ORIGINAL ARTICLE

Recovery and Visualisation of Methamphetamine-Contaminated Fingermarks from Non-Porous Surfaces

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ABSTRACT

Introduction: Fingermarks left at a crime scene can indicate the presence of an individual and his/her involvement in the crime. Fingermarks, usually invisible, can appear on any surface and may be contaminated by any exogenous substances, including drug substance. Recovery of fingermarks contaminated by drug substance is crucial to link an individual with the drug-related crimes. Hence, this study was aimed to investigate the recovery and visualisation of methamphetamine-contaminated fingermarks from various non-porous surface materials. **Methods:** In this study, fingermarks were deposited on 11 types of surface materials varied by the presence of methamphetamine contamination, immediacy of deposition, and their concentration levels. Each fingermark was then developed using white and black fingerprint powders, graded, and compared based on the different settings. **Results:** Application of fingerprint powder was good in developing fingermarks; however, its suitability depends on the nature of the surface materials. Black fingerprint powder produced better visualisation where the fingermarks on all the 11 surface materials tested in this study were successfully recovered compared to white fingerprint powders. Methamphetamine-contaminated fingermarks could still be recovered using the fingerprint powder dusting method, but the fingermark grade was reduced due to the presence of exogenous substance. **Conclusion:** To conclude, the recovery and visualisation of methamphetamine-contaminated fingermarks on non-porous surfaces were successfully carried out through the application of fingerprint powder. A more severe contamination might lead to lower fingermark grade showing lesser ridge details.
Malaysian Journal of Medicine and Health Sciences (2023) 19(6):178-185. doi:10.47836/mjmhs.19.6.24

Keywords: Contamination, fingermark, fingerprint powder, methamphetamine, visualisation

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INTRODUCTION

An individual may leave his/her fingermarks at a crime scene, especially when physical contact occurs between a surface and the fingers (1). Latent fingermarks, appear invisible, requires additional processing to render it visible. Nonetheless, due to its fragility, forensic investigators must choose the most appropriate technique during scene processing to maximise the probability of fingermark recovery and development (2). Among the techniques for latent fingermark development, powder dusting using the granular fingerprint powders continues to be practiced, especially on any non-porous and semi-porous surfaces (2, 3). Powder dusting technique is a physical technique which applies the fine particles of fingerprint powder to the latent fingermarks utilising a brush or wand. Due to the affinity for fatty deposits and moisture, these particles will then selectively adhere to the fingermark residues present on a surface, revealing the latent fingermark (2, 4-5).

In real case scenarios, a latent fingermark might not exist in a clean or perfect form but could possibly be contaminated by exogenous substances, such as trace level of drug substances, cosmetic products, explosive materials, or gunshot residues (6, 7). The presence of these exogenous substances together with the primary fingermark residues might affect the recovery and quality level of developed fingermarks, and subsequently the interpretation of such evidence in relation to the case scenarios (6). Previously, studies involving drug-contaminated fingermarks had been carried out coupling the application of fingerprint powders and instrumental techniques. West and Went (8) reported on the utilisation of Raman spectroscopy to analyse contaminated fingermarks dusted with aluminium or iron-based powders, even after tape-lifting procedure. Kaplan-Sandquist et al. (9) demonstrated that matrix-assisted laser desorption/ionisation-mass spectrometry (MALDI-MS) allowed for the generation of mass spectra and chemical images of drug substances (ibuprofen, acetaminophen, aspirin, and pseudoephedrine) within fingermark residues upon application of conventional fingerprint development methods and MALDI matrix processing procedure. MALDI-MS was also used by Groeneveld et al. (10) which allowed for determination by retrieving the chemical structures and/or generation of two-dimensional maps of fingermark ridge details based on their ion signals. In addition, Szynkowska-Jyźwik et al. (11) found that the usage of black fingerprint powder on fingermarks did not interfere with the Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) analysis. However, such instrumental studies were limited to the laboratory setting and might not be practical during on-site investigation.

Drug-contaminated fingermark can be found when a fingertip with drug substance was directly placed onto a surface. Rowell et al. (12) reported on the application of spectrometric analysis allowed for the detection of the drug and its metabolites from the fingermarks. Szynkowska-Jyźwik et al. (11) also demonstrated the effectiveness of ToF-SIMS in detecting drug substance transferred from a finger to surface with no interference from the black powder during the recovery procedure. According to Jang et al. (13), the drug substance was found to be persistence towards the environmental insults, in which it could still be detected even after the fingermark development process. These studies were mainly focused on the detection of drug substance; however, the effect of contaminant towards the fingermark grading was not investigated. Different from the above-mentioned studies where the drug residues were directly applied onto the fingertip prior to fingermark deposition, in this study, interaction of clean fingermarks and contaminants before and after deposition was explored.

During the investigation of a clandestine drug laboratory, numerous fingermarks could be found within the crime scene where these fingermarks could be either related or unrelated to the illegal activities. Individuals operating a clandestine laboratory tend to leave their fingermarks on any surfaces in the scene and these fingermarks are important for identification. However, fingermarks related to a case could also appear in a clandestine laboratory as they could have been existed on a surface prior to the initiation of illegal activities or deposited after a clandestine activity ended (14). Hence, the recovery and detection of fingermarks on any surfaces could aid in identifying the owner of fingermarks. Apart from that, the immediacy of deposition and contamination could provide information on how a fingermark deposited on a surface, whether the deposition occurs before a surface was contaminated or a fingermark was deposited on an already contaminated surface.

In this study, methamphetamine was chosen as the target substance due to its high prevalence of abuse in Malaysia according to the National Anti-Drug Agency (15). Amphetamine-type stimulant was declared as the most dominant drug of abuse, used on 64.8% drug abusers of the country (15). Furthermore, methamphetamine facilities were constantly dismantled in our country, indicating the seriousness of clandestine drug activities (16). Fingermarks contaminated with methamphetamine were recovered through powder dusting techniques, followed by visualisation and interpretation. Immediacy of deposition and contamination level of a fingermark were also investigated for the determination of the potential factor which might influence its recovery. It is hoped that this study would be beneficial to the law enforcement agencies, especially those involved in forensic investigation of drug-related activities in suggesting the most appropriate method for the recovery and development of drug-contaminated fingermarks.

MATERIALS AND METHODS

Preparation of methamphetamine solution

Methamphetamine hydrochloride (≥99% purity) was obtained from the Department of Chemistry Malaysia upon approval. A methamphetamine solution was prepared by dissolving the methamphetamine hydrochloride standard in methanol (Merck, Kenilworth, NJ, USA) at a concentration of 1 mg/mL.

Preparation of fingermark samples

In this study, sebaceous-eccrine fingermarks were chosen as the representative fingermark to standardise the compositions, producing clear and consistent fingermarks (17). Only one single donor was involved in the preparation of fingermarks to avoid inter-donor variations. Fingermark was groomed by wiping the cleaned and dried thumb around the nose and forehead regions and pressed onto the surface materials for 5 seconds according to the procedure recommended by Fieldhouse (18). This study was approved by the Human Research Ethics Committee (JEPeM) of Universiti Sains Malaysia (USM/JEPeM/18050228).

Comparison of the recovery of fingermarks by two powder dusting techniques from eleven non-porous surface materials

Two types of fingerprint powders, namely the "Hi-Fi" Volcanic Latent Print Powder, Indestructible White (Sirchie, Youngsville, NC) and "Hi-Fi" Volcano Latent Print Powder, Silk Black (Sirchie, Youngsville, NC) were used. Their effectiveness in recovering fingermarks was compared. Sebaceous-eccrine groomed fingermarks were applied on the 11 surface materials (Table I), and

Table I: Eleven surface materials utilised in the study.

Label	Surface material
A	White PVC laminated particle board
B	Brown melamine particle board
C	White plastic tray
D	Quartz countertop
E	White tile
F	Beige tile
G	Brown laminated MDF sheet
H	Metal tray
I	Metal plate
J	Aluminium sheet
K	Glass

they were developed using the two fingerprint powders separately utilising a squirrel fingerprint brushes (Sirchie, Youngsville, NC). Note that the surface materials used in this study are the commonly found materials in a household setting, simulating a clandestine laboratory set up within a residential structure. Fingermarks developed by the two fingerprint powders were visualised, graded, and compared. It was noted that each comparison procedure was performed in triplicate. Fingerprint powder which provided higher grade during the visualisation of developed fingermarks on the eleven surfaces was determined. All fingermark preparation, visualisation, grading, and comparison procedures were carried out in a controlled laboratory environment with temperature ranging between 24 - 28°C and humidity between 40% - 50%.

Investigation on the effect of methamphetamine contamination on the recovery of fingermarks

Fingermarks without and with contamination by methamphetamine upon recovery and development were prepared and graded. Latent fingermarks were treated as uncontaminated fingermarks and deposited on respective clean surface materials. On the other hand, methamphetamine-contaminated fingermarks were prepared by firstly spraying the methamphetamine solution at a concentration of 1 mg/mL on the surface materials and allowed to dry. Once dried, the groomed fingermark was deposited on top of the contaminated surface. For consistency and repeatability, methamphetamine solution was used to transfer an exact amount of drug substance onto a surface followed by evaporation of the solvent (19). These two fingermarks, i.e. latent fingermarks (uncontaminated) and methamphetamine-contaminated fingermarks, were prepared in triplicate and subjected to powder dusting techniques followed by visualisation. The fingermark grades were then compared.

Investigation of the immediacy of deposition on the recovery of fingermarks

Prior-contaminated fingermarks refer to fingermarks deposited on a contaminated surface [Figure 1(a)], while post-contaminated fingermarks are those that appeared on a surface but were subsequently contaminated with methamphetamine [Figure 1(b)]. Prior-contaminated fingermarks were prepared by depositing the fingermarks on a methamphetamine-contaminated surface [i.e. was priorly sprayed with 1 mL of methamphetamine solution (1 mg/mL) and allowed to dry]. For the preparation of post-contaminated fingermark, they fingermark was first deposited onto respective surface materials, which upon 15 min of deposition, a 1 mL of the methamphetamine solution (1 mg/mL) was sprayed onto the surfaces bearing the fingermark and allowed to dry. Prior-contaminated and post-contaminated fingermarks, both prepared in triplicate, were then dusted with fingerprint powders using fingerprint brush. Any association on the immediacy of fingermarks deposition with their recoveries from the surfaces was investigated.

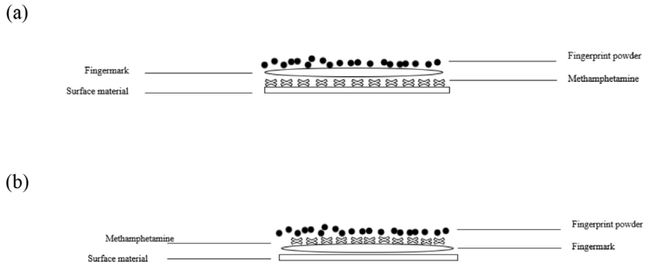

Figure 1: Cross-sectional observation of (a) prior-contaminated fingermark dusted with fingerprint powder; and (b) post-contaminated fingermark dusted with fingerprint powder.

Investigation on the effect of methamphetamine contamination levels on the recovery of fingermarks

Contaminated fingermarks by three concentration levels of methamphetamine, namely 0.25 mg/mL, 0.5 mg/mL, and 1.0 mg/mL, were prepared in triplicate. Subsequently, these contaminated fingermarks were recovered through the powder dusting technique. These methamphetamine solutions, upon spraying and drying, led to the presence of defined masses of methamphetamine (0.25 mg, 0.5 mg, and 1.0 mg) on each surface material with an area of 100 cm^2. The fingermark grades upon recoveries with different degree of contamination levels were evaluated and compared.

Visualisation and evaluation of fingermarks

After powder dusting, the fingermarks were visualised optically and photographed using a Canon EOS 50D digital single-lens reflect (SLR) camera with Canon EFS 60mm f/2.8 Macro USM lens (Canon, Ota City, Tokyo). A tripod was used to hold the camera in its position during photography. The lens aperture and the International Standard Organisation (ISO) speed were set to f/2.8 and 100, respectively, while the shutter speed was manually adjusted to ensure that all captured images had the same exposure without pixel saturation. Once photographed, the fingermarks were lifted using tape (Daiso, Higashihiroshima, Hiroshima) and placed on white paper (PaperOne™, Raffles Places, Singapore) or black paper (CAMPAP, Butterworth, Penang) to preserve the fingermarks. Note that white paper was used to keep fingermarks developed using black fingerprint powder, and while a black paper was used for fingermark developed using white powder.

The developed fingermarks were graded based on the fingermark grading system recommended by Centre for Applied Science & Technology (CAST) United Kingdom (20) as demonstrated in Table II. IBM SPSS Statistics version 27 (SPSS Inc., Chicago, IL, USA) was used for data analysis. Based on the guidelines for the use and statistical analysis of the Home Office fingermark grading scheme (21), the different degrees of fingermark development were categorised as Class 0 to Class 4. Serving as categorical data, Chi-square tests were utilised to investigate the association between fingermark grade with different parameters, covering the choice of fingerprint powders, types of surfaces deposited with fingermarks, comparison between uncontaminated and methamphetamine-contaminated fingermarks, immediacy of fingermark deposition, as well as the contamination levels of methamphetamine on the fingermarks. Ordinal logistic regression was also used to model the relationship between the ordinal fingermark classes and the predictive variables. A p-value <0.05 was considered statistically significant.

Table II: Fingermark grooming score

Class	Detail visualised
Class 0	No evidence of fingermark
Class 1	Some evidence of fingermark
Class 2	Less than 1/3 clear ridge detail
Class 3	Between 1/3 and 2/3 clear ridge detail
Class 4	Over 2/3 clear ridge detail

RESULTS

Visualisation of fingermarks

Latent fingermarks are hardly visible by unaided eyes, needing the application of fingerprint powder or other chemicals during forensic investigation. In this study, the sebaceous-eccrine fingermarks deposited onto the selected surfaces were recovered using both white and black fingerprint powders, followed by visualisation and grading. Figure 2 shows the representative developed fingermarks on glass surface upon dusting by white and black fingerprint powders, respectively.

Comparison of the recovery of fingermarks by two powder dusting techniques from eleven non-porous surface materials

The finely formulation of granular fingerprint powder was found to be mechanically adhered to the residual sweat and oils on a surface originated from the fingermarks, showing the ridge pattern for grading and comparison (22). A Chi-square statistical test indicated that the choice of fingerprint powders was significantly associated with the grades of fingermark (χ^2(4, N=396) = 126.71, p < 0.001). Through an ordinal logistic regression, the application of white fingerprint powder has lower likelihood in higher grade compared to black fingerprint powder (B= -1.727, 95%CI: -2,.127, -1.328; p < 0.001). In other words, application of white fingerprint powder gave significantly lower grades, regardless of the surface materials deposited with fingermarks. Comparing among surface materials deposited with fingermarks, the grades were found to be significantly different across different types of surfaces (χ^2(40, N=396) = 336.98, p < 0.001). Subsequent post-hoc analyses determined the combination of surface materials which showed statistically significant differences in the fingermark grades (marked as * in Table III). Note that separate Chi-square tests were carried out on each combination for comparison and an adjusted p-values of less than 0.001 was considered as statistically significant based on the 55 possible combinations (0.05/55 = 0.0009).

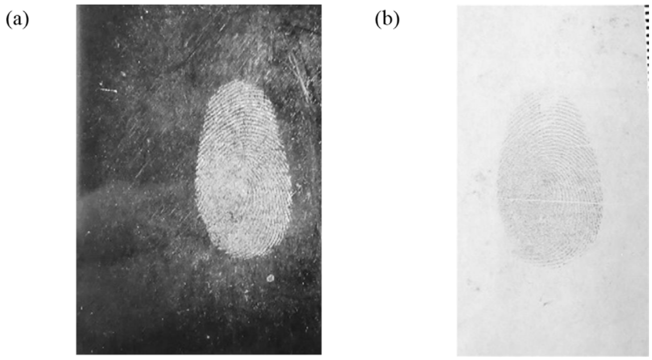

Figure 2: Fingermarks on glass surface those developed with (a) white fingerprint powder, and (b) black fingerprint powder.

Chi-square test was also performed to determine the choice of fingerprint powder that gave a significantly higher grade on each surface material. Table IV demonstrates the statistical results between the fingermark grades of the two fingerprint powder application procedures on the 11 surface materials. In detail, statistical differences were found in six surface materials, namely white PVC laminated particle board (χ^2(2, N=36) = 36.00, p < 0.001), brown melamine particle board (χ^2(2, N=36) = 9.655, p = 0.008), plastic tray (χ^2(3, N=36) = 36.00, p < 0.001), quartz countertop (χ^2(2, N=36) = 36.00, p < 0.001), white tile (χ^2(3, N=36) = 36.00, p < 0.001), and beige tile (χ^2(3, N=36) = 36.00, p < 0.001). Black fingerprint powder was found to give higher fingermark grades for these surface materials, suggesting it as a better choice. For other surfaces, no significant difference was found, indicating that both white and black fingerprint powders are good in recovering fingermarks.

Investigation on the effect of methamphetamine contamination on the recovery of fingermarks

In a clandestine drug laboratory or on surfaces related to illicit drugs, fingermarks could be contaminated with the drugs and might affect the recovery and the

Table III: The combination of surface materials with significant differences on the fingermark grades.

Surfaces	A	B	C	D	E	F	G	H	I	J
A										
B	< 0.001*									
C	0.460	< 0.001*								
D	< 0.001*	< 0.001*	< 0.001*							
E	0.297	< 0.001*	0.599	< 0.001*						
F	< 0.001*	0.004	< 0.001*	< 0.001*	< 0.001*					
G	0.040	< 0.001*	0.154	< 0.001*	0.670	< 0.001*				
H	< 0.001*	< 0.001*	0.435	< 0.001*	< 0.001*	< 0.001*	< 0.001*			
I	< 0.001*	< 0.001*	0.542	< 0.001*	< 0.001*	< 0.001*	< 0.001*	0.785		
J	< 0.001*	< 0.001*	0.223	< 0.001*	< 0.001*	< 0.001*	< 0.001*	0.564	0.505	
K	< 0.001*	< 0.001*	0.011	< 0.001*	< 0.001*	< 0.001*	< 0.001*	0.168	0.159	0.042

* Statistically significant (p <0.001)
Note: A- white PVC laminated particle board; B - brown coloured laminated MDF sheet; C- plastic tray; D- quartz countertop; E- white coloured tile; F- beige coloured tile; G- brown melamine particle board; H- metal tray; I- metal plate; J- uncoated aluminium sheet; K- glass sheet.

Table IV: Chi-square statistical output comparing the fingermark scores between black and white fingerprint powders on each surface.

Fingermark score	df	χ^2	*p*-value
White PVC laminated particle board	2	36.00	< 0.001*
Brown melamine particle board	2	9.655	0.008*
Plastic tray	3	36.00	< 0.001*
Quartz countertop	2	36.00	< 0.001*
White tile	3	36.00	< 0.001*
Beige tile	3	36.00	< 0.001*
Brown laminated MDF sheet	2	4.615	0.099
Metal tray	2	0.682	0.711
Metal plate	3	4.952	0.175
Aluminium sheet	2	0.611	0.737
Glass	2	0.188	0.910

* Statistically significant (p <0.05)

fingermark grades upon powder dusting. A Chi-square statistical test was carried out to compare the fingermark grades between uncontaminated fingermarks and methamphetamine-contaminated fingermarks. It was concluded that the methamphetamine contamination was associated with the fingermark grade (χ^2(4, N=396) = 77.246, p < 0.001). Based on an ordinal logistic regression, significantly higher frequency of fingermark grade with class 4 (38.9%) was reported in the former group as compared to the latter group (0%) (B= 1.461, 95%CI: 0.942, 1.980; p < 0.001).

Investigation of the immediacy of deposition on the recovery of fingermarks

A drug-contaminated fingermarks on a surface can be either one of the types here, i.e. a clean fingermarks directly deposited on a drug-contaminated surface or a priorly deposited fingermark on a clean surface that was subsequently contaminated by the illicit drug. Chi-square test was carried to the effect of immediacy of fingermark deposition which were subsequently subjected to the application of black fingerprint powders. Significant result was reported (χ^2(4, N=198) = 19.171, p < 0.001). There was a greater frequency of class 4 fingermark grade (20.2%) among post-contaminated fingermarks compared to prior-contaminated fingermakrs (4.0%). In other words, prior-contaminated fingermarks have lowe likelihood in higher fingermark grade compared to post-contaminated fingermarks (B= -1.064, 95%CI: -1.617, -0.512; p < 0.001). A separate Chi-square statistical result involving white fingerprint powder was found to be not significant (χ^2(4, N=198) = 5.243, p = 0.263) in term of the fingermark grades when the fingermarks were subjected to either prior- or post-contaminations and followed by the application of white fingerprint powder for the recovery. There was no association between the immediacy of fingermark deposition and their grades upon recovery with white fingerprint powder.

Investigation on the effect of methamphetamine contamination levels on the recovery of fingermarks

The effects of methamphetamine contamination at three concentration levels towards hindrance of recovery were investigated through a Chi-square test. A statistically significant difference in fingermark grades among the three concentration levels (χ^2(7, N=198) = 67.795, p < 0.001) was reported. An ordinal logistic regression was subsequently carried out, indicating the concentration levels at 0.25 mg/mL has a higher probability in providing better fingermark grade compared to fingermarks contaminated with 1.00 mg/mL methamphetamine (B= 2.413, 95%CI: 1.676, 3.150, p < 0.001). However, no significant difference was evident for 0.50 mg/mL and 1.00 mg/mL on the fingermark grades (B= 0.142, 95%CI: -0.547, 0.831; p = 0.686). In the experiment involving white fingerprint powder, the Chi-square test showed that there was also statistically significant difference in the fingermark grades obtained among the three concentration levels (χ^2(8, N=198) = 56.061, p < 0.001). Similar to black fingerprint powder, the concentration levels at 0.25 mg/mL and 1.00 mg/mL (B= 0.697, 95%CI: 0.062, 1.332; p = 0.032) were significantly different in term of the fingermark grades. However, no significant difference was evident for 0.50 mg/mL and 1.00 mg/mL on the fingermark grades (B= -0.092, 95%CI: -0.741, 0.556; p = 0.780).

DISCUSSION

From the experimental results, the granular fingerprint powder made up of carbon-based asymmetrical spherical particles are suitable for developing latent fingermarks. Although the surface materials tested in this study appeared to be non-porous in nature, their porosity could be slightly varied from a comparatively porous particle board to a highly non-porous glass surface as tabulated in Table I. The least porous surfaces, including the metal, aluminium, glass sheets demonstrated higher proportion of excellent fingermark grade (class 4) as compared to the relatively more porous materials. A previous study also suggested that the minutiae to be observed from fingermarks deposited on glass surfaces always more prominent than those on plastic surfaces due to the porosity (23). Apart from that, a textured surface might also lead to the incomplete contact between the friction ridge skin and the surface during contact. As a result, discontinuous fingermarks lacking in fine details were produced as evident on the surfaces of quartz countertop and tile. These fingermarks were said to be hardly developed through the application of fingerprint powders and brush, leading to lower fingermark grade (24).

Application of black fingerprint powder had successfully recovered all fingermarks deposited on the 11 tested surfaces, while the white powder was found more difficult to retrieve fingermarks from certain surface materials, specifically the light-coloured plastic tray, tiles, quartz countertop and PVC laminated particle board. The pigments in fingerprint powder could offer contrast and definition of the friction ridge pattern against the background surface (24), and therefore, the developed fingermark with a poor contrast on these surfaces had limited the visualisation and produced lower fingermark grades. Furthermore, white colour fingerprint powder was said to potentially contribute to "background noise" which might interfere the visualisation (25). In real case scenario, it is particularly crucial in selecting the correct fingerprint powder prior to powder dusting procedure as its application onto any surface in a crime scene carries destructive nature which tends to destroy critical forensic evidence (24).

Unlike the controlled study in the laboratory setting, fingermark contamination by any exogenous substance in real case scenarios occurs, and such contamination might affect fingermark recovery. Our study showed that the presence of drug residue contamination could reduce the grading of recovered fingermarks where more effort shall be taken for interpretation. Methamphetamine particles could adhere to the fingermark residue due to the physical interaction. Subsequently, the presence of methamphetamine particles along with a fingermark would diminish the possibility for adherence of powder particle onto the residues and the lack of such interaction limited the development of fingermarks carrying good ridge details (26). A background contamination tends to restrict the successful powder suspension on the fingermarks (27).

In a previous study, the immediacy of fingermark deposition either on a drug-contaminated surface or on a clean surface but subjected to further contamination was investigated using a scanning electron microscope. The presence of drug substances appearing as crystals at the peripheral regions of fingermark ridges indicated the deposition of fingermark onto a contaminated surface due to subsequent pressure exerted by a finger (14). In this study, the immediacy of deposition was found hardly differentiated as it did not involve observation under electron microscope; however, the drug-contaminated fingermarks remained possible to recover and develop through the application of fingerprint powder. The presence of the extraneous particles such as drug substance did not restrict the successfully recovery of fingermarks, suggesting that forensic investigator could implement the fingerprint powders onto any surfaces suspected to have contained fingermark to allow for suspect identification.

Regardless of the choice of fingerprint powders, higher fingermark grade was reported with lower contamination level by methamphetamine than the other two groups with slightly higher concentration levels. This was supported by previous findings where a heavily contaminated surfaces with fingermark tend to be problematic for the recovery and development of fingermarks (17,27). In other words, a severely contaminated fingermark might be difficult to be recovered or rendered visible, nonetheless, whenever a fingermark was highly contaminated, attempt should be made but expected with the lack of extent and clarity of the ridge details, leading to lower fingermark grade.

CONCLUSION

In this study, the recovery, development, and visualisation of methamphetamine-contaminated fingermarks were successfully carried out where black fingerprint powder had produced better contrast and visualisation of fingermarks. Among the 11 tested surface materials deposited with fingermarks, the slightly more porous surface materials could have restricted the recovery and development of high-grade fingermarks. The presence of methamphetamine as exogenous substance had contributed as contaminant, leading to lower fingermark grades. Apart from that, a highly contaminated fingermark tends to produce lower grading upon dusting by fingerprint powder. However, the immediacy of fingermark deposition did not demonstrate any significant difference on their recoveries. As future recommendation, the variations of donors and ageing of contaminated fingermarks which might influence the recovery shall be investigated. Additionally, sensitivity of fingerprint powder dusting procedure towards successful development of fingermarks shall also be explored to maximise the values of such evidence in a real case scenario.

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