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Crime scene DNA sampling by wet-vacuum applying M-Vac

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ABSTRACT

A possible alternative to conventional stain recovery by swabbing, taping or cutting, is the M-Vac wet-vacuum instrument (M-Vac Systems Inc.). We have evaluated M-Vac for sampling of dried saliva on porous and non-porous surfaces, shed cells on clothes and touch DNA. M-Vac gave significantly higher DNA yields for dried saliva stains on laminated wood, compared with cotton swabs (average DNA concentrations 1.14 vs. 0.57 ng/μL, $p = 0.02$). For stains on glass, M-Vac and cotton swabs gave comparable DNA yields. Additionally, M-Vac retrieved three times as much DNA from saliva stains on cotton fabric (T-shirt) compared with saliva on towels (terry cloth), showing that the absorption properties of the surface affect wet-vacuum sampling. M-Vac was also applied for retrieving wearer DNA from clothes, enabling generation of complete DNA profiles from denim jeans, leggings and cotton T-shirt. A mixed DNA profile was retrieved from an "aggressor" pressing a hand against the shoulder area of a worn T-shirt. Since the major component of the obtained mixed DNA profile was from the wearer, M-Vac may not be ideal for touch DNA sampling of clothes. Wet-vacuum sampling requires a fairly large instrument, trained users and DNA extraction procedures handling large sample volumes. The complexity of M-Vac sampling prevents it from being extensively used, but in specific and important cases it can be a valuable sampling tool.

1. Introduction

Swabbing, cutting and tape-lifting are the conventional methods for crime scene and laboratory sampling of biological stains for DNA analysis. The methods complement each other, as swabs are generally suitable for non-porous surfaces, whereas cutting and tape-lifting can be applied for porous surfaces such as fabrics. However, the size of the area of interest is limiting for these methods. A possible sampling alternative is the Microbial Vac (M-Vac) wet-vacuum instrument (M-Vac Systems Inc.). M-Vac was developed for microbial sampling of larger surfaces. Lately, it has been applied for human identification purposes: for sampling of saliva from human skin [1] and of bloodstains on different surfaces [2]. We have evaluated M-Vac for sampling of dried saliva on porous and non-porous surfaces, shed cells on clothes and touch DNA.

2. Materials and methods

Human saliva from one person was spread out on laminated wood (100 μL saliva on 9 × 9 cm surface), glass (100 μL/9 × 9 cm), terry cloth towel (200 μL/9 × 9 cm) and cotton fabric (200 μL/half of T-shirt collar) and left to dry at room temperature overnight (duplicates or triplicates for each sampling method). Denim jeans, leggings and cotton T-shirt, worn 1–2 days, were applied to test sampling of shed cells/wearer DNA. One "aggressor" rubbed a hand on the shoulder area of a worn cotton T-shirt to test sampling of touch DNA. M-Vac sampling was performed with Butterfield buffer, applying 7–14 mL buffer for the wood and glass surfaces, and 16–29 mL buffer for the fabrics. Cotton swab sampling on wood and glass was performed with NaCl (0.9% w/v) moisturised swabs. A follow-up swabbing was performed following M-Vac and cotton swab sampling, to investigate the efficiency of the uptake. DNA extraction was performed with a Chelex-based method with an initial centrifugation (10 min at 3300 × RCF) and pelleting for M-Vac samples, to remove most of the buffer. Quantification was performed using Quantifiler Human DNA Quantification kit on a 7500 Real-Time PCR Systems (Thermo Fisher Scientific). STR analysis was performed using PowerPlex ESX 16 System (Promega

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Table 1
DNA yields from M-Vac and cotton swab sampling. For glass and laminated wood, 100 μL saliva was dried on 9 × 9 cm squares. For terry cloth and cotton fabric, 200 μL saliva was used. *P* values from *t*-tests are also presented.

Surface	Sampling method	Average DNA concentration (ng/μL) ± S.D.	*P* value
Laminated wood	Cotton swab ($n = 3$) M-Vac ($n = 3$)	0.57 ± 0.12 1.14 ± 0.32	0.02
Glass	Cotton swab ($n = 2$) M-Vac (n = 2)	1.20 ± 0.35 1.34 ± 0.41	0.38
Laminated wood	2nd swab following cotton swab ($n = 3$) 2nd swab following M-Vac ($n = 3$)	0.095 ± 0.016 0.15 ± 0.16	0.30
Glass	2nd swab following cotton swab ($n = 2$) 2nd swab following M-Vac ($n = 2$)	0.097 ± 0.034 0.11 ± 0.024	0.39
Terry cloth (towel) Cotton fabric (T-shirt)	M-Vac ($n = 3$) M-Vac ($n = 2$)	0.13 ± 0.025 0.42 ± 0.004	0.0003

Corporation), Applied Biosystems GeneAmp PCR System 9700, Applied Biosystems 3130*xl* Genetic Analyzer, and GeneMapper ID-X Software v1.3 (Thermo Fisher Scientific).

3. Results and discussion

M-Vac gave significantly higher DNA yields for dried saliva stains on laminated wood, compared with cotton swabs (average DNA concentrations 1.14 vs. 0.57 ng/μL, $p = 0.02$, Table 1). For stains on glass, M-Vac and cotton swabs presented comparable DNA yields. The follow-up sampling (with swabs) gave similar DNA amounts for surfaces sampled with M-Vac and cotton swabs, indicating that they are equally efficient in terms of sample uptake (Table 1). In a previous study, M-Vac performed better than cotton swabs for porous surfaces (denim and carpet) but not for non-porous surfaces (tiles) [2]. We find that depending on the type of non-porous surface, M-Vac may provide greater yields than swabs.

M-Vac retrieved three times as much DNA from saliva stains on cotton fabric (T-shirt) compared with saliva on terry cloth towels (average DNA concentrations 0.42 vs. 0.13 ng/μL, $p = 0.0003$, Table 1). The more absorbing towel material thus partly hinders M-Vac sampling. Also, considerably less DNA was retrieved from the porous materials compared with laminated wood and glass, taking into consideration also that twice as much saliva was applied to the former surfaces.

Additionally, M-Vac was applied for retrieving wearer DNA from clothes, enabling generation of complete DNA profiles from denim jeans, leggings and cotton T-shirt (data not shown). Several of the DNA profiles contained alleles other than the wearer's, of which some could be attributed to the wearer's family members. In casework, mixed DNA profiles are frequently encountered on garments, meaning that this may not reflect M-Vac performance. A mixed DNA profile was retrieved from an "aggressor" pressing his hand against the shoulder area of a worn T-shirt (data not shown). There, the major component of the resulting mixed DNA profile was from the wearer/"victim", indicating that M-Vac may not be the ideal choice for sampling of touch DNA from clothes. Likely, tape-lifting is a better alternative, minimizing the impact of wearer DNA from the other side of the garment.

4. Conclusions

M-Vac wet-vacuum enables sampling of larger biological stains that may be difficult to recover using conventional methods. For certain materials and stain sizes it retrieves more DNA than cotton swabs. The complexity of the sampling procedure prevents M-Vac from being extensively used at crime scenes, but in specific and important cases it can be a valuable sampling tool.

Conflicts of interest

None.

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