International Congress Series 1239 (2003) 947–951

Qualitative and quantitative analysis of DNA recovered from fingerprints

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Abstract

This work reports a validation study to demonstrate that DNA can be successfully extracted from fingerprints and analysed using short tandem repeat (STR) profiling.

Keywords: STRs; Fingerprints; Capillary electrophoresis

1. Introduction

The literature contains preliminary studies or case histories on the possibility of recovering DNA from fingerprints left on the skin or in rope, cord, wire, etc., used for strangling, gloves, knives, solid parts of cars and other objects, and on the interference of substances used to highlight fingerprints during later genetic analysis [1–3]. These works report on isolated experiments, dictated by the need to resolve definite cases, but systematic studies on recovery techniques, interference by contaminants, the influence of individual and exogenous factors in the number of cells left with the fingerprint, the quantity of DNA which can be extracted from prints prepared with various modes of contact and on various types of substrate (wood, glass, metal), and the percentage of success in PCR analysis of the genetic impression from nuclear DNA, have not been exhaustively carried out.

2. Materials and methods

The fingerprints of 11 persons working in a laboratory were applied on the following clean substrates, glass, metal and wood. Experiments were repeated three times without

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0531-5131/03
PII: S0531-5131(02)00572-1

washing the hands and three times with clean hands. Fingerprints were prepared in two different ways: pressure at a standard time of 30 s, and tangential contact with a rolling friction effect on the skin. In addition, dactyloscopic powders were investigated for their influence on DNA: the fingerprints on glass of six persons were visualized by sprinkling powders on them and shaking the surface manually. A brush was not used to apply powders, as it removes DNA [4]. The surfaces of substrates were first swabbed with digestion buffer (10 mM Tris–HCl pH 8, 10 mM EDTA pH 8, 100 mM NaCl, 0.5% SDS) and residual moisture was then recovered by swabbing the surface with a dry swab. Both swabs were then immersed in 400 mcl of the same digestion buffer. 10 mcl of 2-mercaptoethanol and 25 mcl of Proteinase K (10 mg/ml) were added and samples were incubated at 56 °C overnight [5]. DNA was extracted with phenol–chloroform, quantified using the dot-blot procedure and concentrated using the Microcon-30 procedure (Amicon, Beverley, MA, USA). Using the AmpFlSTR Profiler Plus kit (PE/AB), amplification reactions were carried out on a GenAmp System 9700 thermal cycler (PE/AB), following the manufacturer's recommendations. After denaturation, PCR products were electrophoresed on an ABI Prism 310 Genetic Analyzer in POP 4 (PE/AB).

3. Results

3.1. Fingerprints on various substrates

In the first experiment, subjects were asked to touch the various substrates with unwashed hands. The quantities of DNA extracted are showed in Table 1. The DNA profiles obtained with unwashed hands gave—(a) glass: unambiguous profiles for only one sample, partial profiles for eight samples, and two negatives; (b) metal: eight positive and three partial profiles; (c) wood: eight positive and three partial. Mixed profiles were obtained in 63% of cases. The results of experiments performed with clean hands gave—(d) glass: seven partial and four negative profiles; (e) metal: three positive, seven partial and only one negative profile; (f) wood: only one positive and ten partial profiles.

3.2. DNA typing of powdered fingerprints

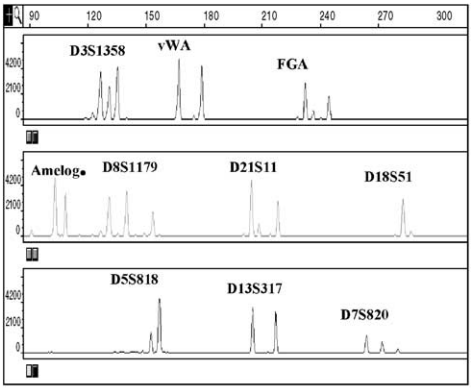
A series of experiments was carried out in order to verify the effects of dactyloscopic powders. Two positive and four partial profiles were obtained on glass. Further confirmation that these powders do not influence DNA typing came from the fact that, when 11 tampons prepared with cells from oral mucosa and powdered were typed, complete profiles were obtained.

3.3. Casework analysis

Analysis of fingerprints on a knife used in a case of matricide revealed a mixed profile. A method previously described for typing DNA mixtures was applied [6,7],

Table 1
Quantification, expressed in ng/mcl, obtained from three tests carried out by each subject on three different substrates, with clean and unwashed hands

Mode	Substrates	1	2	3	4	5	6	7	8	9	10	11
Unwashed hands	Glass	0–0.04	0–0.04	0–0.04	0.04–0.2	0.04–0.1	0.04–0.1	0.04–0.1	0.1–0.2	0.2–0.15	0.04–0.2	0.08–2
	Wood	0.1–0.2	0.08–0.15	0.04–0.1	0–0.04	0.04–0.1	0.1–0.15	0.04–0.1	0.04	0.4–1	0.1–0.15	0–0.04
	Metal	0.15–0.2	0.15–0.2	0.04–0.1	0–0.04	0.04–0.1	0.04–0.1	0.04–0.1	0.04–0.1	0.15–0.4	0.1–0.15	0–0.1
Clean hands	Glass	0–0.4	0–0.4	0–0.4	0–0.4	0–0.4	0–0.4	0.1–0.2	0.1–0.2	0.04–0.2	0.04–0.2	0.04–0.1
	Wood	0–0.04	0–0.04	0–0.04	0–0.04	0–0.04	0–0.04	0–0.04	0–0.04	0–0.04	0.04–0.1	0–0.04
	Metal	0–0.04	0–0.04	0–0.04	0–0.04	0–0.04	0–0.04	0–0.04	0–0.04	0.04–0.08	0–0.04	0–0.04



LOCUS	ALLELE	PEAK AREA	POSSIBLE GENOTYPE COMBINATION	
D3S1358	16 17 18	45118 28680 38250	16-16 17-17 18-18 16-17 16-17 16-18	17-18 16-18 16-17 17-18 16-18 17-18
VWA	14 17	44625 38602	14-14 14-14 14-17	14-17 17-17 14-17
FGA	22 23 25	23887 5895 14870	22-22 23-23 25-25 22-23 22-23 22-25	23-25 22-25 22-23 23-25 22-25 23-25
Amelogenins	X Y	58817 27849	XX	XY
D8S1179	10 12 15	37267 33628 17675	12-15 10-15 10-12 12-15 10-15 12-15	10-10 12-12 15-15 10-12 10-12 10-15
D21S11	29 30 32.2	38572 7742 22522	29-29 30-30 32.2-32.2 29-30 29-30 29-32.2	30-32.2 29-32.2 29-30 30-32.2 29-32.2 30-32.2
D18S51	12 13	26556 3910	12-12 12-12 12-13	12-13 13-13 12-13
D5S818	12 13	14230 43439	13-13 13-13 12-13	12-13 12-12 12-13
D13S317	8 11	31432 27477	8-8 8-8 8-11	8-11 11-11 8-11
D7S820	8 10 12	13162 9307 3401	8-8 10-10 12-12 8-10 8-10 8-12	10-12 8-12 8-10 10-12 8-12 10-12

Fig. 1. Mixed profile obtained from a fingerprint on a knife used in a case of matricide. Note acceptable combinations, since those in which inconsistent ratios and heterozygotic peak imbalances were observed had been excluded.

assuming that the profile derived from two different individuals by the history surrounding the case (Fig. 1). The approximate ratio of the mixture at each locus was ~ 3–4:1.

4. Discussion

The results obtained in this study show that it is possible to type DNA from biological material left by simple skin contact on several kinds of substrate. Unambiguous profiles were obtained from fingerprints left by subjects with clean hands, and mixed profiles were often found in DNA of fingerprints from subjects with unwashed hands. It was noted that the quantity of DNA left on glass was greater than on the other substrates, probably due to the increased perspiration occurring when skin comes into contact with glass. The partial profiles were characterized by allele and locus drop-outs for the heavier systems (FGA, D18S51, D7S820). Mixed profiles, which decrease the statistical power of the results, may depend on various factors, e.g., presence of extraneous biological material on the skin of the person leaving the fingerprint. There are two remaining major problems in the forensic practice of using fingerprints as genetic markers. The first is the possibility of finding fingerprints belonging to more than one person, perhaps extraneous to the crime under investigation, because of the extreme facility with which the material is deposited. The second is the difficulty of identifying fingerprints, even when dactyloscopic powders are used, on substrates with rough or porous surfaces.

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