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REVIEW ARTICLE

Potential utility of Touch DNA in forensic investigations

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Abstract

Chance prints available at the crime scene and secondarily transferred cellular material can be a good source of DNA if processed properly. DNA transferred on to the contact surface is directly correlated to perspiration, and the shedder status of an individual. The advantage of this technique is that the latent fingerprints can be first used for fingerprint analysis by application of powder method and can then be processed for generating profiles. This review article focuses on the individual specific factors affecting transfer of DNA, impact of handling time, pressure and environmental factors etc. This literature survey has been done to summarize the various factors influencing touch DNA recovery, its methods of collection and extraction. It is crucial to analyse DNA recovery using various protocols. This article discusses the significance and potential utility of touch DNA in investigation of medico-legal cases.

Keywords

Forensic Science; Touch DNA; Perspiration; Epithelial cells; Fingerprint; Genotype.

Introduction

In forensic investigations, the analysis of trace evidences recovered from crime scene is very crucial. The mutual exchange of traces, which takes place between the criminal, victim and the crime scene, plays a very significant role in the identification of people and in tracing the culprits in cases of murder, physical violence, sexual assault, child abuse, hit and run etc.[1] Biological evidences i.e. blood, semen, saliva, urine etc. are considered as the most reliable sources of identification as these evidences provide conclusive information about suspects and victims.[2] These samples are routinely analysed for determining the source of origin, species, sex, race and age in forensic investigations.[3] There are a number of techniques such as blood grouping, immunoassays and RNA based analysis, etc. for determination of origin of species and sex determination. DNA analysis has proved to be the best technique for the personal identification due to its uniqueness and higher power of discrimination. DNA evidences were proven significant for the first time by two renowned cases in which Florida rapist Tommie Lee Andrews was convicted and in the other case the conviction of Gary Dotson was overturned on the basis of DNA analysis.[4]

In India, the crime rate is increasing at an alarming rate and with every passing year, there is an increase in registered crime cases. An increase of 3.6% and 1.3% in registered cases was observed in 2017 and 2018. [5, 6] It is assumed that the conviction rate depends on the sensitivity, specificity and accuracy of the techniques and results obtained from them. Though the complete DNA profile can be generated with a small quantity of biological samples, in few cases, biological evidences may be present in negligible amount that might be untraceable (e.g. latent fingerprints). When detected, the quantity is not sufficient to get a complete DNA profiles. With increase in crime rate, the significance of effective collection and processing of such evidences is pertinent to enhance DNA yield. Therefore, the methods which can detect the traces of DNA (touch DNA/contact trace DNA) transferred during contact of individual with any surface has proved to be highly significant. In the absence of any other body fluids, cells which are transferred/shed with every contact (direct/indirect) at the crime scene (weapon of offence, victim, documents, clothing etc.) can be a substantial in forensic investigations. [7] The present review article provides an overview of the concept of touch DNA, i.e. types and methods of transfer, DNA analysis protocols, factors affecting transfer of DNA and its advantages and limitations.

Transfer of trace DNA

The quantity of trace DNA detected may vary with its mode of transfer. Primary transfer of DNA is by direct contact through touching, speaking, coughing or sneezing. While speaking, coughing or sneezing, mucous along with saliva is transferred which contains leucocytes and epithelial cells and these can be utilised for DNA extraction.[8] By touching any object, DNA gets transferred through epidermal cells, however, the transfer of these cells (shedder status) may vary among individuals depending upon their perspiration rate.[9-11] The studies suggest that the shedder status of an individual can directly influence the quantity of touch DNA and the DNA of a good shedder can

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be recovered from an object even by secondary transfer. Moreover, relative DNA shedding propensity of fingers is more than the palmar surface.[10-12]

The secondary transfer of DNA (indirect transfer from individual to individual or individual to items like glass, fabric and wood) is quite common.[13] Though, the amount of DNA is comparatively less than primary transfer, it can be significant when no other evidence is available. On the basis of secondary transfer, individuals can be classified into two categories i.e. good shedder and bad shedder.[11,14,16] Szkuta et al. observed that the relative shedding ability of depositor and the contributing individual and the delay in deposition of a handprint are two factors that have substantial effect on the resultant detection of the contributing profile.[11,15] However, no impact of shedding was observed by Phipps et al. on the DNA amount.[16] In assault cases, it is important to analyse the persistence of offender's DNA on accessible parts of the victim. Bowman et al. analysed DNA transfer with medium pressure and without friction, in another case with heavy pressure with friction on the wrist and upper arm of the victim and concluded that DNA transfer increases with increase in pressure and friction.[17] On clothes, along with the wearer's DNA which is directly correlated to the shedder status of the wearer, secondary transfer of DNA from multiple contributors can also be observed.[18]

Impact of surface on touch DNA

In addition to shedder status, touch DNA recovery is dependent on the type of surface on which cells have been transferred. It has been observed that quantity of touch DNA transferred through latent fingerprints onto porous surfaces is higher than non-porous surfaces.[19] However, a few studies reported appreciable DNA recovery from non-porous objects like glass, cups etc. in sexual assault cases. [20,21] Studies have also been conducted to recover touch DNA from the cartridge case or ammunition wherein the transfer occured while loading magazines.[22] Meixner et al. reported the persistence of touch DNA on pig skin smeared with human blood even after several days of submersion is in cold water.[23]

Impact of handling time on touch DNA

Handling time plays a significant role in touch DNA recovery as it is directly correlated with the duration of contact and interval between deposition and collection. Different handling time sufficient to transfer has been reported by various researchers. Breathnach et al. concluded that at least 15 seconds of handling time is required for a successful DNA profile to be generated.[24] In 2019, Sessa et al. used swabbing, cutting and adhesive tape lifting methods for sample collection from a brassier and concluded that a successful DNA profile can be generated even if the garment is touched for two seconds.[25] The objects which are regularly used by any person may contain DNA of regular users in addition to that of the recent depositor and may produce mixed DNA profiles. Meakin et al. analysed the deposition and persistence of directly and indirectly transferred DNA on regularly used knives and observed that DNA attributed to the regular user persisted for at least a week, declining with increasing time between DNA deposition and recovery.[26] In a similar study conducted by Butcher et al., <16% non-donor DNA from indirect transfer events was recovered from knives. The ratio of DNA transfer between regular user and secondary user was observed to be approximately 4:1, 2:1 and 1:1 for specific durations of use by the second user of 2, 30 and 60 seconds, respectively. [27] In a study conducted by Helmus et al. the probability of obtaining DNA from post-use cleaned objects was tested.[28] The study concluded that DNA traces (blood, saliva, epithelial cells) on different objects (knives, plates, glasses, and plastic lids) can persist on the surface despite cleaning (by hand-washing). However, use of dishwasher rendered almost everything completely DNA free.

Impact of deposition pressure

As mentioned earlier, in assault cases, handling pressure and friction plays a significant role in the pre-deposition of DNA. There is direct correlation between pressure and friction with DNA recovery and a gradual decrease in DNA recovery can be observed with the passage of time.[17] Hefetz et al. examined DNA recovery from finger marks on glass, polythene and paper under a range of weights from 0.1 to 10 kg and demonstrated significant increase in DNA recovery with an increase in deposition pressure.[29]

Impact of environmental factors

Environmental factors like heat, temperature, UV radiations, humidity etc. affect DNA persistency. Different kind of pollutants at a crime scene greatly accelerate the degradation rate of trace materials, thus, making their testing and analysis difficult.[30] Biological samples like blood, keratinocytes etc. show highly variable persistence of DNA in tropical rainforest climate as compared to items placed indoors at an ambient temperature.[31] The analysis of touch DNA on submerged skin revealed that cold water samples yielded a completely reproducible DNA profile even after 7 days, whereas, the recovery rate reduced to 2 days when submersion was in room temperature water and warm water. The recovery was further affected by the presence of water insects and snails in the pond, and, mud in the stream.[23] Impact of water pressure and temperature on touch DNA analysis was reported by Helmus et al. Maximum recovery (up to two weeks) from cotton clothes (rinsed for different duration using tap, pond, bathtub and river water) was observed during the winter season and in water flowing with low pressure.[28]

Touch DNA collection techniques

To achieve optimal results for the forensic analysis of trace

DNA, choosing the right collection technique is crucial.[32] For homicidal cases, touch DNA can be recovered from the murder weapon such as knife, firearms etc. Whereas, it can be detected from documents in forgeries and from the stolen items in cases of burglary. Many methods of collection of touch DNA have been standardized i.e. swabbing, cutting, scraping and tape lifting etc. Scraping and tape lifting are the preferable techniques as these are non-destructive techniques, [32] but, cutting method can be employed for clothes. A moistened cotton swab can be used on non-porous surfaces such as glass, plastic etc. by moving and rotating it on the target surfaces with low pressure. Thomasma et al. (2013) advocated that a detergent-based swabbing solution yields more DNA than that of moistening swabs, due to the amphiphilic nature of detergents.[33] Many types of swabs are available commercially i.e. cotton swab, SimpleSwab2™ swab, 4N6FLOQSwabs®: Genetics, SwabSaver®, Prionics cardboard evidence collection kit, COPAN 4N6FLOQSwabs™ (Genetics variety), Puritan FAB-MINI-AP, Sarstedt Forensic Swab, iPrep Forensic Kit, and PrepFiler *Express* BTA™ Kit and SceneSafe Fast™ etc. and can be used to collect cellular components.[22,32,34] In a comparative study conducted by Comte et al. four swabs (Prionics cardboard evidence collection kit, COPAN 4N6FLOQSwabs™ (Genetics variety), Puritan FAB-MINI-AP and Sarstedt Forensic Swab) were compared for trace DNA collection and they concluded that the COPAN 4N6FLOQSwabs™ (Genetics variety) are the most convenient swabs to use.[34] In a study comparing iPrep Forensic Kit, and PrepFiler *Express* BTA™ Kit and SceneSafe Fast™ minitapes, conducted by Stoop et al. , SceneSafe Fast™ minitapes method gave encouraging results with phenol chloroform extraction method.[32] Kirgiz and Calloway promoted FTA paper scraping method over conventional methods due to its potential to give higher DNA yields from touch DNA evidence deposited on non-porous surfaces. [35]

In forensic investigations, fingerprints are a valuable source for DNA profiling. Latent fingerprints are usually visualized with powder methods and then often transferred to tapes or gelatin lifters for storage. Studies concluded that gelatin lifters are more promising for DNA recovery as more than 80% of the DNA from a fingerprint gets transferred to the gelatin lifter.[34] Subhani et al. observed that sufficient amount of DNA profile was generated when fingerprints were lifted with one of the four powders i.e. black powder, magnetic powder, aluminum powder and magnetic flake powders and three lifting methods i.e. tape lifting, gelatine and Isomark™. [36] A non-destructive Diamond™ nucleic acid dye technique was also explored for the detection of cellular material from fingerprint and lip prints by staining. [37, 38]

Touch DNA analysis

a. Extraction and purification of touch DNA: For extraction of DNA from any biological sample, many organic and inorganic extraction protocols e.g. organic extraction (phenol-chloroform based), Chelex method and Silica-based method, magnetic bead based, have been established. As the amount of sample and the subsequent DNA quantity is less in trace evidences, recovery of sufficient DNA for complete profile generation is essential. In comparative analysis of three commonly used DNA extraction protocols i.e., organic extraction (phenol-chloroform based), Chelex method and Silica-based method, Sowmyya concluded that silica-based extraction is best for touch DNA as it recovered in higher quantity as compared to other methods.[38] It is recommended to purify DNA especially in cases of secondary transfer to remove the contaminants.[31]

b. DNA Quantification: After extraction and purification, the sample is processed for quantity and quality. Capillary electrophoresis, Fluorescent inter-chelating dye, Yield gel technique, Dot blot technique and Real-time quantitative PCR can be used to determine the quantity of DNA in trace samples.[39] Real-time quantitative PCR has been found to be a better option as it determines the most appropriate downstream method for genotyping.[40]

c. Amplification and genetic analysis: Autosomal STR and Y-STR amplification kits are used commonly for direct PCR which includes AmpFlSTR® Identifiler® Direct, AmpFlSTR NGM SElect™ Express and AmpFlSTR Yfiler® Direct. In a comparative analysis for the efficiency of two extraction kits (DNA IQ™ System and Casework Direct Kit (both Promega Corporation)) for touch DNA samples, Casework Direct Kit was found to be better.[41]

d. **DNA profiling and evaluation**: It has been observed that the profiles generated by primary transfer are more promising than those by secondary transfer.[19] Sessa et al. conducted a study to analyse impact of handling time on handlers' and wearers' DNA (wearing brassieres) using swabbing, cutting and adhesive tape lifting.[25] In this study, cutting method gave better profile for handlers and adhesive tape lifting method gave significant DNA profile for wearers. Cavanaugh and Bathrick concluded that full DNA prolife was obtained from donors characterised as good shedder and partial DNA profile was obtained may be due to allele imbalance in heterozygous loci.[40] Kanokwongnuwut et al. concluded that full DNA profile was obtained from enhanced and stained fingerprints and partial profile was obtained when staining and dusting process was applied.[36] In a study conducted by Meixner et al., full DNA profile was obtained from blood stains even after several days.[23] Helmus et al. concluded that during indoor experiments, full DNA profile was obtained from cloth after rinsing followed by keeping it in a bathtub for one week.[28] Also, the complete profile from touch DNA has been obtained from screwdrivers, shirt/t-shirt collar and steering wheels. [42]

Conclusion

Touch DNA analysis is an important technique for challenging samples where traces of biological samples are transferred. Touch DNA can be transferred either directly or indirectly onto porous as well as on non-porous surfaces. The persistence of DNA on different surfaces, its collection methods and improvement in these techniques are the areas of concern. Many factors that can influence the quantity of touch DNA i.e. shedder status of an individual, pressure applied, type of surface and handling time are subject specific variables. However, the impact of environmental factors and improvement in collection methods and DNA extraction protocols are controllable factors and are areas of improvement.

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