

SUSPECT DNA PROFILES OBTAINED FROM THE HANDLES OF WEAPONS RECOVERED AT CRIME SCENES

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Abstract

PCR DNA typing offers the forensic scientist a very sensitive and versatile tool for locating and comparing questioned material left at a crime scene to known samples. As sensitivity increases, so too does the variety of potential sources of questioned DNA, including sloughed skin cells. A case history will be presented demonstrating the transfer of epithelial cells to the handles of weapons left at a murder crime scene.

Introduction

A case history will be presented in which DNA was recovered from the wooden handles of two knives discarded at the scene of a murder. DNA was successfully extracted, identified, and compared to known samples from the deceased, and a murder suspect. A PCR DNA typing profile matching the deceased was obtained from blood identified on the blade of one knife, identifying it as the murder weapon. A mixture of male and female DNA was found on the handle of the murder weapon. A second knife discarded near the first, yielded a DNA profile originating from a single male source. This profile was later matched to that of a male suspect. PCR DNA typing was successful in all 11 loci attempted, including amelogenin (gender determination).

Case Details

In the murder case in point, an assailant broke into a single family residence and removed two steak knives from the kitchen drawer (see figure 1). He then entered the bedroom of two eight year old twin girls, and subsequently stabbed one girl with a single fatal thrust. The murder weapon and the second knife were then dropped on the deceased's bed (see figures 2 and 3). The father, who was awakened by screaming, confronted the intruder. Not knowing the full circumstances, the father struggled with, and ejected the intruder.

Investigating members of the Royal Canadian Mounted Police attended the scene. Along with a number of exhibits, the two wooden handled serrated edged steak knives were seized (see figure 4). Following the normal course of investigation, family members were interviewed, and possible suspects developed. Due to darkness and confusion, the suspect was misidentified by the father. The wrongfully accused individual was eliminated by investigators, due to an airtight alibi. The two knives were subsequently examined for the presence of suspect fingerprints using cyanoacrylate fuming and metal deposition techniques. No fingerprints were located. The two knives and were submitted along with exhibits seized by investigators to the R.C.M.P. Forensic Laboratory Regina.

Scientific Investigation

Blood was identified on the blade of one of the knives (knife A). No blood was identified on the blade of the second knife (knife B). The blade of knife A and handles of each knife A and knife B were swabbed with distilled water. DNA was extracted from these swabs using a single-step phenol/chloroform extraction procedure, followed by Microcon 100 purification (1,2). The DNA was then quantified using a commercially available kit (ACES 2.0+ Human DNA Quantification System - Gibco BRL, Gaithersburg, MD). Known blood samples from the deceased and the suspect were processed separately and at later dates relative to questioned samples, utilizing the same technique described above. The known sample from the suspect was received and processed after results from the questioned samples were generated. Legislation governing the confidentiality of profiles generated from DNA Warrant Samples dictates their exclusion from display in this case summary.

The DNA was amplified using three separate PCR multiplex systems developed by the RCMP (3-9). These systems are referred to as STR1, STR2, and STR3. The amplified DNA was then analysed using an ABI Prism® 377 gene sequencer (ABI Prism®, Foster City, CA) with 4% acrylamide: bis-acrylamide (19:1), 6M urea denaturing gels. The three separate multiplex systems (STR1, STR2, and STR3) were utilized to provide a profile of 10 polymorphic loci and 1 gender-determining locus (amelogenin). Approximately 5 nanograms of purified DNA was utilized for STR1, 10 nanograms for STR2, and 5 nanograms for STR3, for each sample tested. Incorporation of an internal lane standard (GeneScan® 350 ROX) enables use of ABD (Applied BioSystems Division) GeneScan® 2.0.2 and ABD Genotyper 1.1 (ABI Prism®, Foster City, CA) software for sizing STR DNA fragments.

Results

The swab from the blood identified on the blade of knife A yielded approximately 392 nanograms of human DNA. The swab from the handle of knife A yielded approximately 10 nanograms of human DNA. The swab from the handle of knife B yielded approximately 49 nanograms of human DNA.

Multiplex PCR DNA typing was successful in obtaining profiles from the blade of knife A, the handles of both knife A and knife B, and known blood samples from the deceased and a suspect. Three separate multiplex systems were utilized to compose DNA profiles (see figures 5, 6, and 7). Band sizes were generated electronically through the use of GeneScan® software (ABD - Applied BioSystems Division) (see table 1). Comparisons were made between the known samples from the deceased and the suspect and the questioned profiles.

The DNA profile produced from the blood identified on the blade of knife A matched the deceased. Due to the reduced forensic significance of this finding, as the knife was found beside the deceased, only one multiplex system was utilized.

The DNA profile produced from the swab of the handle of the knife A matched the deceased, with a trace male profile. These trace minor peaks fall below the RCMP minimum peak size guidelines (unpublished: 20 for STR1, STR2, and amelogenin; and 40 for STR3), therefore they were not reported. The 10 nanograms of human DNA found on the handle of knife A was consumed in the production of the DNA profile using two STR multiplex systems.

The handle of knife B, found on the bed of the deceased, provided a DNA profile using three multiplex systems. This DNA profile matched that of the known suspect blood sample within a very narrow tolerance. The largest discrepancy was within the FGA locus at 0.28 bases, with much smaller variation seen at other loci. A large number of replicates of duplicate known samples within the same gel, between different gels, and between different instruments (ABI Model 377 Gene Sequencers), has supported the use of a 0.75 base match window. Each locus falls well within this tolerance. Therefore, a match was declared between the knife handle and the suspect's known sample, within a high degree of reliability.

Discussion

Assessing the evidentiary value of DNA type profile matches has long been a topic for debate. It is generally conceded that once a DNA type profile is generated, the chances of randomly selecting a matching profile from an unrelated individual is extremely remote. This does not consider the forensic context of the finding, however. Establishment of an opinion regarding the significance of forensic findings should include consideration of the following features:

- 1) Access - The suspect population is confined to those with access to the area.
- 2) Transfer - The suspect must shed the DNA bearing cells at the scene, in a significant location. These cells must then be recovered in sufficient amount and condition in order to generate interpretable findings.
- 3) Discrimination power - The DNA type profile generated by these questioned cells must match those of the suspect known sample. This point is represented by the Estimated Frequency of Occurrence.

In this case, the combined Estimated Frequency of Occurrence in the Canadian Caucasian Population (RCMP data, unpublished) for the ten matching loci shared between the knife B handle and the suspect equals

approximately 1 in 85 Billion. When the forensic context is considered along with the Estimated Frequency of Occurrence, a strong opinion may be stated regarding the origin of the DNA profile generated from the knife B handle. This strength of this opinion is reduced accordingly with a decreased number and discriminating power of loci available, as is the case with knife A handle (seven loci) and blade (three loci)(see table 1).

The potential use of sloughed epithelial cells as a source of questioned DNA for forensic comparison has been demonstrated (10,11,12). Although PCR STR typing is utilizing a very minute quantity of DNA for a successful comparison, several hundred or thousand cells are contributing to the profiles seen. The area of cellular origin of those cells can only be speculated in the absence of some confirmatory testing, such as identification of blood from the knife A blade. Intuitively, epithelial cells sloughed through active handling onto a porous and jagged substrate (at the microscopic level), should comprise a good portion of the DNA yielding cells. Other possible explanations for potential DNA sources exist. The hands may act as vectors of transmission for cells from other body areas (13). These areas include the mouth, nose, and eyes. For example, the cells of both the corneal epithelium (eyeball) and the bulbar epithelium (interior of eyelids and edges of eyeball) are nucleated, and regenerated continuously, being totally replaced every 6 to 24 hours(14). As such, both are potential sources for the DNA found. Rubbing one's eyes may effectively load the hands with DNA bearing cells for transfer. Recent case experience bears out the DNA potential of the eyes as a DNA source, as a full DNA profile was obtained from fragments of contact lens found at a crime scene (15).

The major source of the cells furnishing the DNA used to develop the resulting DNA profiles are thought to be epithelial cells sloughed from the hands. The rough and porous substrate of the knives is also an excellent substrate for the active transfer of fingerprint ridges sheared through friction. It is interesting to note that STR DNA type profiling was successful, even after processing for fingerprints, using cyanoacrylate fuming and metal deposition techniques. It is speculated that rather than jeopardize recovery of DNA bearing cells, the application of a very thin layer of acrylic through the fingerprint fuming process may help seal cells in place, to be removed later through swabbing. Conversely, the rough wooden handle may have resulted in very poor adherence of fingerprint reagents, making their use "non-DNA-destructive". In light of these results, and the mechanical nature of traditional mechanical dusting for fingerprints, it is recommended that cyanoacrylate fuming and metal deposition techniques be the methods of choice for non-DNA-destructive fingerprint examination.

Dried blood often reaches a powdery consistency, and loses adherence from substrates, while held in evidence. These blood flakes are susceptible to static, particularly when packaged in plastic. As a result of handling, blood flakes originating from victims may serve as a potential contaminant to suspect DNA on weapon handles. Therefore, it is recommended that bloodied ends of weapons be packaged separately from handles, in order to prevent mixtures through cross contamination.

Summary/Conclusion

A match was declared between the knife handle and the suspect's known sample, within a high degree of reliability. The combined Estimated Frequency of Occurrence in the Canadian Caucasian Population (RCMP data, unpublished) for the ten matching loci equals approximately 1 in 85 Billion. The suspect was charged with murder, and subsequently plead guilty to the offence. This case demonstrates the probative value of swabbing weapon handles for the purposes of association with suspect individuals.

Table 1: STR DNA Profiles

STR Loci	Known blood sample -victim	Knife A blade	Knife A handle	Knife B handle
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Band Sizes	Band Size	Allele	Band Size	Allele2	Band Size [Peak Height]	Allele3	Band Size	Allele4
D3S1358 112.30 to 145.31	126.30 134.53	15 17					126.29 134.59	15 17
D21S11 202.14 to 246.93	222.54 240.71	29 33.2					218.33	28
FGA 254.18 to 302.00	283.67	24					279.35 283.37	23 24
vWA31/A 124.85 to 169.76	139.23 143.75	14 15			139.20 [338] 143.56 [259] 148.07 [11] ¹ 152.08 [25]	14 15 16 17	147.97 152.01	16 17
TH01 153.10 to 180.51	158.79 173.53	6 9.3			158.75 [474] 170.56 [35] 173.58 [360]	6 9 9.3	158.82 170.62	6 9
F13A1 177.46 to 239.00	187.66 195.83	5 7			187.44 [89] 195.56 [90]	5 7	187.44 195.51	5 7
fes/fps 209.32 to 237.52	223.30 231.33	11 13			223.04 [250] 231.08 [195]	11 13	223.01	11
Amelogenin and 106 and 112	106.10	X	106.04	X	106.02 [1021] 112.12 [36]	X Y	106.02 112.12	X Y
D5S818 130.81 to 167.65	149.89 157.64	11 13	150.00 157.78	11 13	150.00 [251] 157.79 [260]	11 13	150.00 157.73	11 13
D13S317 171.74 to 203.91	189.69	12	189.87	12	189.87 [1406]	12	189.84	12
D7S820 208.07 to 240.51	225.98 230.12	11 12	226.10 230.17	11 12	217.88 [33] ¹ 226.10 [556] 230.17 [552]	9 11 12	217.92 230.16	9 12

1- peak heights are below RCMP unpublished guidelines (20 for vWA31/A, and 40 for D7S820) and are therefore shown only for illustration.

2 - The combined Estimated Frequency of Occurrence in the Canadian Caucasian Population (RCMP data,

unpublished) for the three matching loci between the knife A blade and the deceased equals approximately 1 in 1.1 Thousand.

3 - The combined Estimated Frequency of Occurrence in the Canadian Caucasian Population (RCMP data, unpublished) for the seven matching loci between the knife A handle and the deceased equals approximately 1 in 55 Million.

4 - The combined Estimated Frequency of Occurrence in the Canadian Caucasian Population (RCMP data, unpublished) for the ten matching loci between the knife B handle and the suspect (not shown for privacy regulations) equals approximately 1 in 85 Billion.

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Figure 1: Kitchen drawer from which knives A and B were removed



Figure 2: View of bed, knife A encircled



Figure 3: View of bed, knife B encircled



Figure 4: Close-up view of knife A



Figure 5: STR 3 DNA Type Profiles

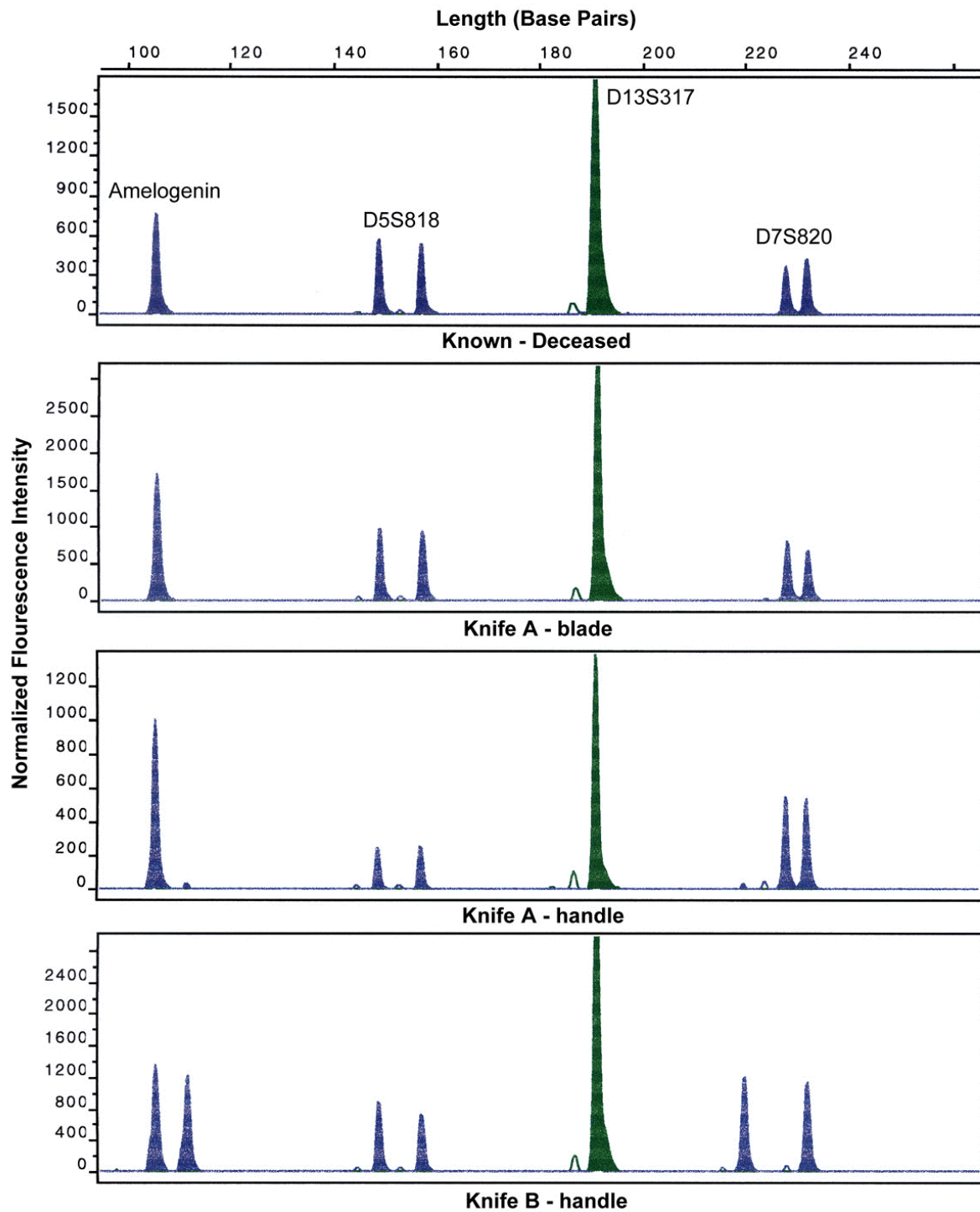


Figure 6: STR 2 DNA Type Profiles

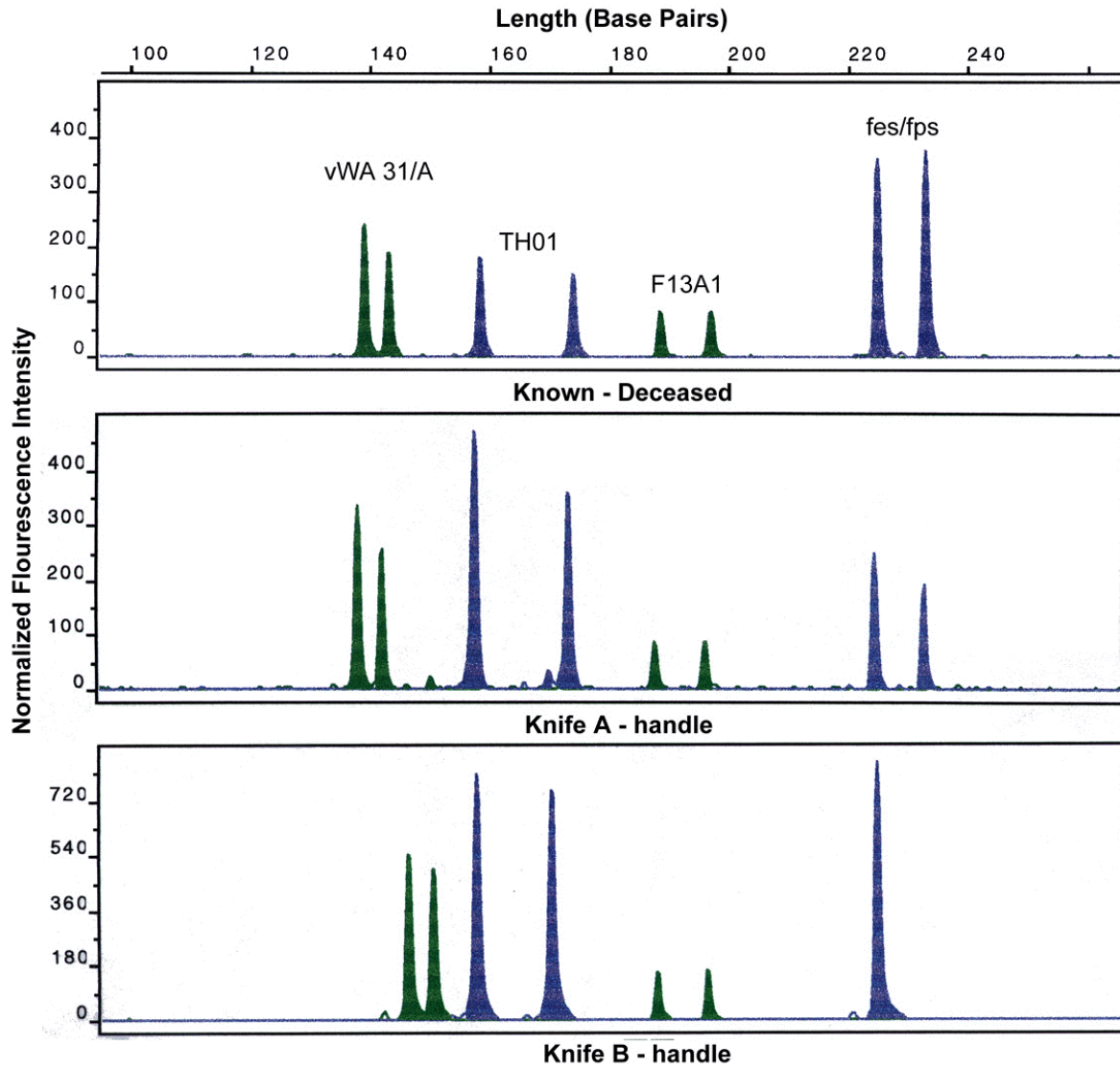


Figure 7: STR 1 DNA Type Profiles

