



Genetic analysis of fingernail debris: application to forensic casework

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Abstract

DNA typing of fingernail debris in cases in which a struggle is suspected can be a relevant issue in forensic casework. In this study, we analyzed 106 samples of fingernail material from 40 forensic cases. A mixture of the victim and the offender was found in eight samples from the victims' fingernails in six different criminal cases, allowing the identification of the suspect in four of them. © 2003 Elsevier Science B.V. All rights reserved.

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1. Introduction

In the course of violent crimes, multiple actions of aggression and defense are frequent. In cases where victims struggled or defended themselves, victims' fingernail debris has been described as a possible source of DNA from the perpetrator [1–3]. In this work, we present the results of the genetic analysis of 106 samples of fingernails debris from 40 forensic cases submitted to our center.

2. Material

2.1. Samples

Ninety-two samples from 31 homicides, eleven samples from seven rapes, two from an accident and one from a natural death were analyzed. One hundred samples came

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from the victim (94.34%), five (4.72%) came from the suspect and one (0.94%) was collected from the crime scene. Three samples from the suspect were collected between 1 and 4 days after the offense. Fingernail clippings were the most frequent sample (69), while 20 samples of debris scrapes (without any physical support) were submitted by the coroner. Other samples were wood or plastic sticks (15 samples) and sterile swabs (2 samples).

2.2. Cases

The forensic purpose of the analysis was to find any signs of struggle in all cases except a sexual abuse case in which a male was accused of having introduced his fingers in the vagina of the victim. In most cases (22), the purpose was to exclude the possibility of struggle. In eight cases, the coroner suspected some struggle but no signs of it had been found (struggle suspicion). In nine cases, other evidences of aggression–defence were known and the aim was to confirm this (struggle confirmation).

In the investigations in which the victim was dead, the causes of death were: stabbing (10 cases), head traumatism (6), strangulation (5), shooting (5), cardiac death (3), suffocation (1), throwing (1) and unknown (2 cases).

3. Methods

To collect any possible cellular debris, fingernail clippings were cleaned by elution in sodium acetate for an hour at 56 °C and then extracted. The other samples (nail scrapes, sticks and swabs) were directly extracted. The DNA was obtained by a lysis with Proteinase K, DTT and SDS followed by organic extraction and concentration and purification with Centricon 100. The samples were electrophoresed in a 0.7% agarose gel and quantified by the Quantiblot System. DNA typing was performed by the PCR analysis of different multiplex amplification systems including some with manual detection (DIS80, HLA-DQA-1, PM, CTT and FFV) and those coupled to the ABI Prism 377 DNA Sequencer (Profiler or Profiler Plus and Cofiler). In the analysis of mixtures with the Genotyper, only those peaks higher than 100 RFU were considered and published guidelines were followed [4].

4. Results

DNA was obtained from almost all samples (95.28%) except two swabs and three clippings. 93.4% of all samples was typed and compared with the victim and/or suspect reference samples.

4.1. Types of profiles obtained

In most samples (79.24% of 106), the donor profile was found. In two of these cases, the unique profile matching the victim agreed with the other forensic investigations being

consistent with a natural death and an accident. However, neither of the five samples coming from the suspect yielded a mixture with the victim.

A mixture of the victim and the offender was found in eight samples (7.55% of 106) from the victim fingernails of six different criminal cases (four homicides and two sexual assaults) allowing the identification of the suspect in four of them. The main characteristics of the mixed samples are shown in Table 1. In the cases in which a mixture was found all victims were females and all suspects were males, except one strangulation in which both victim and offender were males.

Inconclusive results included a 5.66% (six samples) of unbalanced mixtures (donor profile with some alleles of a second individual) and no STR results in one sample (0.94%).

4.1.1. Significance of mixtures matching the victim and suspect DNA profile

The analysis of fingernail debris allowed the confirmation of a struggle in four cases out of nine in which it was strongly suspected. In one of the other two cases in which a mixture was found the evidence of struggle was weak and in the other one the aim was to exclude the possibility of struggle.

4.1.2. Identification of the suspect in four cases

In a case of strangulation, one fingernail clipping was the only sample of evidential value so it allowed the identification of the aggressor. Both the aggressor and the victims were males.

Three cases: A mixture matching the victim and suspect DNA profiles was found in four samples of fingernail debris (Table 1). The same mixture was also found in bloodstains or

Table 1
Characteristics of mixed samples

Mixed sample	Type of sample ^a	DNA amount (ng/ml)	Number of contributors to the mixture	Consistency with the suspect reference samples	Legal investigation
Sample no. 1	Clippings from 1 nail R	0.125	2	Suspect identification	Homicide no. 1: strangulation
Sample no. 2	Nail scrape from 10 nails R L	0.625	2	Suspect identification	Homicide no. 2: strangulation
Sample no. 3	Clippings from 10 nails R L	2	2	Suspect identification	Sexual assault no. 1
Sample no. 4	Clippings from 1 nail R	0.02	2	Suspect no. 1 identification	Sexual assault no. 2
Sample no. 5	Clippings from 2 nails L	0.08	2	Suspect no. 1 identification	Sexual assault no. 2
Sample no. 6	Clippings from 4 nails R	0.2	3	Suspects no. 1 and no. 2 identification	Sexual assault no. 2
Sample no. 7	Clippings from 3 nails R	0.5	2	No compared with the suspect	Homicide no. 3: shooting
Sample no. 8	Clippings from 4 nails L	<0.03	2	3 Suspects excluded	Homicide no. 4: head traumatism

^a R: sample from the right hand. L: sample from the left hand.

semen stains. Furthermore, in one of these cases (sexual assault No. 2) a complex mixture of three individuals was found in one fingernail-clipping sample from four nails of the right hand. The third contribution of this sample matched a second offender and it was also found in the semen stains (and a vaginal swab) and in the saliva stains on the breast of the victim.

4.1.3. One case not compared with the suspect

In a firearm crime in which the suspect was the partner of the victim, a mixture of the victim and a male was found in one clipping sample, but comparison with the suspect reference sample was not requested by the judge.

4.1.4. No identification of the suspect in one case

A mixture from the victim and a second individual (that was only found in the victims left hand clipping) allowed the exclusion of three suspects of the crime. This case remains unsolved to date.

5. Discussion

In our opinion, DNA analysis of fingernail debris could be a useful approach, especially when a struggle between the victim and the offender is suspected. Further investigation is needed to evaluate the influence of the handling and the laboratory procedures on the possibility to obtain DNA from the scratched.

In most cases, fingernail debris originated from the fingernails themselves, leading to the problem of identification of a secondary minor source of DNA. In mixtures of unbalanced DNA amounts from different donors, the interpretation must be carefully done. Other strategies such as reamplification with more cycles, new typing systems and chromosome Y typing can increase the possibility of finding an additional profile.

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