Touch Dna as Forensic Aid: A Review

Indresh Kumar Mishra[1], Bhoopendra Singh[2], Amarnath Mishra[3], Braja Kishore Mohapatra[4], Ruchika Kaushik[5], C Behera [6]

[1]Assistant Director, Biology, [2]Scientific Assistant, Regional Forensic Science laboratory, Chanakyapuri, GOVT of NCT of Delhi, India, [3]Assistant Professor, Forensic Sciences, Amity Institute of Forensic Sciences, Amity University, Noida, Uttar Pradesh, India, [4]Principal Scientific Officer, Biology, Central Forensic Science Laboratory (CBI), CGO Complex, New Delhi, India, [5]PhD Scholar, [6]Associate Professor, Dept. of Forensic Medicine & Toxicology, AIIMS, New Delhi

Abstract

Touch DNA technique which is being used in many advanced countries as a modern tool in criminal justice system. It is basically meant for acquiring genetic information from biological substances (cells released from epidermal surfaces) left on touched samples to establish it's relatedness. It refers to recovery of traces of DNA from the biological cells released during the contact which is in a very low quantity, for further analysis and generation of a DNA profile of a person. Released dead cells are not visible to naked eyes and hence it is difficult to locate and recover successfully. DNA profiling from touched samples is difficult and hence require sensitive approach in recovery, extraction and amplification. Success of Touch DNA analysis, therefore, depends upon various factors like collection, sampling and preservation, removal of contaminations, quantification, amplification, analysis and interpretations. Various methods have been developed for the collection of Touch DNA over the time. Sophisticated kits and instrument and well equipped forensic laboratories help to provide concrete DNA profiles thus helping to the Criminal Justice System.

Keywords: *Touch DNA, Contact DNA, Trace DNA, DNA fingerprinting, criminal investigation, forensic science, Real Time PCR, PCR*

Introduction

High profile cases including exoneration of Timothy Masters and the Jon Benet Ramsey homicide investigation has increased interest in Touch DNA[1]. The ability to recover DNA sample from epithelial cells was reported for the first time in 1997 by Van Oorschot and Jones. Touch DNA can be very useful in different cases, including sexual assault, rape, and murder[2]. Millions of skin cells are shed each day by humans and these cells may be transferred to any object coming in our skin's contact. It is possible to deposit sufficient number of skin cells to any object at the scene of crime. The DNA from the cells of the perpetrator/ depositor can be lifted and utilized as a potential source of physical evidence to link him with the scene of crime. DNA profiles can be obtained from the clothing that have been worn by the perpetrator act as potential physical obtained from the transferred skin cells. DNA profile from inside of the shoe can link a wearer of the shoe thus increasing the evidential value of the forensic evidence. Castella and Mangin conducted a touch DNA study on 1739 case samples and found only 26% suitable DNA profiles[3]. Raymond et al conducted a touch DNA study on 252 case samples and found only 44% suitable DNA profiles[4].

In keeping the view of challenges various sensitive DNA typing kits have been evolved to develop DNA profiles from just a few cells having trace DNA from objects such as postage stamps, documents, bullets, knives, door handles[1]. Touch DNA can be recovered from a variety of items like bottles, cans, handled items, personal items, forehead marks, cutlery, food,

Corresponding Author:
Dr. Chittaranjan Behera
Associate Professor, Dept. of Forensic Medicine & Toxicology, AIIMS, New Delhi
Email: drchitta75@rediffmail.com

envelopes, letters, postage stamps, etc.[6]. Chew gums, cigarette butts, hats, upper garments, gloves, socks, shoes, underwear, etc. have been used as the potential source of the touch DNA.

This review articles throws some light on the conventional to the latest sampling methods, benefits, evidential value and limitations of Touch DNA. Touch DNA Analysis requires trained laboratory personnel/ investigating officers/Police personnel to lift, handle and transport exhibit from scene of crime to the forensic laboratories. Several factors affect the quality of STR profile of Touch DNA i.e. pressure, area, time and personnel's state of mind. More the touch pressure, touch area and touch time, more is the chances of obtaining good quality STR profiles. The rough substrate has greater chances of having Touch DNA. Various methods have been developed for the collection of Touch DNA over the time. Sophisticated kits and instrument and well equipped forensic laboratories help to provide concrete DNA profiles thus helping to the Criminal Justice System[5].

Methods of Lifting Touch DNA Sample

Swabbing Techniques: Traditionally, dry sterile cotton wool swabs are used to lift touch DNA samples from the scene of crime called dry swabbing which are being replaced by wet sterile cotton wool swabbing. Swabbing techniques recovered less DNA, therefore, it is further advanced with tape lifting technique. Cotton wool swabs are still being used to collect Touch DNA from the handled objects. Cotton wool swabs are useful to plain substrates but results in the huge loss of DNA from the rough and porous substrate. Indianapolis implemented the use of prepackaged touch DNA swab kits (TriggerPro) for collecting touch DNA samples from a seized firearm during 2008-09. TriggerPro contained three moistened swabs with antimicrobial fluid to be used by police officers[7]. Sterile distilled water is replaced with non-polar surfactants as wetting agents for the sterile cotton wool swabs to collect the Touch DNA from the suspected articles might be used at crime scene. As swabbing techniques recover very little amount of sample, the extracted amount of the DNA from the swab of touched area is very less.

Tape Lifting: Collection of Touch DNA via tape lifting from fabrics in many jurisdictions done routinely. Now water soluble tape lifts are available increasing the amount of touch DNA e.g. SceneSafe Fast™ minitapes.

Cutting/Scraping: The best method to obtain Touch DNA is cutting/scraping the suspected touch area but being destructive in nature generally nondestructive techniques like swabbing and tape lifting techniques are used to lift touch DNA from the scene of crime.

FTA Card: FTA Cards, MicroFLOQ swabs have been devised for direct PCR amplification reducing the chances of loss of touch DNA during DNA extraction and quantification[8].

Touch DNA Extraction

Bright and Petricevic conducted organic (phenol:CHCl3) and Chelex 100 resin method for the recovery of DNA on swabs collected from the hands and feet of volunteers showed that organic extraction gave increased yield[9]. A study has shown organic DNA extraction method is most effective method for extracting trace DNA from crime scene samples in DNA laboratory[10]. DNA extraction from saliva samples by using SceneSafe Fast™ minitapes is most efficient with conventional organic Phenol-chloroform-isoamylalcohol method on the other hand "iPrep Forensic Kit" and "PrepFiler Express BTA™ Kit" (Thermofisher) proved to be safe and fast as compared to conventional organic solvent extraction method[11].

Silica based magnetic automated DNA extraction systems viz. EZ1/XL BioRobot (Qiagen), Maxwell® FSC (Promega) etc.; provide a good quality genomic DNA and reduces chances of contamination during manual handling as well as rapid.

A Low DNA Content BioChipSet (LDC BCS) designed to function in the fully automated Accelerated Nuclear DNA Equipment (ANDE) performs efficient DNA purification followed by microfluidic ultrafiltration of DNA, maximizing the quantity of DNA for subsequent amplification, electrophoretic separation, and detection of amplified fragments[5]. Recently a 96-well centrifugal filtration plate has been designed and used in an automated DNA extraction method of touched objects. 92 Samples can be processed for extraction and purification automatically on a robotic workstation in 90 minutes[12].

Quantification

The quantification step plays an important role in determining how a sample will be processed downstream. Advantage of DNA quantification includes

results in fewer off-scale, over & under amplified samples, gives normalized profiles, resulting in reliable data interpretation, designed to reduce the need for downstream reanalysis which enables long-term cost savings. DNA quantification can be done using various instruments i.e. UV – spectrophotometry, Micro drop / Nano drop (based on UV spectrophotometry) or Real Time PCR which provide variable data quantity of DNA from isolated samples[8]. Real time PCR is considered above spectrophotometry as it gives actual initial concentration of human DNA being amplified whereas absorbance may vary due to contaminants.

Amplification And Detection

Amplification of extracted DNA is a crucial step as the whole profiling is read on the basis of those amplified loci. Multiplexing is used for STR profiling, for which various sophisticated kits are available from different manufacturers for example: AmpF*l*STR SGM Plus™, AmpF*l*STR Identifiler Plus, Globel filer™ PCR Amplification Kit system (Applied Biosystems) Investigator 24Ples QS kit (Qiagen), PowerPlex® 21/18D System (Promega) etc. by following the recommended protocols. In many cases where partial profiles are found, another approach for generating profile can be done using Mini STR kit. As initial sample concentration in such cases in too low an increase in the number of PCR cycles can result in successful STR profiling[13]. Separation of DNA fragments is done using capillary electrophoresis by using any of the Genetic Analyzer (3100, 3130, 3500, 3500XL) and the software for data analyses is Gene Mapper ID-X software (Applied Biosystems)[9].

Automation in Dna Profiling

Bio Chip Set based fully automated Accelerated Nuclear DNA Equipment (ANDE), RapidHIT ID System for Human Identification systems enables direct processing of samples right after collection. The automated process does right from cell lysis, amplification, and capillary electrophoresis to generation of STR profiling in less than 2 hours. Self-contained sample cartridges transform a multi-component protocol into a single instrument and single user-initiated task.

Results Interpretation

The profiles obtained from the samples are classified as either full DNA profile, partial DNA profiles, mixed DNA profiles (for profiles containing DNA from 2 or more people) or no result depending on the number of alleles detected[9]. Touch DNA interpretation can be done after STR profiling. When two DNA profile match to each other is considered as 'Inclusion' and two profile not matches to each other is considered as 'Exclusion'[14].

Problems in Analysis

Sampling and handling problems-Various methods i.e. swabbing, tape lifting, cutting, scraping, etc. have been utilized to obtain Touch DNA from the scene of crime. Special care should be taken while lifting Touch DNA as there are chances of DNA contamination from the person himself lifting the DNA and from the other sources at the crime scene. The method of recovering the DNA should be chosen depending on the nature of the substrate[1]. Though swabbing techniques are simple and nondestructive, recovers less Touch DNA and have higher chances of contaminations. Only the trained-laboratory personnel/police personnel should be allowed to lift touch DNA from exhibits.

Contamination problems- Touch DNA analysis faces a various variety of contamination due to improper handling, sampling and preservation inhibition by bacteria or any other type of chemical such as EDTA, sodium fluoride, saline solution, microbial development and environmental effects. Contamination problems in DNA Samples increase with high demand of DNA analysis in forensic laboratories[15]. Despite the consciousness, the risk of contamination arises from the first handler police staff, during transportation and even in forensic laboratories. Special care should be taken while lifting the touch DNA samples. High recommendations should be made for the use of aprons, face masks, head masks, gloves, sterile forceps, scissors, etc.

Preservation and transportation problems- Biological samples are preserved by drying using any of processes of *viz.* desiccation, refrigeration and freezing. Transportation of these samples requires special handling procedures without which there is chances of degradation/decomposition of biological samples rendering it unsuitable for DNA fingerprinting analysis[16]. Delay in sample freezing and temperature fluctuation during transportation from one place from to another place makes biological samples unfit for DNA fingerprinting analysis. An emphasis is being made on the development of storage devices at room temperature, thus reducing the cost of freezing or refrigeration[17].

Benefits of Touch DNA

Touch DNA reflects an implicit decision that the marginal benefits of DNA collection are greater than that of additional patrol resources made available if touch DNA is not used by officers[7]. Benefits of Touch DNA lies in its specificity. Even minute quantity of DNA from just a few cells from the scene of crime can provide complete DNA profiles of perpetrator. Touch DNA is very fast, it can be applied on a variety of surfaces, and it can be used on a very small sample. Latest more sensitive kits, sophisticated equipments have proved boon to touch DNA technology.

Limitations of Touch DNA

The amount of deposition of Touch DNA is variable due to differrent factors for examples on rough and porous surface as compare to smooth surfaces, and some persons are known to leave more Touch DNA while some others are known to leave less DNA, person during stress or during sweating leave more Touch DNA as compare to normal persons. Touch DNA being a biological material is prone to environmental and biological degradation by fungal bacterial contaminations[13].

Touch DNA samples being very small in quantity can be easily destroyed and can't be recreated. DNA material in aerosols can contaminate the laboratory environment by making other DNA material unfit for further profiling. Touch DNA technology depends on well trained personnel. Any error during processing technique may result in incorrect or incomplete DNA profiles. False/erroneous interpretation of results can lead to wrongful conclusions which in turn mislead the case.

Conclusions

The success of Touch DNA use as a forensic tool lies in the optimization of techniques starting with collection of biological samples, preservation, extraction, amplification and genotyping. Many newer methods have been developed, sophisticated kits, instruments along with well-equipped established laboratories which will help right from recovery of biological samples at crime scene to handling to profile generation. However, a careful and meticulous planning is required success for individual cases. The limitations of Touch DNA technique should be also kept under consideration while interpreting the results.

References

1. Williamson AL. Touch DNA: Forensic collection and application to investigations. J Assoc Crime Scene Reconstr. 2012; 18(1): 1-5.
2. Alketbi SK. The Affecting Factors of Touch DNA. J Forensic Res. 2018: 9(3): 424.
3. Raymond JJ, van Oorschot RAH, Gunn PR, Walsh SJ, Roux C. Trace DNA success rates relating to volume crime offences. Forensic Sci Int Genet. 2009; 2(1): 136-137.
4. Castella V, Mangin P. DNA profiling success and relevance of 1739 contact stains from caseworks. Forensic Sci Int Genet 2008; 1(1): 405-407.
5. Turingan RS, Vasantgadkar S, Palombo L, Hogan C, Jiang H, Tan E, Selden RF. Rapid DNA analysis for automated processing and interpretation of low DNA content samples. Investigative Genetics. 2016; 7(2): 1-12.
6. Sweet D, Lorente M, Lorente JA, Valenzuela A, Villanueva E. An improved method to recover saliva from human skin: the double swab technique. J Forens Sci. 1997; 42(2): 320–322.
7. Nunn S. Touch DNA collection versus firearm fingerprinting: comparing evidence production and identification outcomes. Journal of forensic sciences. 2013; 58(3): 601-608.
8. Gammon K, Jones KM, Shenton D, Wood Z, Mayers C. Touch DNA on objects can be analysed at low cost using simplified direct amplification methods. bioRxiv. 2019; 1-4.
9. Bright JA, Petricevic SF. Recovery of trace DNA and its application to DNA profiling of shoe insoles. Forens Sci Int. 2004; 145(1): 7–12.
10. Harbison SA, Fallow M, Bushell D. An analysis of the success rate of 908 trace DNA samples submitted to the Crime Sample Database Unit in New Zealand. Aust. J. Forensic Sci. 2008; 40 (1): 49–53.
11. Stoop B, Defaux PM, Utz S, Zieger M. Touch DNA sampling with SceneSafe Fast™ minitapes. Legal Medicine. 2017; 29: 68-71.
12. Zhou R, Meng Q, Li P, Chen J, Sun Y, Li M. Improved high throughput processing of touch DNA samples. Australian Journal of Forensic Sciences. 2016; 48(1): 1-8.
13. Wickenheiser RA. Trace DNA: a review, discussion of theory, and application of the transfer

of trace quantities of DNA through skin contact. J Forens Sci. 2002; 47(3): 442–450.

14. John M Butler: Fundamentals of forensic DNA typing, 1st Edition, Academic Press Elsevier: 2010: 9-10.
15. Basset P, Castella V. Lessons from a study of DNA contaminations from police services and forensic laboratories in Switzerland. Forensic Sci Int Genet. 2018; 33: 147-154.
16. Maguire S, Ellaway B, Bowyer VL, Graham EM, Rutty GN. Retrieval of DNA from the faces of children aged 0–5 years: a technical note. Journal of Forensic Nursing. 2008; 4(1): 40–44.
17. Swinfield CE, Graham EAM, Nuttall D, Maguire S, Kemp A, Rutty GN. The use of DNA stabilizing solution to enable room temperature storage and transportation of buccal and trace sample swabs. Forensic Science International: Genetics Supplement Series. 2009; 2(1): 183–184.