

Fingerprint Transfer Mechanism to Adhesive Tapes Through Latex Gloves

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Abstract: In forensic science, latex gloves are used to prevent law enforcement personnel from contaminating crime scenes or evidence with DNA or marks from the hands. Law enforcement personnel, however, are not the only people who want to avoid leaving DNA or latent marks at a crime scene. Perpetrators of crimes may also wear latex gloves. Alas, several forensic scientists reported that in certain cases even while wearing latex gloves, fingerprints transferred to adhesive tapes while attempting to process the tape for latent marks. Pressure sensitive tapes tend to be ideal surfaces for recovering latent marks and are commonly encountered in criminal cases involving drug packaging, explosive devices, or violent crimes (e.g., binding a victim's hands and feet). When a latent mark is developed on the adhesive surface of the tape, it may not be obvious if the latent mark was made by a bare finger or a gloved finger. Knowing that a suspect wore gloves could sometimes discourage the investigation unit from performing fingermark development procedures, as the odds to recover evidence successfully are limited. This study examines the feasibility of the transfer of friction ridge details through latex gloves to different types of adhesive tapes and uncovers the required conditions and a possible mechanism for the occurrence of this phenomenon. The findings of this work show that it is possible to develop and identify fingermarks transferred originally by gloved fingers. This study also shows that visualization of ridge details on adhesive tapes surfaces contain unique characteristics, which aid differentiating between bare or gloved hands.

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Introduction

Friction ridge impressions found on exhibits collected from crime scenes can provide a direct link to person(s) involved [1]. Gloves are a common method, used by both perpetrators and law enforcement personnel, to prevent leaving friction ridge impressions or undesired contaminants (e.g., DNA) at the scene or on items of evidence. Surgical gloves made of latex are often used as they are widely available, cheap, easily acquired, and allow delicate work. Alas, there are reported cases of friction ridge impressions from crime scenes being linked to offenders or law enforcement personnel despite wearing gloves [1 – 7].

Some reports indicate that mechanical pressure could cause residues from the skin to permeate through the glove [1, 2, 5], while other studies examined various factors such as fluid flow through the gloves [3, 4, 6]. Lounsbury et al. examined several types of gloves, and found for example, that when the external side of a vinyl glove became contaminated, details of the friction ridge skin could be transferred to the surface because the glove's membrane was sufficiently thin to mold to the raised ridges of the skin [8].

Glove impressions can be two-dimensional or three-dimensional depending on the nature of the surface contacted by the glove [9]. Levin-Elad examined fingermarks passing through gloves to various surfaces, such as paper or glass, and found that plastic 3-dimensional (3D) fingermarks transferred through gloves to the plasticine surface while biological substances did not transfer [10]. The literature recommends wearing two pairs of gloves on each hand as a minimum when handling exhibits for fingerprint development [4, 7, 11, 12]. Arbeli et al., studied and found a method for developing fingermarks on latex gloves using a ninhydrin solution [13]. As part of their study, they examined the structure of latex gloves using Scanning Electron Microscopy (SEM). However, the mechanism for this transfer, by either a visual printed pattern or material transfer, was not discussed by Arbeli et al.

Some of the most common exhibits encountered in criminal cases involving drug packages, explosive devices, rape, murder, kidnapping, etc. are adhesive tapes. Pressure Sensitive Adhesive (PSA) tapes are challenging surfaces since they are difficult to

handle without the tape unwittingly adhering to parts of the hand. This means offenders may leave friction ridge impressions despite wearing gloves to avoid detection, or law enforcement personnel may add friction ridge impressions to the surface, even when taking the standard precaution of wearing gloves.

This work focused on the transferring of friction ridge details through gloves to the adhesive side of PSAs. The authors wish to show how ridges can pass through gloves and suggest a possible mechanism describing the transfer process. It is possible that forensic investigators, in some cases, could use this information to determine whether or not a friction ridge impression was deposited while a person was wearing gloves.

Materials and Methods

Phase I

The first phase of the study examined whether latex gloves (most commonly found at crime scenes) could pass friction ridge details to the adhesive sides of six different tapes and be developed using a black powder suspension.

Surfaces

Six types of Pressure Sensitive Adhesives (PSAs) [14, 15], commonly found in crime scenes, were used:

1. Electrical tape - Scotch ® Vinyl Electrical Tape 35.
2. Magic tape - Scotch ® Magic TM tape 810.
3. Box-sealing tape - Tartan™ General Purpose Box Sealing Tape.
4. Duct tape - 3M™ Duct Tape 1900
5. Surgical tape - 3M™ Transpore™ Surgical Tape.
6. Double sided tape - VHB™ Acrylic Foam Tape 4910F

Fingerprint Deposition Process

Six donors, three men and three women 30 to 50 years old, participated in the study. Each donor deposited two fingermarks (using the index finger) onto six different tapes: one using a bare finger (not groomed), and another one using a clean latex glove. The development procedure took place at three time-periods: immediately, 5 hours, and 24 hours after deposition, corresponding to a fingerprint pilot study [16]. In total, 216 fingermarks were deposited and examined.

The gloves used for the experiment were "PureShield™ Powder-Free" natural rubber disposable latex examination gloves. The donors were not instructed to wash their hands prior to wearing gloves. The gloves were worn not less than 10 min and not above 30 min, to allow adequate sweat acquiring randomly, while performing their regular duties in the lab before depositing the fingermarks.

Fingermark Development Process

The development method used was black powder suspension (Black Wetwop™; Kjell Carlsson Innovation, Sweden.), which is a common developing method for the sticky side of adhesive tapes [17].

Photographing

The fingermarks were photographed using a DCS 5 system (Foster & Freeman) and a Nikon D810 SLR with 105mm micro NIKKOR lens. No image processing steps were performed except color transition to gray scale.

Fingermark Assessment Process

An expert in the examination of friction ridge impressions performed a quality assessment of the fingermarks according to a scale of four grades. Each grade was explained by the potential value that can be gained [18] to the investigative unit, as shown in Table 1.

Grade	1	2	3	4
Number of points for Comparison	0	1-3	4-8	Over 9
Value of Use	No Details	Poor ridge detail result, not suff. for comparison	Suff. for intelligence gathering (not to be used in court)	Suff. for Comparison

Table 1

The grading scale of the fingermarks.

Phase II

The second phase of the research focused on assessing the potential mechanism for the transfer of friction ridge details to the adhesive sides of the tapes using several visualization techniques.

Surfaces

The second phase of the study focused only on the three adhesive tapes with better transfer results (grade 3 or 4 according to the assessment in Table 1). These three tapes included Electrical tape, Magic tape, and Box-sealing tape.

Fingerprint Deposition Process

The index finger of a subject was charged with residue and a fingerprint deposited on the adhesive surface of each tape (bare fingerprint). The same donor finger was also charged with residue, dressed in a latex glove, and a fingerprint deposited on the adhesive surface of each tape (gloved fingerprint). In the gloved fingerprints, the exterior of the latex glove was not charged with residue. The gloves used were "PureShield™"

Powder-Free” natural rubber disposable latex examination gloves.

Optical Microscopy (OM) and Scanning Electron Microscopy (SEM) Examination

After deposition, the adhesive tapes were coated with gold-palladium (Au-Pd; 80:20 mix) for 20 seconds using a Turbomolecular-pumped coating system Quorum, model Q150T ES. The purpose of the coating was to create an electrical conduction for high quality, and uncharged, SEM images; these images were obtained using a JEOL JSM 6480LV Scanning Electron Microscope.

The adhesive tapes were examined and photographed using a Leica M205 C Stereo-Microscope; before fingerprint deposition, after fingerprint deposition, and after coating with the gold-palladium.

Results and Discussion

The first phase of the study examined the feasibility of friction ridge details to appear after deposition of fingerprints by bare fingers and via latex gloves, onto six types of Pressure Sensitive Adhesives. The results in Table 2 show that sharp ridge details passed through latex gloves onto the "Electrical", "Magic" and "Box-sealing" tapes. These tapes were scored 2 or higher, showing good transfer of ridges or patterns. The duct tape, surgical tape, and double-sided tape, however, consistently ranked at the lowest grade (1) for fingerprints through latex gloves, showing no transfer of ridges pattern.

Figure 1 is an example of the best-obtained fingerprints in all six tapes. The difference in the grades of the marks visualized is probably the result of the interference caused by the structure and texture of the adhesives themselves. The adhesive surfaces of the duct, surgical, and double-sided tapes are characterized by rough textures that create higher signal-to-noise ratios, disrupting the recording of the ridges and providing background noise in the furrows. The flat-like structure of the adhesive part of the three successful tapes appears to have contributed to the better signal-to-noise ratio.

Development Time after deposition	Donor	Electrical		Magic		Box sealing		Duct		Surgical		Double sided	
		B	G	B	G	B	G	B	G	B	G	B	G
Immediately	D1	4	4	3	3	3	2	4	1	1	1	4	2
	D2	4	2	3	3	3	4	4	1	2	1	4	1
	D3	4	2	3	1	3	1	4	1	2	1	3	2
	D4	4	2	2	2	4	2	4	1	2	1	4	1
	D5	4	3	4	2	4	1	4	1	2	1	4	1
	D6	4	1	3	2	4	2	3	1	2	1	3	1
5 hours	D1	4	3	4	3	4	2	4	1	2	1	4	1
	D2	4	3	4	3	3	3	4	1	1	1	4	1
	D3	4	2	4	2	3	2	3	1	2	1	4	2
	D4	4	1	4	2	4	1	4	1	1	1	4	1
	D5	4	2	4	2	4	1	4	1	2	1	4	1
	D6	3	1	2	2	3	2	3	1	1	1	4	1
24 hours	D1	4	4	4	3	4	1	4	1	2	1	4	1
	D2	4	4	4	4	3	3	4	1	2	1	4	1
	D3	4	2	3	1	3	1	4	1	1	1	3	1
	D4	4	1	3	1	3	1	4	1	1	1	4	1
	D5	4	2	2	1	2	1	4	1	1	1	4	1
	D6	4	2	2	2	3	2	4	1	2	1	4	1

B = Bare fingers

G = Gloved fingers

Table 2

Raw data of fingerprint scores after deposition using bare and gloved fingers.

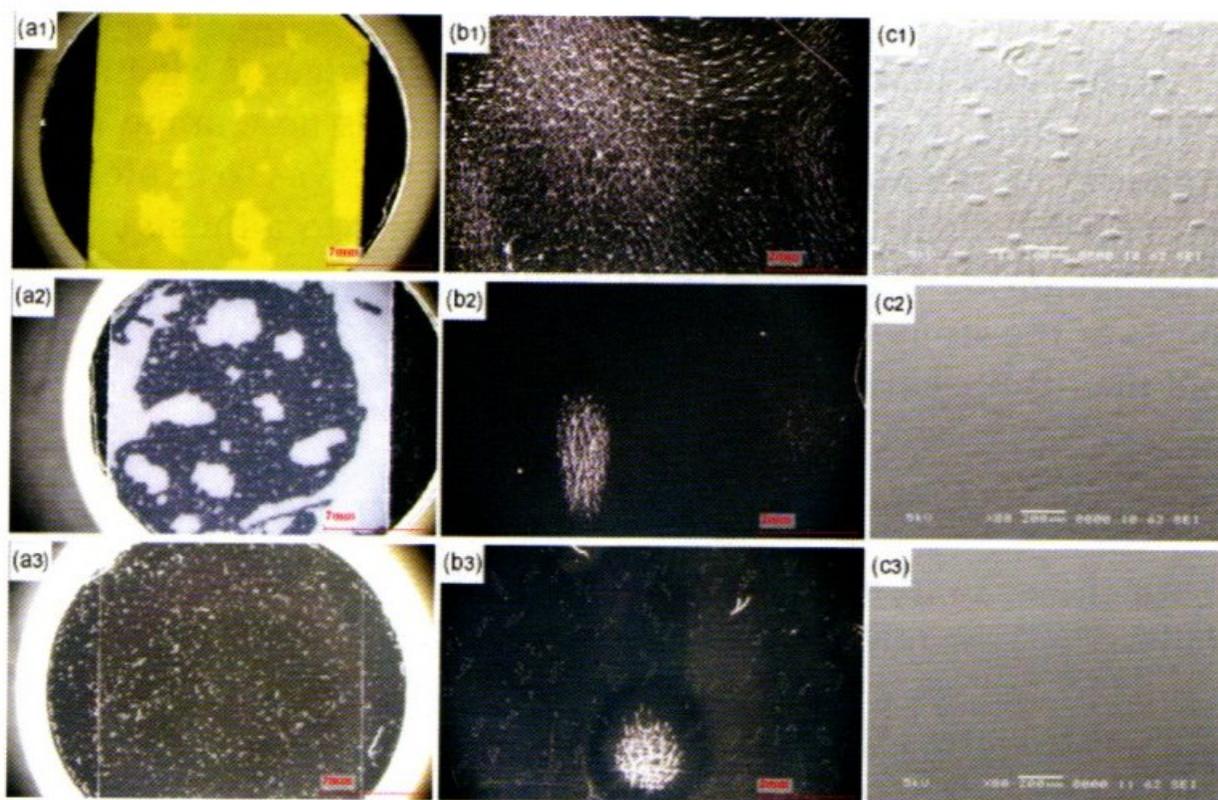


Figure 2

Texture imaging of (1) Electrical tape; (2) Magic tape; (3) Box sealing tape. (a) OM before gold-palladium coating; (b) OM after coating; (c) SEM imaging after coating.

The Texture of Latex Gloves

The macrostructure of the texture of the external surface of the latex gloves is shown by OM in Figure 3 and is characterized by lumps. The OM images allow the calculation of the diameter of the lumps which is approximately 150-400 μm .



Figure 3

Macrostructure (via OM) of the latex gloves showing the lumpy texture.

The microstructure of the texture of the external surface of the latex gloves is shown by SEM in Figure 4 and is characterized by flake-like texture. The SEM images allow the calculation of the diameter of the flakes which is approximately 2-5 μm .

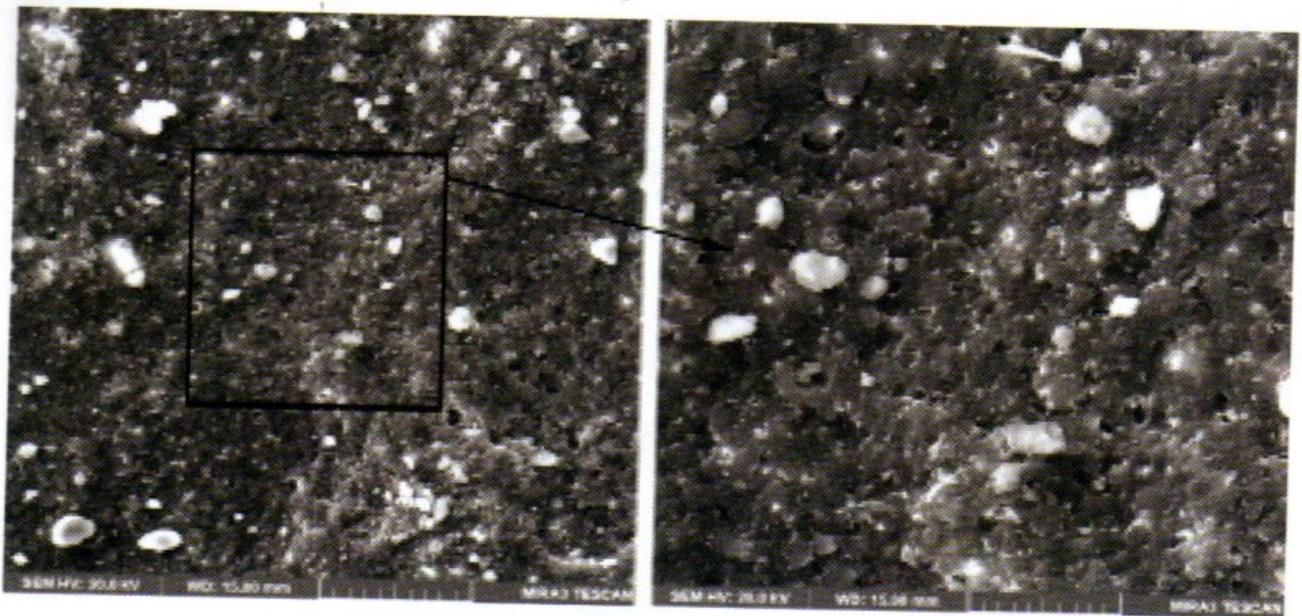


Figure 4

Microstructure (via SEM) of the latex gloves showing the flake-like texture.

Bare Fingerprint deposition on adhesive tapes

Macrostructure examination of fingerprints deposited with bare fingers on all three types of adhesive tapes shows the familiar structure of ridges and pores. The optical microscopy images in Figure 5 capture the macrostructure of the ridge detail on the Electrical, Magic, and Box sealing tapes.

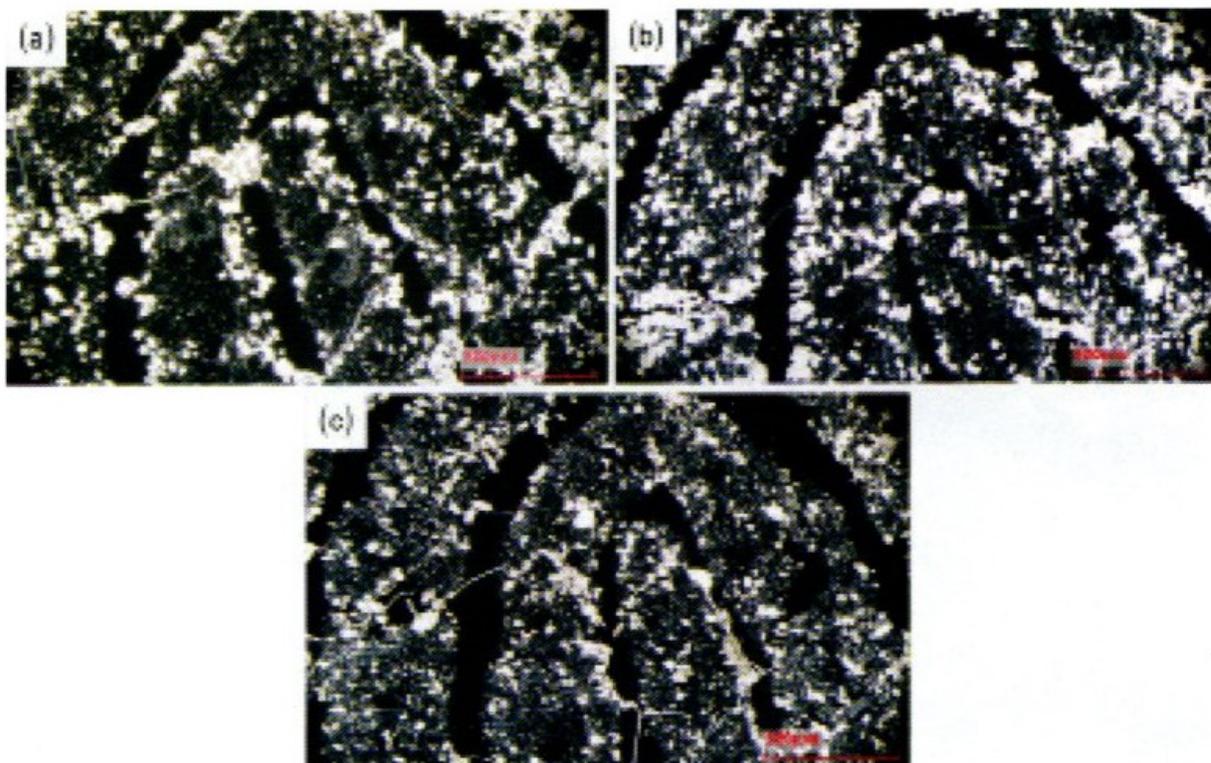


Figure 5

OM images of marks on (a) Electrical tape; (b) Magic tape; (c) Box sealing tape deposited using a bare finger.

Microstructure examination of these samples via SEM shows that the ridges appeared to consist of natural residue material (e.g., no lotions, blood, or other contaminants). The residue on the adhesive surface, in all samples, has a wrinkle appearance of the adhesive around the residue. The images in Figure 6 capture the microstructure of the ridge detail on the Electrical, Magic, and Box sealing tapes. The close-up images (a1, b1, and c1) show the wrinkled appearance of the adhesives.

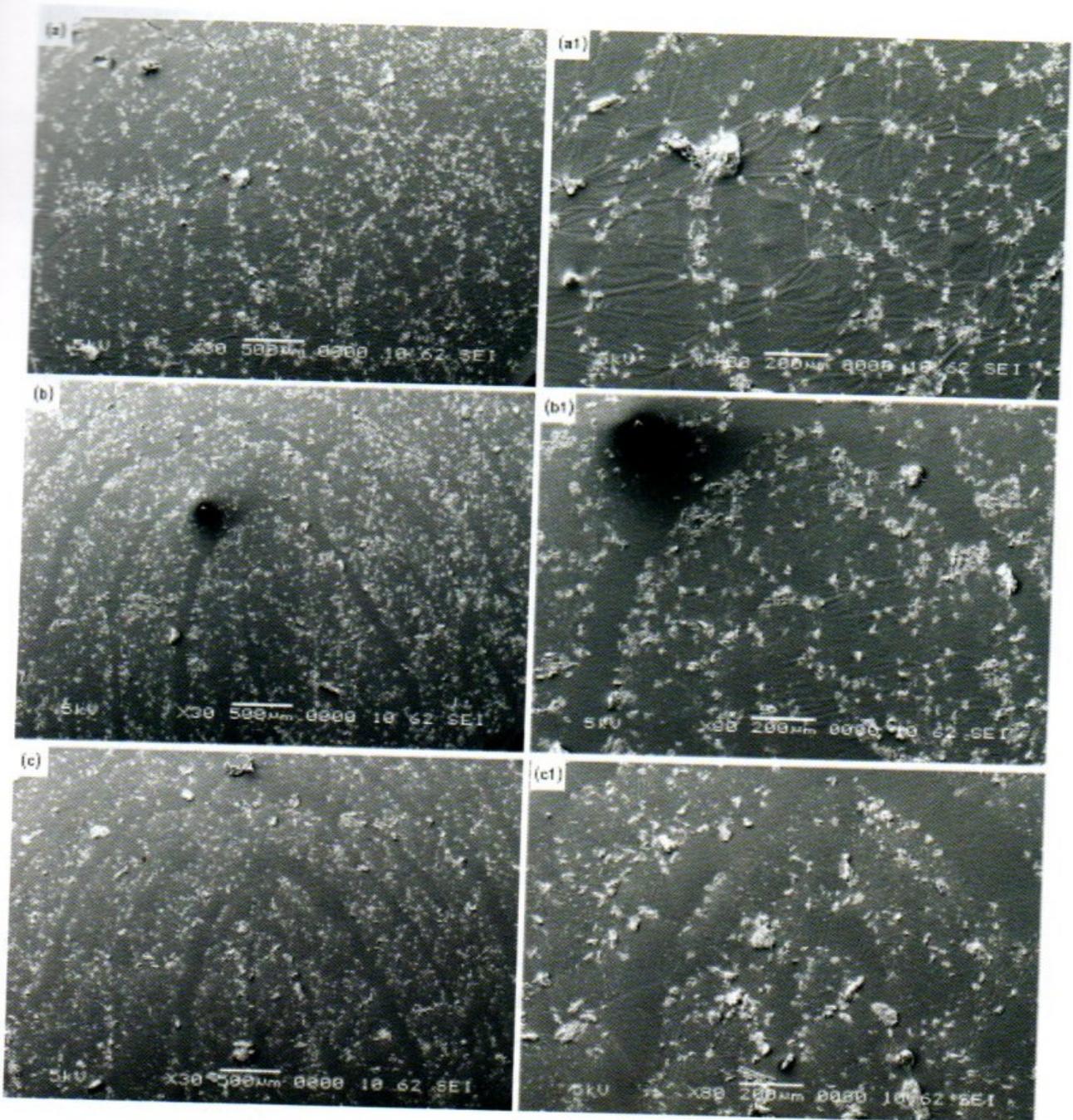


Figure 6

SEM images of fingermarks on adhesive tapes showing residue materials on the ridges transferred from the fingers: (a) Electrical tape; (b) Magic tape; (c) Box sealing tape. Close-up images a1, b1, and c1 show the wrinkles present in each of the adhesives.

Fingermark deposition through a glove

Macrostructure examinations via OM of fingermarks deposited through gloves onto Electrical, Magic, and Box sealing tapes revealed clear fingermarks. Figure 7 displays fingermarks from each type of tape demonstrating overall distinct ridges and furrows with readily interpretable patterns and minutiae.

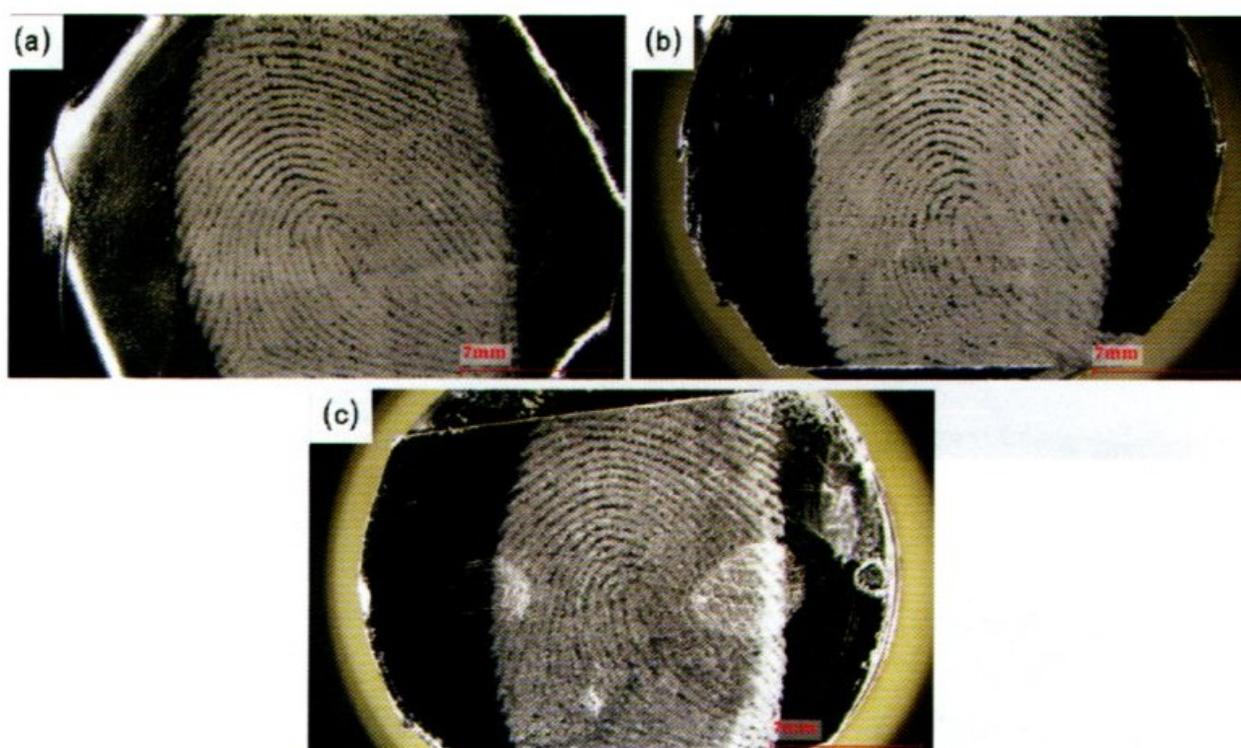


Figure 7

OM images of fingermarks deposited through gloves onto all three types of adhesive tapes: (a) Electrical tape; (b) Magic tape; (c) Box sealing tape.

SEM examination of depositions through gloves on these adhesive tapes shows well-defined impressions. It is possible to see the macro and microstructure of the gloves replicated on the tapes. An example of the SEM images for magic tape is shown in Figure 8. In figures 8a and 8b it is possible to see that the characteristics of the glove on the tape are similar to the characteristics of the glove observed in Figure 3. It is very easy to observe the lumps of the gloves, characterized by a diameter of 150-400 μm . In figures 8c and 8d it is possible to see the micro characteristics of the structure of gloves showing flakes, characterized by a diameter of 2-5 μm , similar to those seen in Figure 4. The images in Figure 8 are very different from the images in Figure 5 and Figure 6, where deposition using a bare finger was performed. The signature of the residue and the surface wrinkles observed in the fingermarks in Figures 5 and 6 are not seen in the fingermarks deposited through the gloves as shown in Figure 8.

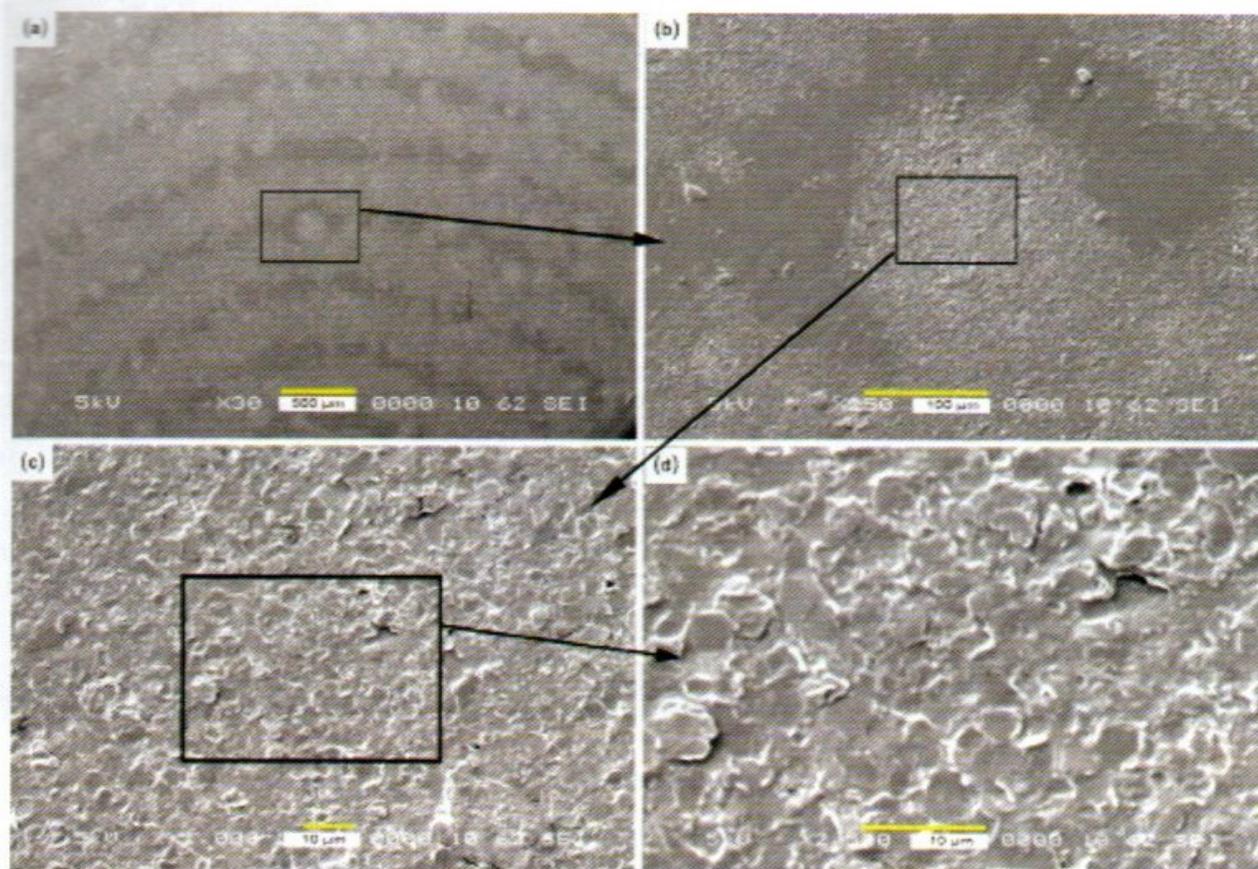


Figure 8

SEM images of the micro and macro structures of a fingerprint transferred through glove onto Magic tape. Image 8a provides an overall view of a lump produced by a glove. Images 8b, 8c, and 8d are progressively closer images of the microstructure of the lump, showing the flake texture.

Bare Fingerprint vs. Fingerprint through a Glove Deposition.

Figures 9 and 10 show an example of comparison between OM and SEM images of bare fingerprints vs. fingerprints through glove depositions on Magic tape. In the samples where bare fingerprints were deposited, the boundaries between the ridges and the valleys were clearer and sharper than the fingerprints that were deposited through gloves. Although, high-quality fingerprints were still possible when deposited through gloves under ideal conditions (i.e., lacking distortion factors beyond basic deposition pressure).

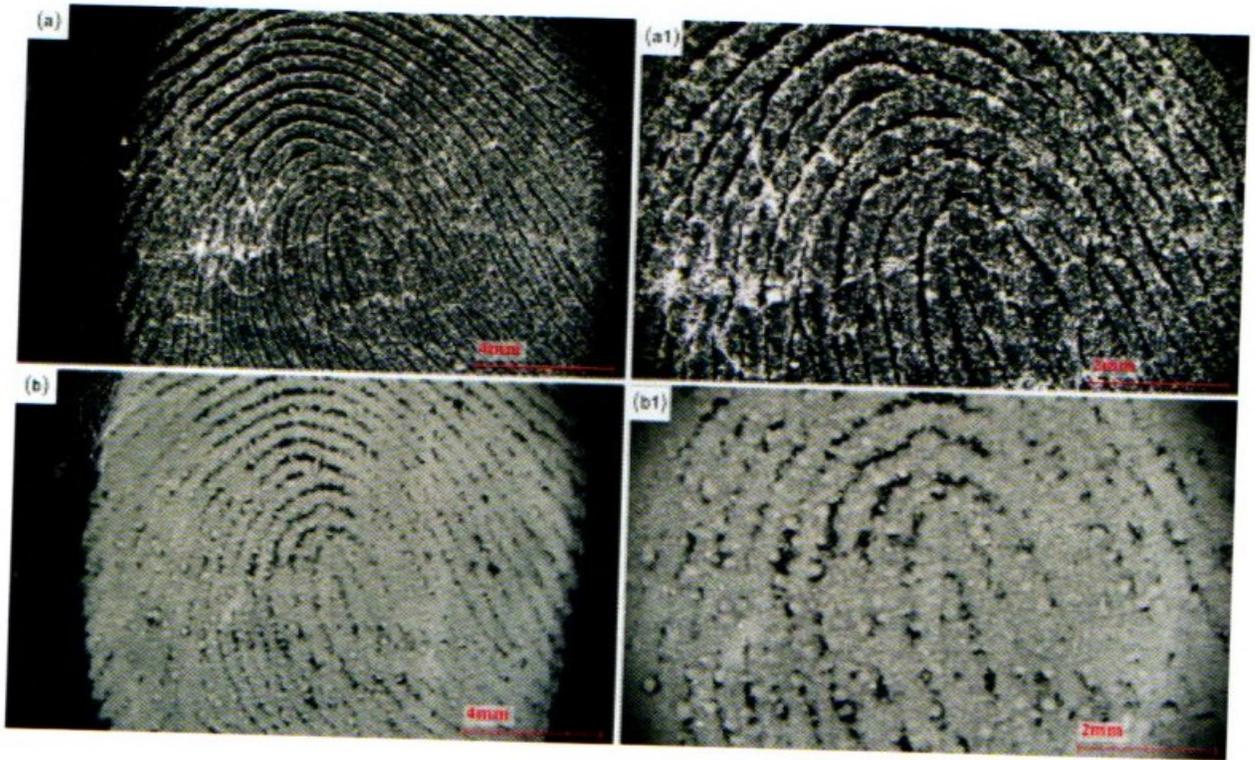


Figure 9

OM images of fingerprints deposited on Magic tape with bare fingers (a) and through a glove (b). Close-up images a1 and b1 illustrate the differences in clarity between the ridges and the furrows in the two impressions and the added textural elements from the glove in the glove print.

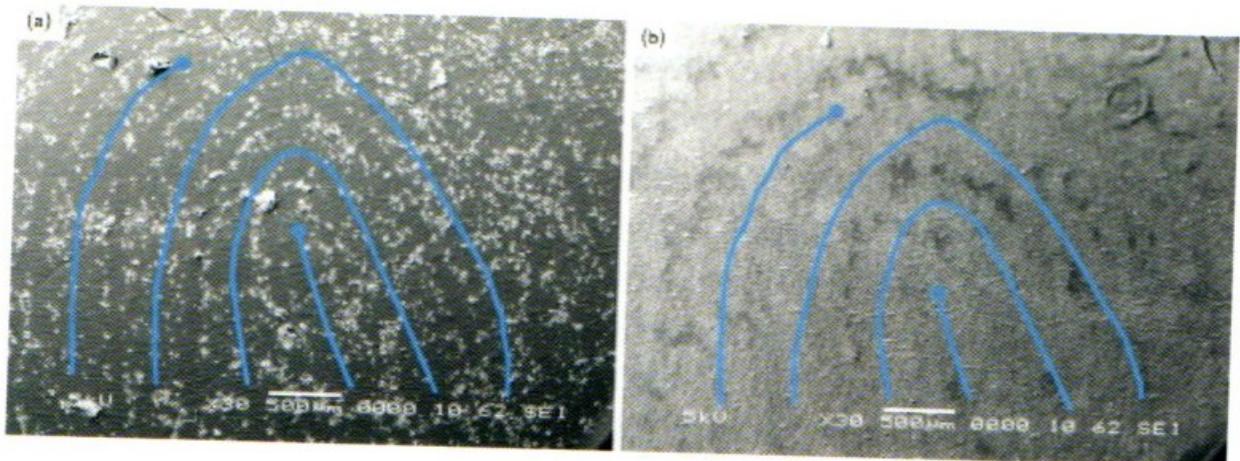


Figure 10

SEM images of fingerprints deposited on Magic tape with bare fingers (a) and through a glove (b). The blue fine lines represent the paths of the ridges through the impressions.

200 *Tonal reversal effect (phase I & II)*

211 Under ordinary circumstances, the friction ridge skin contacts a surface and the ridges deliver residue to the surface. The latent print development reagents then react to this residue, revealing the ridges. This effect was seen in the fingermarks created by the skin touching the adhesive sides of the tapes; the black powder suspension adhered to the ridges. In this study, the gloved fingers were also able to transfer ridges to the adhesive surfaces, despite not being charged with residue.

Re-examination of the 108 fingermarks created through gloves in Phase 1 of this study revealed consistent “tonal reversals”. In these fingermarks, the ridges were brighter than the furrows. The term tonal reversal is used to describe when the furrows (background) react to a latent print reagent (rather than the ridges) or when the ridges simply display greater luminosity than the furrows [19, 20]. Figure 11 displays fingermark development with the black powder suspension during direct skin contact versus glove contact. The skin contact image displays darker ridges, while the glove contact image displays lighter ridges.

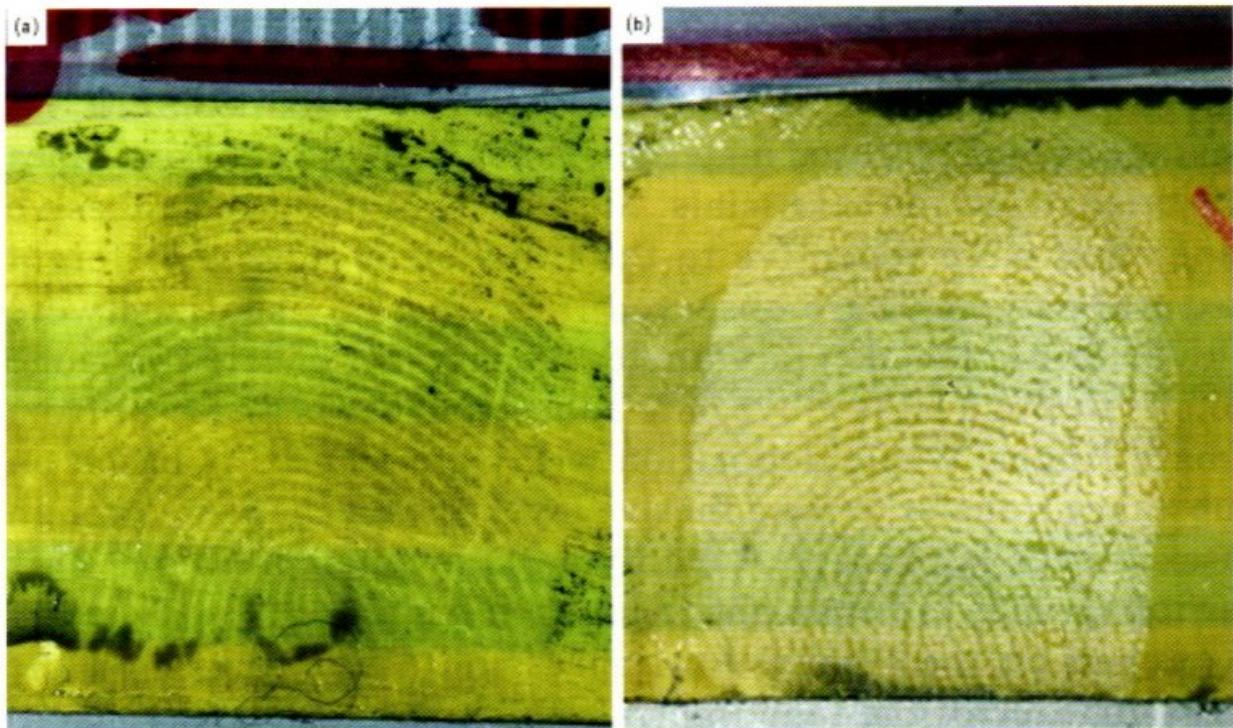


Figure 11

Fingermarks developed with Black WetWop™ displaying darker ridges (direct finger contact) versus lighter ridges (gloved finger contact).

The tonal reversals in the gloved fingerprints could be explained by the pressure applied on the adhesive material thus creating morphological differences in the tapes. Alternatively, it is possible the latex itself transferred material to the surface; however, chemical analysis was not performed to verify this possibility.

The black powder suspension was unreactive to fingerprints deposited through gloves therefore a tonal reversal effect may have appeared. Tonal reversals have also been reported when white gel lifters are used to lift latent print residue from a surface and the white gel lifter is subsequently processed with the same powder suspension used in this study [21].

Conclusions

This study demonstrates the feasibility of fingerprints transferring through latex gloves onto three types of adhesive tapes: Electrical tape, Magic tape, and Box-sealing tape. Transfer of ridges onto other types of adhesives, such as duct tape, surgical tape, and double-sided tape, did not show a similar effect, probably due to interferences caused by texture and structure characteristics.

The results show that the transfer phenomenon may be a physical mechanism. In all the images analyzed by SEM, no passage of human-based material residue onto the adhesive tapes was visualized in these trials. Moreover, in the three adhesive tapes that were receptive to the transfer of ridges, different textural patterns were observed if the marks visualized were gloved or ungloved. The transfer mechanism of friction ridge details through latex glove onto adhesive tapes is different from a bare finger. While deposition with bare fingers is based on substance transfer to the adhesive layer, the mechanism through latex gloves is characterized by a 3D print impression. This 3D topography is better obtained when the glove is sufficiently stretched on the finger. An impression of the finger on the adhesive side of the tape imprints this topography. The macro and microstructure of the texture of the latex glove are also imprinted on the adhesive side of the tape and the typical characteristics of this texture, lumps, and flake-like texture, can then

be seen as well, this phenomenon characterizes viscous surfaces such as the sticky side of tapes [22].

Examination of friction ridge impressions which are glove-based can be performed with magnification tools available in most investigative units, such as a simple magnifying glass or standard optical microscope. The knowledge that friction ridge impressions can be transferred through certain types of gloves could impact the results of a case. For law enforcement officers who process crime scenes or handle exhibits, it is important to know that when dealing with certain sticky surfaces their friction ridge impressions may pass through the gloves. Secondly, when crimes are committed, the investigation unit may learn that although gloves were used (according to video material elicited from security cameras), the suspect may have still deposited friction ridge impressions on surfaces at the crime scene or items of evidence.

A very interesting result observed as well, is the reversal tonal effect of friction ridge impressions deposited through gloves. This was explained by using a black suspension that had no preferable adherence to the ridges, as there was transfer of typical latent print residue (but may have involved transfer of the latex material itself). Future studies will be performed to test if transfer of the ridges can be repeated in other types of gloves encountered in crime scenes as well as the best development method to visualize such marks.

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