Forensic Science International: Genetics Supplement Series 5 (2015) e498–e500

Contents lists available at ScienceDirect

Forensic Science International: Genetics Supplement Series

journal homepage: www.elsevier.com/locate/FSIGSS

The deposition and persistence of indirectly-transferred DNA on regularly-used knives

Georgina E. Meakin[a,b,*], Emma V. Butcher[a,c], Roland A.H. van Oorschot[d], Ruth M. Morgan[a,b]

[a] UCL Centre for the Forensic Sciences, 35 Tavistock Square, London WC1H 9EZ, UK
[b] UCL Department of Security and Crime Science, 35 Tavistock Square, London WC1H 9EZ, UK
[c] UCL Division of Biosciences, Medical Sciences Building, Gower Street, London WC1E 6BT, UK
[d] Office of the Chief Forensic Scientist, Victoria Police Forensic Services Department, Melbourne, Australia

ARTICLE INFO

Article history:
Received 17 August 2015
Accepted 12 September 2015
Available online 1 October 2015

Keywords:
Trace DNA
DNA transfer
DNA persistence

ABSTRACT

Considerations concerning how DNA recovered from a crime scene was deposited are of increasing significance to forensic casework. While the possibility of indirect DNA transfer is well established, research into such transfer is limited and focused mainly on the handling of DNA-free items. This study investigated whether secondarily-transferred DNA can be detected on regularly-used items, and if so, for how long might it persist. Volunteers each used a set of knives regularly over a period of two days, after which, each of these 'regular users' shook hands with another person ('handshaker') and then immediately, without touching anything else, repeatedly stabbed one of their own regularly-used knives into foam for 60 s. DNA was recovered from the knife handles using mini-tapes approximately one hour, one day, and one week after the stabbings. In three of the four pairings of volunteers, complete and partial DNA profiles matching those of the regular user and handshaker respectively, at ratios of ~10:1, were recovered from the knives within one hour. Alleles attributed to the handshaker were still detected after one week, but were significantly reduced in number and peak height for two of the three pairings. Unknown alleles were also recovered from the knives, suggesting other indirect DNA transfer events. These included repeated detection of alleles attributed to the DNA profile of a volunteer's partner. For the fourth pairing, only complete single-source DNA profiles matching the regular user's profile were recovered. This study demonstrates that, on regularly-used items, secondarily-transferred DNA can be detected and can persist for at least a week; this has implications for forensic reconstructions.

1. Introduction

Considerations concerning how DNA recovered from a crime scene was deposited are of increasing significance to forensic casework [1]. Of critical importance is the possibility of indirect DNA transfer, a phenomenon which has been demonstrated by empirical research. For example, it has been shown that handling a plastic tube or glass beaker after shaking hands with another person can leave DNA from the handler and/or the handshaker, and the proportions of these DNA contributions can vary from major handler to major handshaker [2,3].

However, such experiments use items that have been cleaned of DNA, but in casework, items are unlikely to have been free of DNA before coming into contact with DNA from the offender. Items may already have a background layer of DNA present; this is particularly true of regularly-used items, such as, items of clothing and some types of weapons. This study therefore investigated whether DNA transferred indirectly via a handshake, could be detected on knife handles that had been artificially set up as 'regularly-used', and if so, for how long it might persist if the knife is not used subsequently. Such studies are important to assist the interpretation of trace DNA evidence in cases, such as R v Reed and Reed [4].

2. Materials and methods

2.1. Experimental design

Four volunteers each prepared a set of 'regularly-used' knives by handling the knife handles in a prescribed manner for 1 min twice a day for two consecutive days. Then once a day, over the next three days, each person shook hands with another volunteer

* Corresponding author at: UCL Centre for the Forensic Sciences, 35 Tavistock Square, London WC1H 9EZ, UK.
E-mail address: g.meakin@ucl.ac.uk (G.E. Meakin).

http://dx.doi.org/10.1016/j.fsigss.2015.09.197
1875-1768/

for 10 s and then immediately, without touching anything else, repeatedly stabbed one of their regularly-used knives into a foam apparatus for 1 min. A different knife was used each day for the stabbing to give triplicate results. This 5-day schedule was repeated across three consecutive weeks to allow DNA to be recovered from the knife handles using mini-tapes at approximately one hour, one day, and one week after the stabbings.

Prior to starting the experiments, the knives and stabbing apparatus were cleaned of DNA using MicroSol3+ or 10% bleach, followed by 70% ethanol and UV-irradiation for 20 min. The foam and foil covering of the apparatus were replaced and cleaned after each stabbing session. Cleaned knives and a sample of the regularly-used knives for each volunteer were mini-taped to provide negative and positive controls, respectively. Volunteers were denoted W, X, Y and Z and buccal swabs were taken from each to provide reference DNA samples. A buccal swab was also taken from the partner of volunteer X to provide an additional reference DNA sample.

2.2. Processing of DNA samples

DNA was extracted from the mini-tapes using the swab protocol of the QIAamp® DNA Investigator Kit and eluted into 35 ml. Extracts were quantified and then profiled using AmpFlSTR® NGM SElect™ (10 ml template in 25 ml reactions, 30 cycles) and interpreted using GeneMapper® 4.0 software (peak height threshold of 100 RFU). Profile percentages were determined on the basis of unique alleles that, for each pairing of volunteers, could be attributed to the reference profile of the handshaker and not to that of the regular user. SPSS® Version 22 software was used to identify significant trends in or differences between the data sets.

3. Results

3.1. Controls

No DNA was detected on the knife handles prior to use in these experiments. The average total quantities of DNA recovered from the regularly-used knives, prior to handshaking and stabbing, were 3.4 ± 0.5, 0.9 ± 0.8, 1.2 ± 0.5 and 10.4 ± 3.7 ng for volunteers W, X, Y and Z, respectively. The amounts of DNA deposited by volunteers W and Z were significantly different from each other and significantly greater than those deposited by volunteers X and Y (ANOVA, $F = 30.79$, $p < 0.01$).

3.2. Indirect transfer of DNA to knife handles

For three of the four sets of regularly-used knives, profiles of DNA from at least three people were recovered from the knife handles an hour after the handshaking and stabbing sessions. These mixtures could be attributed to DNA from the specific regular user and handshaker for each set of knives, and to DNA from unknown sources. DNA contributions from the handshakers were detected as minor profiles, at ratios to regular user DNA of approximately 1:10, 1:7 and 1:11 for the pairings of W:Y, X:Z and Y:W, respectively. Notably, the same unknown alleles were repeatedly seen in the profiles from knives handled by volunteer X; these were found to match those in the DNA profile from the volunteer's partner. For the fourth pairing of Z:X, only complete single-source DNA profiles matching the regular user's DNA profile were recovered.

3.3. Persistence of indirectly-transferred 'handshaker' DNA on knife handles

For the knife handles on which DNA had been indirectly transferred, the DNA attributed to the handshaker was observed as partial profiles. These were still detected after one week, but the numbers of alleles and the heights of those allele peaks were significantly reduced for the pairings of W:Y and Y:W, with only the peak heights being significantly reduced after one week for X:Z. To illustrate, reductions in unique allele peak height and profile percentage of the handshaker's DNA in the pairing of W:Y were significantly correlated with increasing time between DNA deposition and recovery (Pearson's $r = -0.55$ and -0.87, respectively, $p < 0.01$; Fig. 1).

4. Discussion

The results of this study demonstrate that, on regularly-used items, indirectly-transferred DNA can be detected and can persist for at least a week. Although the regularly-used knives were artificially set up, the amounts of DNA recovered (~1–10 ng) prior to handshaking and stabbing were comparable to those previously reported for regularly-used items [5]. However, these amounts of DNA significantly varied among the individual volunteers, supporting the concept that different people deposit different amounts of DNA [3].

When DNA from the handshaker was recovered from the knife handles, it was consistently seen as a partial minor profile, contributing approximately 10% to the total profiles recovered. Unknown DNA was also recovered from these knives, suggesting the occurrence of other indirect DNA transfer events, such as the finding of DNA from a volunteer's partner who had never been in the laboratory. This supports the previous observation of indirect DNA transfer from a spouse to a worn item of clothing [6].

In summary, these findings suggest that, when items already have a background level of DNA present from a regular user, indirectly-transferred DNA may only be detected as a partial minor profile, if at all, when transferred via the regular user immediately after contact with another person. This is in contrast to previous studies using DNA-free items and a longer handshake, in which indirectly-transferred handshaker DNA could occasionally be detected as the major or only profile [2,3]. This study also showed that the indirectly-transferred handshaker DNA could persist for at least a week, but with significantly smaller allele peak heights corresponding to the detection of fewer alleles than samples taken one hour after indirect transfer. This implies that there is a greater

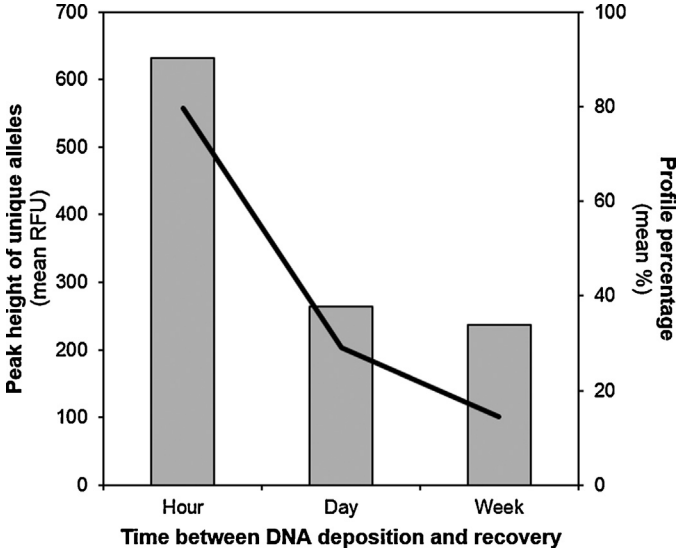

Fig. 1. Average allele peak heights (bar) and profile percentages (line) for DNA attributed to the handshaker, volunteer Y, recovered from knife handles at various time points after use by volunteer W.

chance of recovering secondarily-transferred DNA the sooner an item is sampled after an offence. These results contribute to the body of empirical data, which can provide an evidence base that can assist casework scientists in their interpretation of the finding of trace DNA at crime scenes.

Conflict of interest

None.

Acknowledgement

Ethical approval was granted by the UCL Research Ethics Committee (Ref. no. 5107/001). No financial support was received for this work.

References

[1] G. Meakin, A. Jamieson, DNA transfer: review and implications for casework, Forensic Sci. Int. Genet. 7 (2013) 434–443.
[2] R.K. Farmen, R. Jaghø, P. Cortez, et al., Assessment of individual shedder status and implication for secondary DNA transfer, Forensic Sci. Int. Genet. Suppl. Ser. 1 (2008) 415–417.
[3] A. Lowe, C. Murray, J. Whitaker, et al., The propensity of individuals to deposit DNA and secondary transfer of low level DNA from individuals to inert surfaces, Forensic Sci. Int. 129 (2002) 25–34.
[4] R v Reed and Reed, R v Garmson, Court of Appeal of England and Wales (Criminal Division), EWCA Crim 2698, [2010] 1 Cr App R 23, 2009.
[5] R.A.H. Van Oorschot, M.K. Jones, DNA fingerprints from fingerprints, Nature 387 (1997) 767.
[6] S.L. Stouder, K.J. Reubush, D.L. Hobson, et al., Trace evidence scrapings: a valuable source of DNA? Forensic Sci. Commun. (2001) 4 (online; available: http://www.fbi.gov/about-us/lab/forensic-science-communications/fsc/oct2001/stouder.htm).