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Short Communication

Evaluation of tapelifting as a collection method for touch DNA

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ABSTRACT

The use of tapelifting for collection of touch DNA from fabrics is routine in many jurisdictions. However, there is a paucity of data relating to the effectiveness of different types of tapes for tapelifting, the amount of tapelifting required to generate a useful profile, and whether or not tapelifting is more effective than swabbing from various substrates. This research investigates these questions by comparing two tapes of different adhesive strength currently used in forensic casework (Scotch® Magic™ tape and Scenesafe FAST™ minitapes), for sampling from touch deposits on four different fabrics–cotton flannelette, cotton drill woven fabric, polyester/cotton plain woven fabric and polyester strapping.

Touch DNA was deposited on four replicates of each substrate. Separate areas of each substrate replicate were sampled, either by taping with one of the two tapes or by wet/dry swabbing with cotton swabs. Tape was applied over the defined sampling area once or repeatedly for various numbers of applications. DNA was extracted, quantified and profiled from all tape and swab samples as well as the corresponding sampled substrates.

Significantly more DNA was extracted, and a higher proportion of alleles detected, from Scenesafe FAST™ tape than from Scotch® Magic™ tape. The amount of DNA and number of donor alleles detected generally increased as the tape was reapplied to the surface, although a threshold of collection was seen for both types of tape. For two out of four substrates, taping with Scenesafe FAST™ collected more DNA than swabbing and, for three substrates, generated a greater median number of donor alleles. There was no significant difference in numbers of alleles between swabbing and taping from flannelette. Based on these findings, it is recommended that a tape with stronger adhesion (such as Scenesafe FAST™ tapelifters) is generally preferable; that more than one application of tape is suggested (however, increasing the amount of times the area is sampled can diminish collection efficiency); and that there is an advantage using tapelifting rather than swabbing for fabrics unless, such as with flannelette, there are many loose fibres easily removed during the sampling process.

1. Introduction

Touch DNA has made a substantial contribution to forensic biology casework since the demonstration of its existence in 1997 [1–12]. Difficulties in collection of touch DNA are related to the often trace quantities deposited, its lack of visibility, and current lack of a presumptive test to assist targeted sampling from fabrics. Tapelifting is a technique commonly used to collect biological material (often touch DNA shed from skin), especially from porous substrates, for forensic analysis [2,4,13–17]. Furthermore, wet swabbing of, or direct extraction from, many substrates can involve collection of PCR inhibitors with the biological sample [2,15]. Tapelifting will, theoretically, limit this inhibition considerably.

A variety of tapes are in use for sample collection. An early paper [13] described the use of a simple, single-sided, adhesive tape (brand unknown) with the non-adhesive surface cleaned with 95% ethanol. This approach is still widely used by forensic practitioners, although there now exist a variety of alternative tapes available to the forensic community. These include the certified DNA-free Scenesafe FAST™ minitape (Scenesafe, UK) [14,15]; dissolvable minitapes [15] which, while theoretically enhancing extraction yield by reducing the possibility of the tape retaining cells, tend to increase viscosity of the extract and make it difficult to process [4,15]; and varieties of double-sided tape attached to backings to create lifters which are both easily handled and can be sterilised [4]. A study into optimisation of extraction from tape-lifts [18] also used TAPE-iT forensic lifting tape (LGC Forensics, UK), a tape designed for collection of fibres. This tape is,

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however, large and potentially requires substantial adaptation of currently used extraction methods. Also, it may not be suitable for sampling from many substrates due to its size.

There has been limited direct comparison between the effectiveness of swabbing and tapelifting as collection techniques. Hansson et al. [15] compared the Scenesafe FAST™ minitape (Scenesafe, UK) to three different swab types (cotton, flocked and foam) and found tape to be more efficient than the three swabs for sampling touch DNA from a single type of cotton shirt material.

A wide range of variables can potentially have an impact upon tapelifting but have not been explored. Firstly, the strength of adhesive on the tape surface may affect the amount of sample collected. The optimal number of lifts to take from a substrate is also likely to be highly relevant, as the first lift will collect a certain percentage of the available material, whilst the following lifts will result in an increasing loss of efficiency due to loss of available tape adhesive. The extent to which efficiency is lost after the first and subsequent lifts is, as yet, untested, as tapelifting has generally been performed until the tape is judged to have lost its adhesion completely. Transfer of biological material is affected by the substrate upon which the deposit resides [19–24]. There are currently no published data directly testing the effect of substrate on tapelifting for collection of DNA.

Given the current lack of knowledge regarding tapelifting and reliance on anecdotal evidence to decide whether to tape or swab an item, it is clear that further research on this topic is required. This study addressed three key issues related to tapelifting. Firstly, different types of tape used in forensic casework, Scotch® Magic™ Tape and Scenesafe FAST™ minitapes, were compared to ascertain which can sample DNA more effectively from four different but commonly encountered fabric types; poly/cotton plain-woven shirt material, cotton flannelette, drill-woven cotton, and polyester strapping. Secondly, the effect of taping an area of the substrates multiple times was examined. Finally, tapelifting with both tape types was compared to wet/dry swabbing with a well performing swab (FABswab, Puritan, USA) [25] for the collection of touch DNA from all four substrates.

2. Materials and methods

A printed template depicting twenty 25 mm × 38 mm rectangles separated by 5 mm on each side was placed on fresh filter paper, covered with an overhead transparency, and secured. Pieces of polyester strapping, cotton flannelette, cotton drill woven fabric and polyester/cotton plain woven fabric, each approximately 250 mm × 150 mm, were irradiated with UV on both sides each for 2 h to degrade DNA, and then secured tightly on top of this preparation (Supplementary Fig. 1). A 25 mm × 38 mm area of the pre-prepared fabric was excised as a negative control and processed as per test samples described below. No alleles were detected in any of the negative control samples. Four replicates of each type of fabric were prepared.

DNA was deposited over the remaining 19 sampling areas of each fabric by vigorous rubbing by one donor, previously shown to be a good shedder, with one hand over the entire area. All rectangles sampled were 25 mm × 38 mm; twice as large in area as the collection surface of one Scenesafe FAST™ K544 minitape to ensure the presence of a sufficient quantity of DNA for meaningful analysis. One taping was defined as the application of a lifter with firm pressure to one half of the area, then to the second half; i.e. one complete coverage of the 25 mm × 38 mm sampling area. Fourteen areas of each piece of fabric were sampled in this manner one, two, four, eight, sixteen, thirty-two and sixty-four times, each with a single tape; seven with Scenesafe FAST™ minitapes and the remaining seven with 125 mm pieces of Scotch® 810 Magic™ tape (the tape routinely used for casework in our laboratory) with 25 mm of each side folded back to form a lifter of 25 mm adhesive surface with two adjoining 25 mm handles. For areas where more than one application of the tape was required, application continued sequentially, alternating between the two halves of the area being sampled. The 25 mm × 19 mm adhesive portion of each tape was removed from the handles using a scalpel and rolled around the inside wall of a 2 mL tube with adhesive facing the centre.

Two sampling areas (25 mm × 38 mm) of each touched substrate were swabbed with two cotton FABswabs each (Puritan, USA) following the wet/dry method described by Pang and Cheung [26]. Swabs were returned to swab tubes to air-dry for approximately 48 h. All marked areas of fabric were subsequently excised with a scalpel, then cut into 8 equal parts and inserted into spin baskets suspended in labelled 2 mL Treff tubes for extraction. Three unsampled areas of each substrate were also excised to provide a measure of the amount of DNA deposited as a positive control.

500 μL of TNE buffer containing Proteinase K was added to each sample, which was then incubated at 56 °C for one hour. Samples in spin baskets were centrifuged at maximum speed for 3 min and the spin baskets discarded. In a preliminary study (data not shown) cell elution from tape was enhanced by the addition of 15 mm lengths of nylon DNA-free swab shaft (Puritan, USA) cut with a sterile scalpel, then by vortexing for approximately 30 s to allow sticks to scrape biological material from the adhesive surface. This protocol was applied in the present study for all tape extractions. Tape and sticks were removed from each sample and extraction was carried out using DNA IQ™ (Promega, USA) on Biomek® NX^P (Beckman-Coulter, USA) liquid handling platforms to an end volume of 50 μL as per manufacturer's instructions. Positive and negative extraction controls demonstrated no evidence of extraction problems or contamination during these stages.

Quantification results were obtained with Quantifiler® (Life Technologies, USA). Amplification was carried out using the PowerPlex® 21 system (Promega, USA) with either 0.5 ng of DNA or, if a sample had a concentration of less than 0.033 ng/μL (which occurred with most extracts), 15 μL of sample. Capillary electrophoresis was performed on ABI PRISM® 3500 genetic analysers (Applied Biosystems, USA) and separated fragments were genotyped using Genemapper® ID-X (Applied Biosystems, USA). The donor was homozygous at 5 of 20 loci, leading to a potential maximum of 35 individual donor alleles in each profile. Statistical comparisons were made using IBM SPSS Statistics (IBM, USA).

Percentage recovery rates were calculated by dividing the quantity of DNA present on each tape or swab by the combined quantity of DNA extracted from that sampling device and extracted from the corresponding area of the substrate after sampling.

Within each profile, data describing all peaks with a height of 50 RFU or above were exported from Genemapper® ID-X and the number of alleles that corresponded to the donor's profile was tallied. Occasional non-donor peaks were noted; however, as it has been shown previously, a small number of non-donor alleles are expected in samples of touch DNA [19]. As the extraneous peaks detected herein were infrequent and present as a very minor component of any profiles in which they were detected, they were deemed insignificant. All negative control samples contained no reportable peaks.

3. Results

3.1. Comparison of efficiency between tape types

3.1.1. Quantification results

The mean percentage of DNA recovery using Scenesafe FAST™ tapelifters was significantly higher than values obtained using