International Congress Series 1239 (2003) 953–957

Fingerprints from fingerprints

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Keywords: fingerprint; Nuclear DNA molecule; Corneocyte

1. Introduction

Besides "classical" biological materials such as blood and sperm, epithelial cells from latent fingerprints are targeted in forensic sciences. In addition to studies using latent fingerprints applied to beer glasses [1], T-shirts left on crime scenes [2] and various other objects [3], we report the detection of STR profiles from latent fingerprints deposited on ordinary sheets of paper. In contrast to the relatively high number of epithelial cells from saliva or from excessively pressured fingerprints during strangulation [4,5], the experiments with latent fingerprints are expected to generate only a very small number of epithelial cells. Moreover, cells remaining on objects touched only briefly may be nuclei-free corneocytes only. Thus, the main goal of our investigation was to find out whether briefly touched objects contain nucleated cells and to increase the sensitivity of the methods to target the expected few nuclear DNA molecules from latent fingerprints on paper.

2. Materials and methods

2.1. Sample preparation

Latent fingerprints were deposited from four donors, two males and two females, on ordinary white paper. All papers were touched in the same manner and with the same pressure as when turning over pages. The handling time periods ranged from 1 to 60 s.

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PII: S0531-5131(02)00230-3

2.2. Microscopic examination

The epidermis is a proliferative tissue which renews itself continually through mitotic division of its basal cells. Daughter cells achieve suprabasal position and undergo a slow process of maturation. The upper epidermal layer, the stratum corneum consists of biologically dead, nuclei-free horny cells, corneocytes. To examine whether latent fingerprints contain nucleated cells at all, fingerprints were applied onto microscope slides, stained first with iron hematoxylin Weigert solution for 5 min, and then with van Gieson solution for 7 min, to make the nucleus visible.

2.3. Extraction method

To find the best applicable extraction technique and to achieve the best performance in terms of sensitivity, four extraction protocols were tested. A 2 × 2 cm piece of paper with a standard amount of DNA (150 ng) was prepared as source for recover tests. Two widely used extraction procedures, the phenol/chloroform method and the Qiagen Purification kit were employed. Furthermore, two innovations designed for forensic samples, the Nucleo Spin C + T kit from Macherey–Nagel and the Invisorb Forensic kit from Invitek were applied. The Invitek kit is based on a newly developed silica particles suspension matrix, which bind DNA. The quantity of extracted DNA was measured using a Versa Fluor Fluorometer (BioRad).

After the initial examinations, all extractions were finally carried out using a modified Invisorb Forensic kit protocol. Each handled piece of paper was cut into small fragments to facilitate the extraction. One milliliter of lysis buffer was added to the sample. The solution was incubated at room temperature, followed by centrifugation. Fifteen microliters of carrier suspension were added to the supernatant, followed by incubation at room temperature for binding of DNA to the silica particles. After centrifugation, the supernatant was discarded. The carrier suspension with binding DNA was rinsed two times with wash buffer containing 96% EtOH and centrifuged at maximum speed. Subsequently, the carrier suspension pellet was dried up and the DNA was eluted in 50 μl elution buffer. The solution was centrifuged and then the DNA containing supernatant was transferred into a fresh tube.

2.4. Amplification and electrophoresis

The DNA extracts were amplified using the commercial AmpFlSTR®Profiler Plus™ PCR Amplification kit (Applied Biosystems). The amplification was conducted in a 25-μl final reaction volume containing 10 μl AmpFlSTR PCR Reaction Mix, 5 μl of Primer Set Solution, 2.5 U of AmpliTaq Gold™ DNA Polymerase and 3 μl DNA extract. Amplification conditions: 95 °C 7 min (94 °C 1 min, 59 °C 1 min, 72 °C 1 min) × 38, 62 °C 45 min. All amplifications were conducted in an Eppendorf Mastercycler.

The amplification products were first detected and quantificated by electrophoresis using a 2% agarose gel, and stained with ethidium bromide. To analyse the Profiler Plus amplified products a fluorescent-based capillary electrophoresis was carried out using the

Fig. 1. Nucleated epithelial cell.

ABI Prism 310 Genetic Analyzer (Applied Biosystems) and evaluated using GeneScan® 3.1 software (Applied Biosystems).

3. Results

The light microscope analyses showed, that the majority of epithelial cells from latent fingerprints were nuclei-free corneocytes, with a minimal incidence of nucleated cells (Fig. 1). Quite enough nucleated cells could be found and hence there is a possibility that forensically typeable DNA could be extracted from latent fingerprints.

The results of the DNA recover tests showed, that the Invisorb Forensic kit achieved the best performance in terms of sensitivity. After Qiagen extraction the amount of DNA recovered from the paper was not measurable at all, the phenol/chloroform and Nucleo Spin extraction yielded 10% of the deposited DNA, after Invisorb Forensic kit extraction we recovered 50% of the initial DNA.

Although only a minimal incidence of nucleated cells from latent fingerprints could be detected by microscopic inspection (Fig. 1), evidence of the genetic profiles from each of the donors could be obtained (Table 1). Furthermore, the results show that latent

Table 1
Characteristics of DNA genotyping from latent fingerprint deposited on paper (results from four persons and seven different handling periods)

	Amelog	D3S1358	D8S1179	D5S818	vWA	D21S11	D13S317	FGA	D7S820	D18S51
Number of amplifications	28	28	28	28	28	28	28	28	28	28
Locus amplified (%)	96	96	96	96	96	96	96	93	82	82
Extra alleles (%)[a]	0	18	7	4	11	11	4	0	0	4
False alleles (%)[b]	0	7	7	4	4	0	0	7	0	4
Allele dropout (%)	0	11	7	11	4	7	4	19	9	17

[a] Additional allele present in conjunction with true alleles.

[b] Additional allele in place of true allele, maybe caused by PCR artifact. More than two additional peaks in a profile indicate mixture.

Table 2
Characteristics of DNA genotyping from latent fingerprint for different handling times (results from four persons and seven different handling periods)

	60 s	50 s	30 s	10 s	5 s	2 s	1 s
Full STR profile (%)	100	100	75	25	75	100	100
Acceptable profile >5 STRs (%)	0	0	0	75	25	0	0
Partial profile 1–5 STRs (%)	0	0	25	0	0	0	0
Loci dropout (%)	0	0	23	20	5	0	0
False alleles (%)[a]	4	4	5	4	3	4	3
Allele dropout (%)	3	4	4	4	11	1	2

[a] Additional allele in place of true allele may be caused by PCR artifact. More than two additional peaks in a profile indicate mixture.

fingerprints could be amplified and typed successfully independent of the handling time (60, 50, 30, 10, 5, 2 and 1 s) (Table 2).

4. Discussion

Our investigations showed that it is clearly possible to obtain DNA from fingerprints left by simple skin contact on objects and to determine the genetic DNA profile. This finding completes the results already obtained by others [1–3]. From our experience, after we optimised the Invisorb Forensic kit extraction, until we achieved the best performance in terms of sensitivity, the examination of touched paper can routinely yield the STR-profile of the individual who has touched it. Therefore, a fingerprint can be considered as a potential source of DNA for forensic identification, even when latent fingerprints might not be visualised with traditional methods. Several studies [6–8] showed, that PCR can still be performed on biological material after treatment with classical latent fingerprint techniques. In conclusion, from the data presented in this validation study, we demonstrate that DNA was successfully extracted with the "cut to pieces" method, but further examinations have to be carried out to validate the ability to swab the epithelial cells from paper with sterile moistened cotton, when documents are submitted as exhibits in casework.

Acknowledgements

We thank all donors who supported this study through their generous donation of latent fingerprints. Special thanks are also addressed to members of the Institute of Legal Medicine, Mainz, for their technical support.

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