The effect of pressure on DNA deposition by touch

Samuel H. A. Tobias[a,b], Guilherme S. Jacques[a,c], Ruth M. Morgan[a,b], Georgina E. Meakin[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] National Institute of Criminalistics, Federal Police, SAIS 7, Lote 23, Setor Policial Sul, 70610-200, Brasília, Brazil

* Corresponding author: E-mail: g.meakin@ucl.ac.uk, Tel.: +4420 3108 3275

Abstract

Casework exhibits are routinely examined for DNA that might have been deposited by touch, although the success of downstream profiling can vary. Many variables affect DNA deposition by touch, such as 'shedder status', surface type, and nature of contact. This may include pressure, which has been shown to increase the transfer of DNA between two surfaces, although whether pressure can impact DNA deposition directly from skin has yet to be examined. Therefore, this study uses a novel method to investigate whether pressure can affect the amount and quality of DNA directly deposited by touch. With the fingertips of one hand, volunteers exerted pressure for one minute onto a DNA-free polycarbonate board placed on top of a balance; all five fingermarks were then swabbed and combined as one sample for DNA extraction, quantification and profiling. For each hand, the area of the combined fingertips was used to determine the weight value to which to push the balance to give pressures of 4, 21 or 37 kPa. Volunteers used both their right and left hands at each pressure in a randomised order on each day of three non-consecutive days. Increasing the pressure between skin and surface significantly increased the amount of DNA deposited, which resulted in the detection of more alleles, from both the donor and unknown sources. No significant differences were observed in the amounts of DNA deposited between hands and among different days for each volunteer. DNA amounts significantly varied between individuals at 21 and 37 kPa, but not at 4 kPa. These findings provide insights into the impact of pressure on touch DNA deposition, and suggest that pressure is a key variable for crime scene investigators and forensic examiners to consider when prioritising items/surfaces that are likely to produce successful touch DNA results during a criminal investigation.

Keywords
Touch DNA; Trace DNA; Pressure; DNA transfer

1. Introduction

Since the first observation that touching an item can deposit DNA [1], it has become routine to examine items in casework for so-called 'touch DNA'. Experimental studies have shown that many factors affect DNA deposition, such as 'shedder status', surface type, and nature of contact [2]. Nature of contact includes pressure, which has been shown to increase the transfer of skin cells between two surfaces, depending on the substrate type [3]. However, whether pressure can impact DNA deposition directly from skin has yet to be examined. This study therefore investigates the effect of pressure on DNA deposition by touch. Exploring the impact of these kinds of variables is crucial to furthering our understanding of touch DNA and to inform both prioritisation of samples to test for DNA and interpretation of trace DNA in casework.

2. Materials and Methods

2.1 Materials and volunteers

Polycarbonate boards (150 mm x 150 mm, 2 mm thick) were soaked in 25% bleach for 20 min, rinsed with deionised water and UV-irradiated for 5 min per side to remove any DNA, as confirmed by negative controls. Prior to participation, two volunteers placed their inked fingerprints on 1 mm graph paper, which was scanned and the area of each fingerprint measured using ImageJ 1.50i. These areas were then summed to calculate the total area of contact per hand for each volunteer.

2.2 Experimental design

A polycarbonate board was placed on top of a balance so that, with the fingertips of one hand, a volunteer could press down on the board for 1 min. The weight values to which the balance was pushed were varied depending on the combined fingertip area of the hand, such that pressures were consistently applied at 4, 21, or 37 kPa to represent low, medium, or high pressures. Volunteers wore surgical masks to

minimise DNA transfer via breathing and speaking, and used both their right and left hands at each pressure in a randomised order, with a 10 min gap between each deposition, on each day of three non-consecutive days. Immediately after each deposition, all five fingermarks were swabbed together as one sample with one wet and one dry cotton swab (n = 36).

2.3 Processing of DNA samples

The swab protocol of the QIAamp® DNA Investigator Kit was used to extract DNA from each pair of swabs into 35 µl elution buffer. These were quantified using Quantifiler® Human DNA Quantification Kit and then profiled using AmpF*l*STR® NGM SElect™ (10 µl template in 25 µl reactions, 30 cycles). Profiling data were interpreted using GeneMapper® *IDX* v1.3 software (peak height threshold 100 RFU). Profile percentages were determined from the number of alleles detected that could be attributed to the respective volunteer's reference profile, obtained from buccal swab extracts. SPSS® Statistics v24 software was used to carry out statistical analyses to assess trends in the data.

3. Results and Discussion

3.1 Inter-individual variation in DNA deposition

The amounts of DNA deposited were first examined for any differences between the two volunteers using the Mann Whitney U test. No significant difference was observed between the amounts deposited at 4 kPa (Fig. 1(a); $U = 7.0$, $p = 0.075$), but one volunteer deposited significantly more DNA than the other at the higher pressures (Fig. 1(a); $U = 3.5$, $p = 0.033$ at 21 kPa and $U = 0.0$, $p = 0.004$ at 37 kPa). This supports the concept that DNA deposition differs among different individuals [4, 5], and suggests that pressure of contact may affect the detection of such differences.

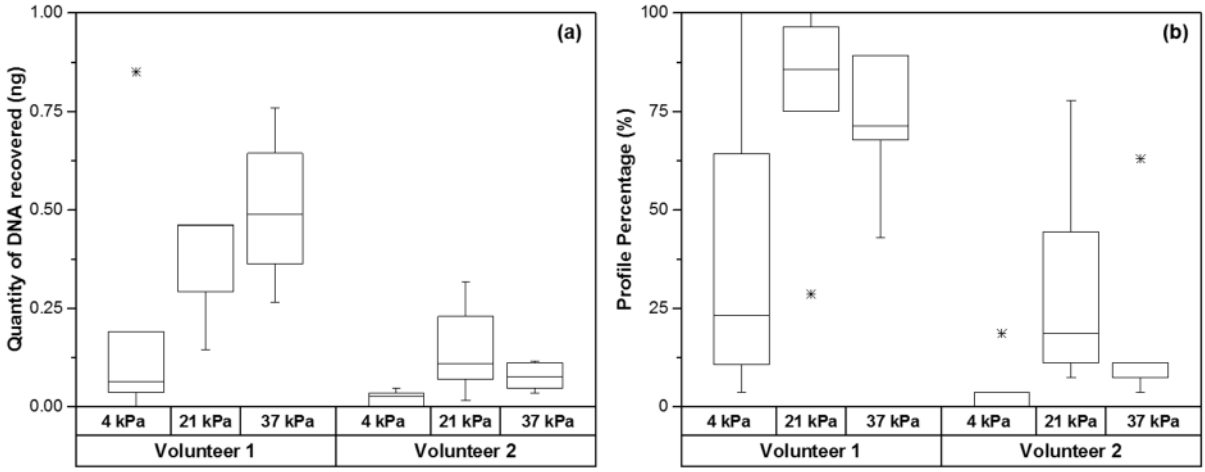

Fig. 1. Box-and-whisker plots of the quantities of DNA (a) and profile percentages (b) obtained at each pressure by each volunteer. Asterisks indicate outliers and, for ease of presentation, an outlier of 3.5 ng deposited by volunteer 1 at 21 kPa is omitted from (a).

3.2 Intra-individual variation in DNA deposition

To verify whether deposits by different hands and those from different days could be combined as replicates at each pressure, the DNA amounts were analysed for any differences as a result of the hand used or day of deposition. Comparisons examining the potential effect of these variables on DNA deposition, at each contact pressure for each volunteer, were made using the Mann-Whitney U or Kruskal-Wallis Chi-square tests. For each volunteer, no significant differences were observed between left and right hands of the same individual, nor among the three days of testing ($p = 0.323$-0.964 for all tests). This supports the findings of a study in which volunteers placed their hands on glass plates [4], although contradicts an earlier study in which participants grasped tubes [6]; this variation could be due to the difference in DNA deposition method.

3.3 The impact of pressure on DNA deposition

For each volunteer, when data from both hands and all three days at each pressure were combined, a statistically significant moderate correlation between the amount of DNA deposited and pressure was detected (Fig. 1(a); Spearman's $rho = 0.5$, $p < 0.05$).

This increase in DNA deposition was most pronounced when the pressure increased from 4 to 21 kPa (Fig. 1(a)). A weak correlation was observed between profile percentage and increasing pressure, although this was not statistically significant (Fig. 1(b); Spearman's $rho = 0.3$, $p > 0.05$). Non-donor alleles were also more frequently deposited at the higher pressures in comparison to 4 kPa.

These results show that pressure increases the transfer of DNA to a surface directly from skin, not just of DNA between surfaces [3]. Furthermore, these findings show that pressure can significantly impact the amount of DNA deposited, even when DNA deposition significantly varies between individuals. This suggests that this pressure effect is independent of an individual's shedder status, although the pressure used in DNA deposition may impact the detection of shedder status. Further research, with a range of volunteers and substrates, is required to expand this proof-of-concept study and test these proposed hypotheses.

4. Conclusion

This proof-of-concept study demonstrates the use of a novel method to examine the effect of pressure on DNA deposition by touch. The data obtained show that increasing the pressure of direct skin to surface contact can significantly increase the amount of DNA deposited, even when DNA deposition significantly varies between individuals. As testing for DNA on forensic evidence is time consuming, costly, and often returns negative results, these findings contribute to a better understanding of the factors affecting touch DNA deposition that can aid in prioritisation of testing, as well as contribute to DNA interpretation in casework.

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Conflict of interest statement

None.

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