with crocodile skin texture.

Contents

List of Tables

List of Figures

1.Introduction

Evidence collected from crime scenes varies in usefulness, as the hierarchy of evidence places evidence with a higher discriminatory value above less discriminatory evidence [1–3]. Fingerprints are considered above other evidence types as each person has a unique fingerprint that forms during the development of the foetus [2–6]. Fingerprints at crime scenes are either plastic, patent, or latent fingerprints [5]. Latent fingerprints are the most common type of fingerprints found at crime scenes and have their own unique challenges as a latent fingerprint is not visible to the naked eye [5]. The main constituent of a fingerprint is either eccrine – sweat-based or sebaceous – oil-based [1,4,5]. A fingerprints main detail falls into one of three categories; arches, whorls or loops which can then be further individualized by the minutiae of the fingerprint [1,5,7]. Fingerprints can be individualised even further if there are unique characteristics present in the finger mark like scars [1,5].

To collect the best fingerprint the aim is to create the most amount of contrast between the fingerprint and the surface the fingerprint is on, there are three ways to increase contrast optical, physical and chemical [5,6,8]. Optical methods include using different light sources to try to visualise the print before enhancement occurs but can also be used to enhance the fingerprint after physical enhancement – powdering has occurred by using alternative light sources to increase visualisation of fluorescent powders or the increased visualisation of fingerprints printed with a darker powder on a dark surface before lifting and in the case of chemical enhancement visualisation of dyes at certain wavelengths that darken the background and enhance the fingerprint [5,6,8] . Physical enhancement of fingerprints includes the use of lifting materials such as adhesive lifters and moulding materials, the use of these methods has been noted on non-porous lightly textured surfaces but a method has not yet been used for the development of fingerprints from textured surfaces including the dashboard of a car [6,9–12].

Knapp [9] uses dental stone to cast fingerprints from non-porous surfaces with no texture and noted that the casted fingerprint held all the detail of the original fingerprint, it was noted that the dental stone was capable of consistently lifting fingerprints of a high calibre form the smooth surfaces and provided good contrast between the powdered fingerprint and dental stone [9]. Dental stone has been used in the recovery of footwear impressions where the surface is textured and has yielded usable results, but has yet to be tried as a method of recovery for fingerprint impressions on textured surfaces [9,10]. Dental alginate has been used by dentists to cast an impression of the mouth as it is cheap and it is quick drying, alginate has also been tried for casting footwear and was found to retrieve more detail of the footwear impression than the dental stone on textured surfaces [10].

Fingerprints have been collected off of the porous surface of bricks using a fluorescent powder as it has been mentioned that the finer nature of the fluorescent powders helps enhance the fingerprint with less spreading and was mentioned to try magnetic powders as the magnetic nature of the powder would open the possibility for some of the excess powder to be removed [6,13]. Gel lifters have been noted to have had some success in lifting fingerprints from textured surfaces [12].

The aim of the following experiment is to find a method that can be employed to recover fingerprint from textured surfaces focusing on car dashboards and to see if a cut-off point can be determined to wear a technique is no longer useful. The research is being conducted as there is no current research that shows a method to recover fingerprints from textured dashboards.

2.Materials and Methods

2.1 Fingerprint deposition

Index finger and middle finger of the right hand were rubbed over the face for ten seconds, then fingerprints were deposited onto the three textured surfaces see Figure 1. Fifteen fingerprints were evaluated for each different powder and lifting method, each fingerprint was deposited after being rubbed over the face for ten seconds. A dilution series of fingerprints was laid out on the surfaces using the index finger in a series of ten prints the fingerprints were added in a consecutive series, this was done in a replication of three.

2.2 Fingerprint powdering

The fingerprints deposited on texture 1,2 and 3 (figure 1) were powdered using black magnetic powder and redescent powder for the fifteen individual prints. The three dilution series were powdered using only black magnetic powder.

2.3 Lifting Techniques

100g of yellow dental stone powder was mixed with 30mls of water until the mixture was homogeneous, the dental stone was then spooned onto the powdered prints, the amount put over the fingerprint was larger than the fingerprint and mounted, so there was a handle to remove the dental stone from the surface by. The dental stone took 30 minutes to dry and harden before it could be removed from the surface, the dental stone was left to dry for a further 24 hours to harden completely.

19g of dental alginate were added to a bowl with the powder being mixed with a spoon to break down the clumps into smaller pieces for a smoother mixture. 40ml of water was then added to the powder and mixed until a smooth mixture and poured over the powdered fingerprints. The dental alginate dried within two minutes changing from a purple colour to blue when dry, the dental alginate was then peeled off the surfaces and left to air dry on paper towels for 24 hours, the dental alginate is dried on paper towels as it sweats water for 24hours after being removed from the surface.

BVDA Transparent gel lifters and BVDA white gel lifters were placed over a powdered print and pressure was added to the back of the lifter to transfer the fingerprint, then the gel lifter was taken off the surface and the acetate sheets was placed over the lifted fingerprint.

Add 19g of thermoplastic beads to a bowl of water at 45oc, wait until the beads turn from white to transparent, then mould the thermoplastic to the shape needed and place of powdered fingerprint, when cool remove after ~30 minutes.

Sculptamould add two parts Sculptamould to one part water and mix together until all the Sculptamould is moist, shape the Sculptamould and place over the powdered fingerprint. Wait 24 hrs until Sculptamould is hardened.

Spray the powdered fingerprints with hairspray to set the powder, brush on the latex in a thin layer, wait 3 minutes for the layer to dry and apply another layer, apply a total of five layers and wait for the final layer to dry, then peel the latex off.

2.4 Cyanoacrylate Fuming

Before fingerprints were powdered, the fingerprints were lifted using the above lifting techniques and fumed using cyanoacrylate.

A fuming chamber was made using a small clear plastic box with a candle placed inside covered in a bridge of aluminium foil with 5 drops of superglue was added, the lid was closed and the dental stone and dental alginate were fumed for 10 minutes.

2.5 Data Analysis

The quality of the fingerprints was determined by the Bandey five-Point Scoring scale(14), Table 1. The percentage of what bandey score was calculated and a mean of the three-dilution series were taken for the three textures.

Table 1: Bandey Five-Point scoring Scale (14)

Score	Level of Detail
0	No evidence of mark
1	Weak development; evidence of contact but no ridge detail
2	Limited development; about 1/3 of ridge details are present but probably cannot be used for identification purposes
3	Strong development; between 1/3 and 2/3 of ridge details; identifiable finger mark
4	Very strong development; full ridge details; identifiable finger mark

A B C

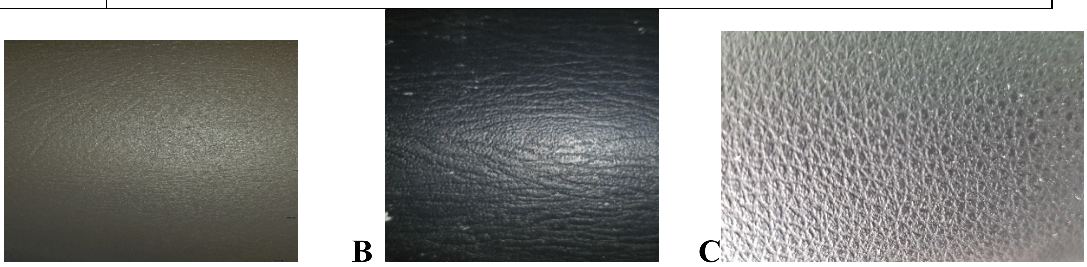

Figure 1: A: texture 1 – grey vinyl dashboard, smooth lines separated by bumpy sections. B: texture 2- black hard plastic dashboard, small smooth lines separate large bumpy sections. C: texture 3- small triangular sections with bumpy texture separated by tiny smooth lines.

3.Results and Discussion

Fifteen individual fingerprints for each lifting technique were deposited onto three different texture dashboards (Figure 1), and powdered using fluorescent magnetic fingerprint powder and black magnetic powder. The fingerprints were able to be visualized on the dashboard after powdering with the use of a torch to identify where the fingerprints were. The fingerprints were lifted using the lifting techniques of: dental stone, dental alginate and gel lifters both white and transparent. A dilution series of ten fingerprints was conducted on the three different textures and was replicated three times, then lifted using the same techniques as was used for the individual fingerprints.

3.1 Development of Fingerprints

The latent fingerprints placed on the three different textured dashboards (Figure 1) were developed with both fluorescent magnetic fingerprint powder and black magnetic fingerprint powder. The choice of magnetic fingerprint powders was made as non-magnetic fingerprint powder has been used in previous studies for the recovery of fingerprints from textured surfaces and found to pack to much powder into the textured surfaces and destroy the fingerprint with the brushing technique (6,13). The finer particle of the fluorescent magnetic powder was problematic as the powder contaminated the surface around the fingerprint and the powder was heavier in the diveted areas of the textured surfaces. The excess fingerprint powder was not able to be removed with the magnetic applicator for either of the powders as had been suggested by Davis and Fisher (6) as trying to do so distorted the fingerprint as the adhered powder followed the applicator thus destroying the fingerprint details. The black magnetic powder was easier to work with as it produced less contamination than the fluorescent powder and due to the mixture of particle size adhered to more details. The fingerprint BVDA white gel lifters picked up most of the containment fluorescent powder when lifting the fingerprint.

3.2 Evaluation of methods

3.2.1 Unsuccessful methods

No results were obtained from the tried methods of thermoplastic, Sculptamould or brush on latex. The thermoplastic failed as the plastic beads, when placed in the water turned clear but became too malleable, and the texture of the polymer was to sticky to use as it couldn't be removed from the gloves.

Sculptamould failed as the mixture was to wet when added to the surface resulting in the powdered fingerprint being disrupted by the water in the mixture. The adherence strength of the Sculptamould to the surface was too great and needed to be scrapped of the surface in order for it to be removed resulting in the fingerprint being destroyed as when being scrapped off the Sculptamould broke into pieces.

Brush on latex failed as a method because in the application of the latex it smudged the fingerprints, when hairspray was sprayed over the powdered fingerprints then brush on latex added the fingerprints did not smudge but the tension in the latex when peeled off the surface coiled leaving the latex in a ball that could not be restraightened rendering the fingerprints lifted unusable.

Lifting the fingerprints before powdering and cyanoacrylate fuming then did not work as the cyanoacrylate did not stick to the dental stone or the dental alginate and the surfaces of the dental stone and dental alginate are porous and semi-porous respectively so when dye rhodamine 6g was added it soaked through the material.

3.2.1 White gel lifter

The BVDA white gel lifters performed poorly as a lifting technique, 100% of the lifted fluorescent powdered fingerprints were scored at a bandey score of 1 (Table 2,4,6). The lifters struggled at lifting the fingerprints printed with the fluorescent magnetic powder as the lifter would also pick up the background contamination of the fluorescent powder making the fingerprint harder to see on the lift. The white gel lifters performed no better with lifting the black magnetic powdered fingerprints from texture 3 as 100% of the fingerprints were scored as 1 (Table 7). The white gel lifter performed best at lifting black magnetic fingerprints from texture 2 followed by texture 1, 7% of the lifted fingerprints scored three on the bandey scale (Table 5) with 27% scoring a two. The white gel lifters did not lift above a grade 2 for all but texture 2 and only a 7% were graded at a 3 for texture 2 (Table 5). The way gel lifters are made with the gelatin material being flexible was detrimental to lifting the powdered fingerprints as the gelatin would stretch as pressure was applied to the lifter distorting the fingerprint, the distortion was not too great with the white gel lifters as the material backing the gelatin was on, was thick and minimised the distortion [(12)]. The low adhesion strength of the gel lifter was a problem as the lifter slipped on the surface when pressure was applied and on the slightly curved surface of the textures the lifter would lift at the edges unless constant pressure was applied [(12)] . The sensitivity of the white gel lifer is low for texture 3 as across the dilution series the lifter lift fingerprints of a constant grade of 1 (Figure 4), the lifter was able to lift two fingerprints of grade two from the second texture at a dilution of five and six (Figure 3). The lifter performed best on texture 1 lifting two grade three fingerprints at a dilution of eight and nine (Figure 2), the better graded fingerprints lifted provided a cut-off point for the white gel lifter for texture 1 and 2, although some fingerprints were lifted at a grade three and could be used for comparison purposes the white gel lifter as a technique is not recommended as the majority of the fingerprints lifted are unable to be used for identification purposes.

Table 2: Percentage (%) of each bandey score for fingerprints, printed with fluorescent magnetic powder and recovered from texture 1.

Bandey Scale	Dental stone	Dental Alginate	White gel lifter	Transparent gel lifter
0	0%	0%	0%	0%
1	73%	100%	100%	100%
2	20%	0%	0%	0%
3	7%	0%	0%	0%
4	0%	0%	0%	0%

Table 3: Percentage (%) of each bandey score for fingerprints, printed with black magnetic powder and recovered from texture 1.

Bandey Scale	Dental stone	Dental Alginate	White gel lifter	Transparent gel lifter
0	0%	0%	0%	0%
1	13%	40%	93%	87%
2	40%	40%	7%	13%
3	27%	20%	0%	0%
4	20%	0%	0%	0%

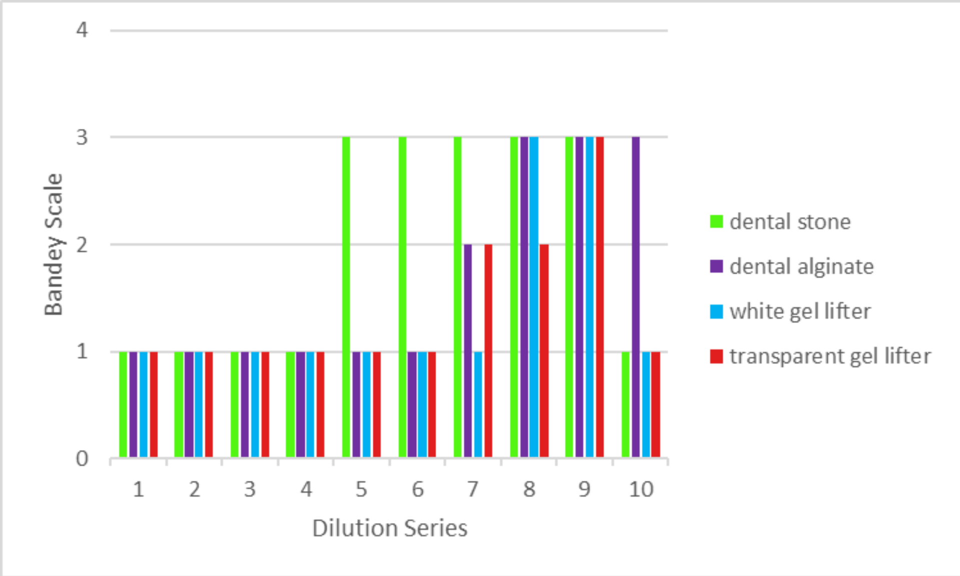

Figure 2: Lifting techniques mean bandey score for the dilution series of ten fingerprints lifted from texture 1.

3.2.2 Transparent gel lifter

The transparent BVDA gel lifters had similar problems to the white gel lifters with the adhesion strength of the gelatin was low but it did not affect the lifting of the fingerprint as much due to the transparent gel lifters having a thinner backing the gelatin was attached to, which enabled the lifter to be bent around the texture surface easier and the see through backing allowed for regulation in the pressure applied to the lifter as the fingerprint could be seen through the lifter so the pressure could be distributed more equally over the fingerprint allow for more of the fingerprint to be lifted. The downside to the thinner backing on the transparent gel lifter was that the gel had more distortion compared to the white gel lifter, but the transparent lifter achieved overall better results than the white gel lifter. The transparent lifter lifted 100% of fluorescent fingerprints at a grade of 1 for texture 1 and 3 (Table 2,6) and 100% graded at a level 1 for texture 3 across both powdering types (Table 5, 6) For lifting the black magnetic powdered fingerprints from texture 1, the technique produced no fingerprints that could be used for identification purposes as 87% of the fingerprints were graded a 1 and 13% were graded a 2 (Table 3). The optimum range for the transparent gel lifter to produce identifiable fingerprints was at a dilution of 9 (Figure 2). The transparent gel lifters performed better on texture 2 than texture 1 at lifting the fingerprints powdered with the black powder as 27% of the fingerprints lifted were graded 3 (Table 5), the dilution series of the fingerprints lifted no fingerprints that could be used for identification purposes but showed the optimum range to be from the fourth to the sixth dilution for the best fingerprints (Figure 3). The lifting technique worked better on texture 2 to texture 1 as the gel lifter adhered better to the plastic surface of texture 2 than the vinyl surface of texture 1 (Figure 1). This technique much like the white gel lifter is not recommended as most of the fingerprints are unusable for identification purposes and the gel lifter has to many variables affecting the quality of the fingerprint lifted.

Table 4: Percentage (%) of each bandey score for fingerprints, printed with fluorescent magnetic powder and recovered from texture 2.

Bandey Scale	Dental stone	Dental Alginate	White gel lifter	Transparent gel lifter
0	0%	0%	0%	0%
1	100%	100%	100%	67%
2	0%	0%	0%	27%
3	0%	0%	0%	7%
4	0%	0%	0%	0%

Table 5: Percentage (%) of each bandey score for fingerprints, printed with black magnetic powder and recovered from texture 2.

Bandey Scale	Dental stone	Dental Alginate	White gel lifter	Transparent gel lifter

0	0%	0%	0%	0%
1	13%	33%	67%	13%
2	13%	67%	27%	60%
3	60%	0%	7%	27%
4	13%	0%	0%	0%

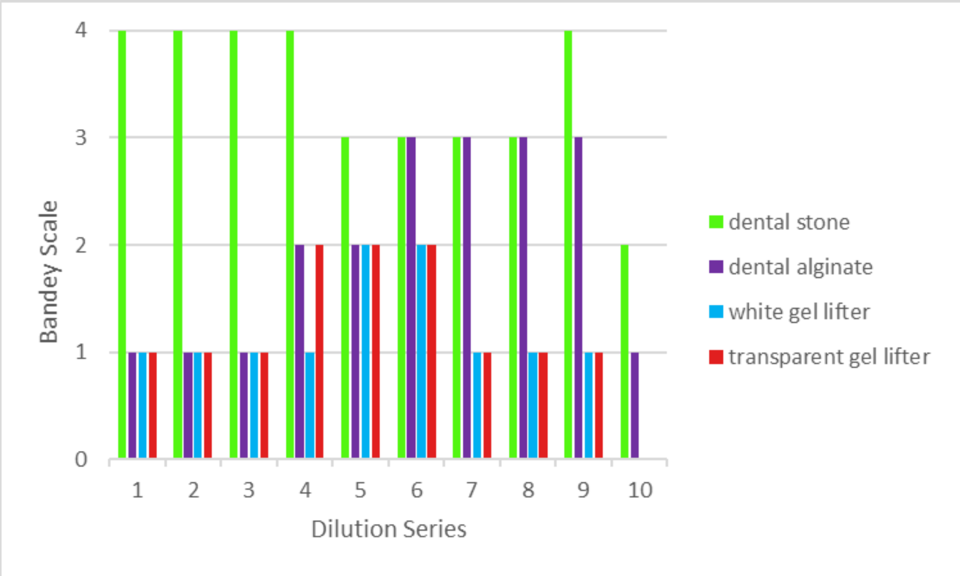

Figure 3: Lifting techniques mean bandey score for the dilution series of ten fingerprints lifted from texture 2.

3.2.3 Dental alginate

Dental alginate as a method for casting footwear impressions has worked well at lifting highly detail impressions [(10)]. Dental alginate works well as a technique for lifting fingerprints as the dental alginate is poured over the fingerprint as a liquid and sets with a silicone like texture within two minutes. The quick drying nature of the dental alginate can be tricky as the dental alginate when added to water requires quick mixing to combine the powder and water together into a mixture that has no lumps in it, a problem with the dental alginate is that the set mixture once lifted from the surface sweats water for 24 hours afterwards and oxidizes the ferrous particles in the magnetic powder turning the fingerprint rust in places. Another problem with the dental alginate is that it sets thin on surfaces and can rip easily when being removed from the surface. The dental alginate performed the same as the BVDA lifters on lifting the fluorescent powdered fingerprints from the three textured surfaces with 100% of the fingerprints at a grade 1 (Table 2,4,6). The dental alginate worked the best out of the lifting techniques at lifting fingerprints from texture 3, with 7% of the lifted fingerprints graded 2 (Table 7). The dilution series of texture 3 (Figure 4) had dental alginate recovering fingerprints from the seventh to ninth dilution that were of grade 3 and could be used as identifiable fingerprints as this was the range that the fingerprint was able to be seen over the background texture on the dental alginate. The dental alginate was able to lift 20% of grade 3 fingerprints from texture 1 when powdered with black magnetic powder (Table 3). Dental alginate lifted black powdered fingerprints were graded at 67% 2 and 33% 3 for texture two (Table 5)indicating that it could be possible for dental alginate to yield identifiable fingerprints if the fingerprints were not as overloaded with sebaceous oils as in the dilution series for texture 2 dental alginate recovered grade 3 fingerprints from the sixth to ninth dilution (Figure 3) and grade 3 fingerprints from the first texture for the eight to tenth dilution (Figure 2), the cut-off point of dental alginate is the ninth dilution before the technique will no longer work at lifting identifiable fingerprints. Overall, the dental alginate did not work as well as expected as the dental alginate gives good dental impressions and was noted to work well in recovering detail from footwear impressions but the sweating was not mentioned [10].

Table 6: Percentage (%) of each bandey score for fingerprints, printed with fluorescent magnetic powder and recovered from texture 3.

Bandey Scale	Dental stone	Dental Alginate	White gel lifter	Transparent gel lifter

0	0%	0%	0%	0%
1	100%	100%	100%	100%
2	0%	0%	0%	0%
3	0%	0%	0%	0%
4	0%	0%	0%	0%

Table 7: Percentage (%) of each bandey score for fingerprints, printed with black magnetic powder and recovered from texture 3.

Bandey Scale	Dental stone	Dental Alginate	White gel lifter	Transparent gel lifter
0	0%	0%	0%	0%
1	100%	93%	100%	100%
2	0%	7%	0%	0%
3	0%	0%	0%	0%
4	0%	0%	0%	0%

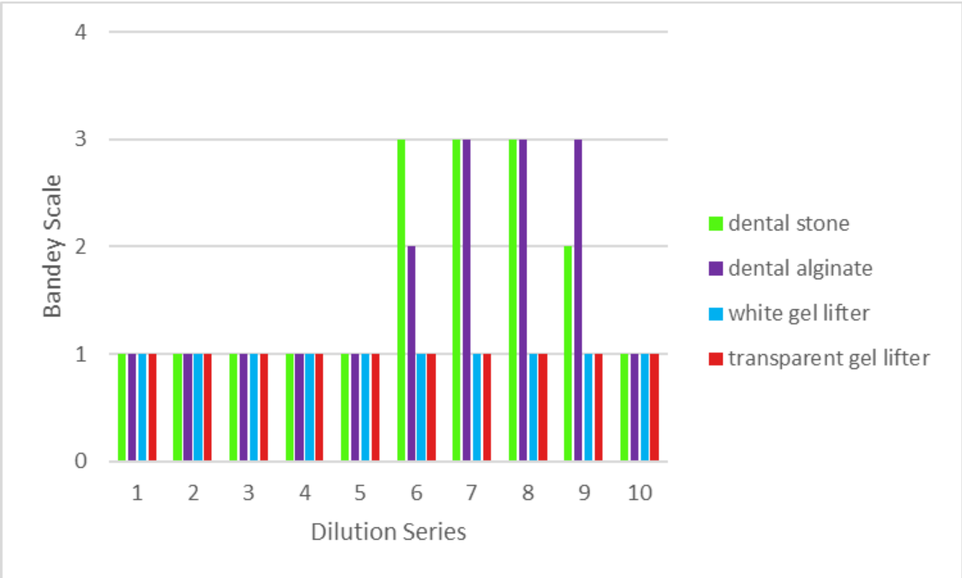

Figure 4: Lifting techniques mean bandey score for the dilution series of ten fingerprints lifted from texture 3.

3.2.4 Dental stone

Dental stone worked the best for texture 1 and 2 out of the lifting techniques tested. Dental stone was the only technique to lift identifiable fingerprints from fluorescent magnetic powder with 7% of the fingerprints graded 3 from texture 1 (Table 2). Dental stone worked best at lifting black magnetic powdered fingerprints because the dental stone was a yellow colour so the black powdered fingerprints had more contrast against the dental stone than the fluorescent powdered fingerprints making grading easier for the black powdered prints. Black powdered fingerprints lifted from texture 1 were graded 27% at grade 3 and 20% at grade 4 (Table 3), the dilution series of texture 1 had dental stone lifts graded at 3 up to the ninth dilution making the cut off of dental stone of texture 1 the ninth dilution (Figure 2). Dental stone lifted 13% grade 4 fingerprints and 60% grade 3 fingerprints from texture 2 (Table 5), and lifted fingerprints of grade 3 and 4 until the ninth dilution (Figure 3) concurring with texture 1 that dental stones cut-off point is at about the ninth dilution for textures that are similar to 1 and 2. The results are consistent with the results achieved by Knaap [9] in that dental stone can lift high quality fingerprints from surfaces, the results build on Knaap's [9] research as Knapp and Farrugia [9,10] did not try dental stone on textured surfaces but also differ from the results of Knaap's [9] research as the dental stone when lifting from a textured surface adheres tightly and is harder to get off needing the dental stone to be in excess over the fingerprint to allow for a handle to pull the dental stone off from but lifts less texture of the surface than other lifting techniques. The major problem with dental stone is that some of the lifts had tiny bubbles in the dental stone disrupting the visualization of the lifted print this could be solve be vibrating the mixture or tapping the bowl before application to pop the air bubbles.

3.3 Dental Stone and Dental Alginate comparison of applicability

The advantages and disadvantages of dental stone and dental alginate were assessed to determine their applicability as a method for forensic use (Table 8). The gel lifters were not assessed as both dental stone and dental alginate performed higher than the gel lifters in ability to lift identifiable fingerprints. The main thing to consider for the applicability of the methods is their friendliness of use and recording of the fingerprint. In the friendliness of use dental alginate is not the best as it is a thin material when lifted that rip easily and is hard to store as the material sweats water for 24hrs afterwards and the ferrous in the fingerprint powder oxidizes destroying the fingerprint.

Table 8: Advantages and disadvantages of dental stone and dental alginate

Method	Advantages	Disadvantages
Dental Stone	- Cheap - easy to use - consistent good results - easy to store	- only comes in light colours - takes 30 minutes to set - adheres strongly - can get air bubbles lifts
Dental alginate	- Quick to set 2 minutes - Good on complex textures - Changes colour when set from purple to blue	- Lumpy mixture - Tears easily - Sweats water for 24 hrs - Ferrous particles rust - Dark blue material low contrast

Dental stone is the better option as it produced the highest graded lifted fingerprints across the textures and had the latest cut-off point for no longer working in a dilution series out of the methods tested. Dental alginate is more useful over the dental stone for texture 3 but needs to be recorded straight away.

3.4 Limitations and further research

The limitations of were that there were only three different textured dashboards used and it is unclear as to how many types of cars have the types of dashboards tested in them. Limitations in regards to the fingerprints were that the fingerprints were all fresh fingerprints, and there was only the one person's fingerprints used. There are variables within the experiment that were not able to be explored due to time such as the amount of pressure applied and whether or not DNA can be collected from the lifted fingerprints. Further research should be conducted on whether DNA can be recovered from the lifted fingerprints as it would be beneficial to known if both the DNA and the fingerprint can be recovered and it would be extremely beneficial to forensic investigations if further research was conducted using different textured dashboards to extend the number of surfaces the methods can be used on.

4.Conclusion

Fluorescent magnetic fingerprint powder generated as no identifiable fingerprints. The BVDA gel lifters did not lift identifiable fingerprints and distorted fingerprints. The dental alginate lifter identifiable fingerprints and worked the best at lifting fingerprints from texture three but due to sweating of the material and oxidisation of the magnetic powders is not as useful in the practical application as the fingerprints get destroyed and the lift cannot be kept. Dental stone worked best as a method to lift latent fingerprints from all three of the tested textures as dental stone lifted identifiable fingerprints from the surfaces and is easy to transfer into practical application as it is easy to use and stores well. Further research needs to be conducted on other textured surfaces and whether DNA can be collected from the lifted samples. Small areas can be targeted with the lifting techniques as the powdering exposes the fingerprint under torch light.

References

1. Holder EH. U.S. Department of Justice Office of Justice Programs. Office.
2. Weston-Ford KA, Moseley ML, Hall LJ, Marsh NP, Morgan RM, Barron LP. The retrieval of fingerprint friction ridge detail from elephant ivory using reduced-scale magnetic and non-magnetic powdering materials. Sci Justice [Internet]. 2016;56(1):1–8. Available from: http://dx.doi.org/10.1016/j.scijus.2015.10.003
3. Subhani Z, Daniel B, Frascione N. DNA Profiles from Fingerprint Lifts—Enhancing the Evidential Value of Fingermarks Through Successful DNA Typing. J Forensic Sci. 2019;64(1):201–6.
4. Cadd S, Islam M, Manson P, Bleay S. Fingerprint composition and aging: A literature review. Sci Justice [Internet]. 2015;55(4):219–38. Available from: http://dx.doi.org/10.1016/j.scijus.2015.02.004
5. Kasper. Latent Print Processing Guide. San Diego: Elsevier Ltd; 2016.
6. Davis L, Fisher R. Fingermark recovery from riot debris: Bricks and stones. Sci Justice [Internet]. 2015;55(2):97–102. Available from: http://dx.doi.org/10.1016/j.scijus.2015.01.006
7. Yager N, Amin A. Fingerprint verification based on minutiae features: A review. Pattern Anal Appl. 2004;7(1):94–113.
8. Choi MJ, McDonagh AM, Maynard PJ, Wuhrer R, Lennard C, Roux C. Preparation and evaluation of metal nanopowders for the detection of fingermarks on nonporous surfaces. J Forensic Identif. 2006;56(5):756–68.

9. Knaap W, Adach E. The Knaap process: Lifting two-dimensional footwear and fingerprint impressions using dental stone. J Forensic Identif. 2002;52(5):561–71.

10. Farrugia KJ, NicDaéid N, Savage KA, Bandey H. Chemical enhancement of footwear impressions in blood deposited on fabric - Evaluating the use of alginate casting materials followed by chemical enhancement. Sci Justice [Internet]. 2010;50(4):200–4. Available from: http://dx.doi.org/10.1016/j.scijus.2010.06.006

11. Sabolich A. compo.pdf. 2017.

12. Plaza DT, Mealy JL, Lane JN, Parsons MN, Bathrick AS, Slack DP. Nondestructive Biological Evidence Collection with Alternative Swabs and Adhesive Lifters. J Forensic Sci. 2016;61(2):485–8.

13. Sari SA, Ningsih H, Jasmidi, Kembaren A, Mahat NA. Development of gambir powder as a cheap and green fingerprint powder for forensic applications. AIP Conf Proc. 2019;2155(September).

14. Sears VG, Bleay SM, Bandey HL, Bowman VJ. A methodology for finger mark research. Sci Justice [Internet]. 2012;52(3):145–60. Available from: http://dx.doi.org/10.1016/j.scijus.2011.10.006