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TECHNICAL NOTE

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An investigation into the transference and survivability of human DNA following simulated manual strangulation with consideration of the problem of third party contamination

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Abstract Amplification was performed on human DNA material transferred during a model of manual strangulation. A total of 29 separate experiments were performed using a single male offender-female victim combination to observe whether DNA was transferred both from the offender's fingers to the victim's neck and vice versa and to consider the period of time after the event during which the material could potentially be recovered and amplified. DNA was amplified from either the victim's neck or the offender's fingers for at least 10 days after the contact although it is discussed whether this is potentially due to primary contact or a secondary/tertiary transfer event. The study highlights the problem of contamination of the offender's hands and victim's neck with third party DNA, the presence of which could have a significant outcome for both the investigating authority and the third party.

Keywords Epithelial cells · Strangulation · Detection · Survivability · Contamination

Introduction

The transference of epithelial cells from the offender onto inanimate objects such as cigarette butts [1], ligatures [2] or the victim themselves, for example on bite marks [3] or debris under fingernails [4, 5] has been known and sought for many years. Unlike these examples where there is a relatively high number of cells transferred onto a small area, Wiegand and Kleiber suggested that during manual strangulation one expects a small number of epithelial cells to be transferred from the offender onto a relatively large skin area of the victim [6, 7]. Following the investigation of 16 suspect-victim combinations of manual strangulation they observed that potentially, DNA from the suspect could be successfully detected on the victim for up to 48 h. However, this remains a little used and known about technique in forensic practice in some parts of the world and there are limited publications in this area especially considering the transfer of victim DNA to an offender.

The results of an experimental model used to verify the findings of Wiegand and Kleiber [6] by assessing whether human DNA is not only transferred from the offender to victim but vice versa are presented. The study reports the time period over which successful retrieval and amplification could be achieved and considers observations related to third party human DNA contamination of both the victim and offender.

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Material and methods

A single victim-offender combination was used for the study. To assist with the interpretation of the results and taking into account a common assault combination, the offender was a male and the victim a single, unmarried female. In the anticipation of third person contamination, the female victim was known to have no active relationship at the time of the study. Both participants worked within the same building, one within an office area and the other within a laboratory environment, the two work areas being separated by three doors and two corridors. Physical contact between the two participants was avoided during the study period although access to the both rooms and a common kitchen area were allowed.

At a pre-determined time the female victim would enter the office where the male offender placed the finger pads of the 2nd and 3rd right fingers in full contact with one side of the neck of the victim, away from the carotid sheath. In accordance with the model used by Wiegand et al. [7], a force was applied to the neck for a period of 1 min. During this period the fingers were moved on the skin to cause friction to simulate movement during manual strangulation. At the end of the 1-min period the area of contact on the neck was immediately sampled with a sterile moistened cotton swab. The offender's finger pads which had been in contact with the skin were also immediately sampled in a similar manner. This procedure was repeated on 10 separate occasions over a 5-day period and 2 experiments were performed each day with a minimal period of 5 h between each test. The side of the neck that had been used as a control in the morning was used as the test in the after-

noon. An area of untouched skin on the opposite side of the neck, away from the area of the application of the offenders fingers was sampled as a control for each test. The neck was washed before the start of each day. The offender's fingers were washed between the morning and afternoon. A control water sample and buccal (mouth) swab from both participants were also taken. All swabs were immediately frozen, without drying, at –20°C prior to analysis.

The experiment was then repeated a further 19 times using a force application time of 1 min but the time period between the secession of the application of the force and the sampling was extended. The periods between the force and the sampling were 1, 5, 10, 15, 30 and 60 min, 2, 3, 4, 5, 6, 7, 8, 24 and 48 h and 3, 4, 5 and 10 days. On each occasion the neck was neither touched nor washed between the application of force and the sampling. The finger pads of the offender did come into contact with inanimate objects such as door handles, light switches, cups, telephones and computer keyboards and were also washed in the normal daily routine of the male.

The samples were extracted in batches in a laboratory dedicated for the extraction of very low levels of DNA. Samples were not quantified but were amplified to a set volume (20µl) using the second generation multiplex plus (SGMplus) system [8]. The PCR products were run on Applied Biosystems automated DNA sequencers, model ABI prism 377 [9]. Samples of interest were re-amplified using low copy number (LCN) conditions [10].

Results and discussion

A total of 29 separate time-based tests were performed. This yielded 116 swabs (29 test neck swabs, 29 test finger pad swabs, 29 control neck and 29 control finger swabs) which were all amplified using SGMplus with selected swabs further amplified using LCN. Of these swabs, 31 which were all from one batch analysis and from the first part of the study and included all 4 test sites, had no amplification result by either method. These should have been the swabs with the greatest chance of DNA amplification and thus an explanation for this observation cannot be given with any certainty. A further 6 swabs from other time periods had no amplification on SGMplus but of these, 2 had amplification results with LCN.

Of the test neck swabs, 19 yielded positive amplification results using SGMplus, 12 showed a victim-only profile and 7 a victim and offender profile with a full offender profile detectable up to 6 h after contact. When LCN was used (17 tests) all showed the offender to be present for all time periods i.e. up to 10 days. In the majority of cases it was a partial offender profile with the majority of the amplification result being a full victim profile. This verified the observations previously published by Wiegand and Kleiber [6] with regard to transfer of offender DNA to the neck of the victim and also supports their observation that the use of moistened sterile cotton wool swabs proved to be a simple and reliable method of DNA retrieval from the skin. Wiegand and Kleiber previously reported successful DNA profiling 48 h after the offender had gripped the neck of the victim [6]. This study supports this observation as long as the neck is not washed nor touched which would be expected to remove any offender DNA from the neck.

Of the test finger swabs, 21 yielded positive amplification results using SGMplus, 13 showed an offender profile without a victim profile and 7 an offender and victim profile. All except one case were partial victim profiles which were detected up to 24 h after contact. In 6 cases where LCN was performed all showed the victim to be present, all except one as a partial profile and up to 10 days after contact. This study suggests that not only can the offender's DNA be transferred onto the victim but the victim's DNA onto the point of contact with the offender. DNA survival on both parties may be for several hours to days. Thus in the case of the living victim seeking assistance from the police or the discovery of a deceased body or the apprehension of a suspected assailant, DNA retrieval from the point(s) of contact on the skin should be considered.

Having made these observations and comments, care must now be expressed in the interpretation of the source of the DNA on the victim and offender and the time periods of survival. One control neck test (the 10-day control) yielded a partial profile of the offender and eight control finger swabs (up to 5 days) yielded a partial profile of the victim despite the fact that the offenders control fingers never came in direct contact with the victim. Finally, partial profiles of one or more third parties were amplified from both test and both control sites for up to 10 days. In most cases where this occurred, the unknown profile was the same. No third party profiles arose from the amplification laboratory.

The explanation for these observations is that of secondary/tertiary transfer. A likely source for both the victim and third party DNA material were inanimate objects handled by both individuals within the building. Thus the finger pads of the offender may not only transfer offender's DNA onto the skin of their victim and vice versa but also transfers third party DNA from objects or the third party themselves, which the offender handled prior to contact with the skin of the victim. This would explain the observation of unknown profiles upon the neck of the victim at the site of contact as well as both hands of the offender. Thus DNA from an innocent person could be amplified from the hands of the offender or the site of contact on the skin of the victim. When considering the apparent time periods of DNA survival, passive transfer of the offender's DNA onto the victim's neck could also explain the presence of offender DNA several days after contact. Unpublished data from the amplification laboratory suggests that survival of DNA beyond a few hours must be questioned although other publications related to the survival of human DNA on inanimate objects such as mortuary instruments and work surfaces support the potential for much longer periods of survival [11, 12].

Having made the observation related to the potential issue of contamination it is still considered that this study does support that if there has been skin-to-skin contact between the victim and the offender one should consider trying to retrieve any DNA exchanged either way between the two parties. When the results are interpreted one must always bear in mind again the issue of innocent pre-laboratory contamination. One must consider the site from which the DNA was obtained, the ratio of whole or partial

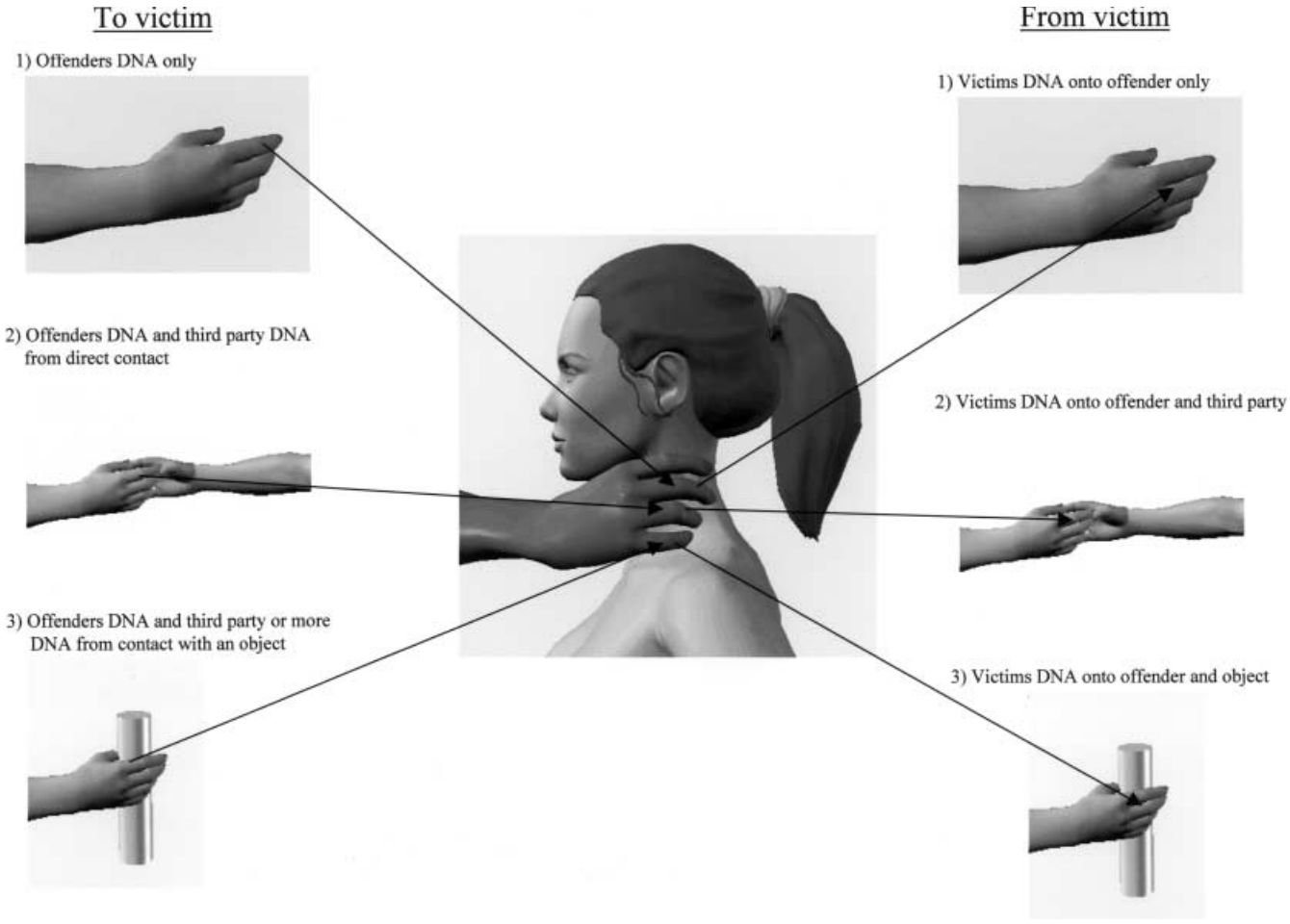

Fig. 1 A summary of the hypothesised sources and routes of transference of human DNA to and from a victim's neck via an offender's hand

profiles present and the relationship of the victim to the alleged offender as well as the analytical technique used. A summary diagram of the potential sources and route of transfer is shown in Fig. 1.

This study has verified the work previously published by Wiegand and colleagues reiterating the potential use of swabbing areas of skin from living or dead victims to assist in the identification of an offender where there has been skin-to-skin contact for example in the case of manual strangulation. It also highlights the problem of DNA transference from one object to another and how an innocent third party could find themselves placed onto the skin of a victim of a crime, onto the skin of an offender or to have the victim's DNA on them without ever coming into direct contact with the victim. This latter observation is of considerable significance to the investigating authority which must consider the potential source of a DNA profile identified from the skin of a victim prior to any conclusion as to it's likely source. Further work in the area of transfer of DNA between one or more humans or inanimate objects and the survival of DNA upon deceased bodies is required.

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References

1. Hochmeister M, Budowle B, Borer UV, Comey CT, Dirnhofer R (1991) PCR-based typing of DNA extracted from cigarette butts. Int J Legal Med 104:229–233
2. Bohnert M, Faller-Marquardt M, Lut S, Amberg R, Weisser HJ, Pollak S (2001) Transfer of biological traces in cases of hanging and ligature strangulation. Forensic Sci Int 116:107–115
3. Szibor R, Schoning R, Plate I, Krause D (1994) Typing of mucoid cell stains at bite marks on victim of sexual homicide crimes. In: Mangin P, Ludes B (eds) Acta Medicinae Legalis vol XLIV. Springer, Berlin, pp 93–95
4. Wiegand P, Bajanowski T, Brinkmann B (1993) DNA typing of debris from fingernails. Int J Legal Med 106:81–84
5. Lederer T, Betz P, Seidl S (2001) DNA analysis of fingernail debris using different multiplex systems: a case report. Int J Legal Med 114:263–266
6. Wiegand P, Kleiber M (1997) DNA typing of epithelial cells after strangulation. Int J Legal Med 110:181–183

7. Wiegand P, Trübner K, Kleiber M (2000) STR typing of biological stains on strangulation tools. In: Sensabaugh GF, Lincoln PJ, Olaisen B (eds) Progress in forensic genetics 8. Elsevier, Amsterdam, pp 508–510
8. Cotton EA, Allsop R, Guest J, Frazier R, Koumi P, Callow IP, Seager A, Sparkes R (2000) Validation of the AMPF/STR®SGMplus™ system for use in forensic casework. Forensic Sci Int 112:151–161
9. Frazier R, Millican ES, Watson SK, Oldroyd NJ, Sparkes RL, Taylor KM, Panchal S, Bark L, Kimpton CP, Gill PD (1996) Validation of the Applied Biosystems Prism 377 automated sequencer for forensic short tandem repeat analysis. Electrophoresis 17:1550–1552
10. Whitaker JP, Cotton EA, Gill P (in press) A comparison of the characteristics of profiles produced with the AMPF/STR®SGMplus™ multiplex system for both conventional and low copy number (LCN) DNA analysis. Forensic Sci Int
11. Rutty GN, Watson S, Davison J (2000) DNA contamination of mortuary instruments and work surfaces: a significant problem in forensic practice? Int J Legal Med 114:56–60
12. Karger B, Rand SP, Brinkman B (2000) Criminal anticipation of DNA investigations resulting in mutilation of a corpse. Int J Legal Med 113:247–248