



DNA Profiling Advances in Forensic Dentistry- A Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAMMR/2023/v35i84993

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here:

<https://www.sdiarticle5.com/review-history/97355>

Received: 05/01/2023

Accepted: 08/03/2023

Published: 14/03/2023

Review Article

ABSTRACT

Forensic Odontology is a branch of forensic science involves in human identification through dental tissues or more specifically teeth when there is the destruction of body tissues in criminal mass disasters. The importance of Forensic Dentistry in recent days lies mainly when there is little remaining material to perform such identification has led dentists working with forensic investigators to become more aware with the new molecular biology technologies. In the last few years, DNA analysis methods are more commonly applied in the forensic cases due to its uniqueness in identification of human remains even in the deceased state. DNA is a genetic material which is unique to each individual. In oral cavity and mainly in tooth structure DNA is found to be in abundant and hence it can be an excellent source of genomic DNA. Recently, DNA profiling has high reliability and is accepted as legal proofs in courts. This article mainly focuses on an overview of DNA and their applications in the last few years, highlighting its importance in forensic investigation.

Keywords: *Forensic odontology; DNA profiling; disaster; human remains.*

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1. INTRODUCTION

Forensic Odontology is a branch of dentistry which deals with proper handling and examination of dental evidence, evaluation, and presentation of dental findings in the interest of justice [1]. Forensic Odontology plays an important role in identifying the victims of crime and disaster. It has always been a key source in man-made and natural disaster especially in case of mass casualties. It also plays an important role in age and gender identification. Some of the most important methods used for investigation with teeth as a source are visual method, microscopic method, and recently many advanced technologies have been employed. Among them DNA profiling has gained popularity due to its genetic confirmation [2].

2. METHODOLOGY

For the current review, the articles were identified by searches on electronic data bases such as Pub med database and EMBASE from 2000 till December 2022. The following search terms were used: "DNA profiling in forensic dentistry", "DNA finger printing in forensic Odontology", "Dental pulp and DNA analysis", "DNA amplification methods", "Applications on DNA profiling in dentistry".

2.1 DNA Profiling

In the field of modern molecular biology, different techniques have led to major evolution in dentistry, among those, DNA plays a major role. DNA profiling is also known as DNA fingerprinting or DNA typing, which was found by Sir Alec Jeffrey's, in 1984. In the failure of conventional methods in identification due to various environmental assaults such as trauma, heat, decomposition, DNA method can be more reliable. The source of DNA is usually protected by epithelial, connective tissue and muscular

tissues whereas dental pulp is protected by enamel, dentin, and cementum [3,4,1].

2.2 History of DNA Profiling

DNA profiling is one of the greatest discoveries in the late 20th century. Alec Jeffrey's in UK found out heritable patterns with multi -locus probe, which was according to the size of the sequence, named as variable number of tandem repeats (TR) and short tandem repeats (STR) [5,6].

2.3 Various Sources of DNA:

Tooth as a source in DNA profiling: Tooth is proved to be the best source to extract DNA, as it is most resistant of all body tissue, and can also be preserved for a longer period. Also, tooth is most resistant to adverse conditions such as humidity, high temperature etc. without causing any damage to the DNA [7].

Saliva as a source in DNA profiling: In the crime investigation, saliva samples can be collected from the deposits on the skin due to biting, licking or kissing. Various proteins, blood groups and enzymes can be analysed using this saliva that can be compared with the suspect. But, it has certain drawbacks such as less concentration in the material, immediate washing of the wound, contamination with blood, etc.

2.4 Principles of DNA Profiling/ Finger Printing

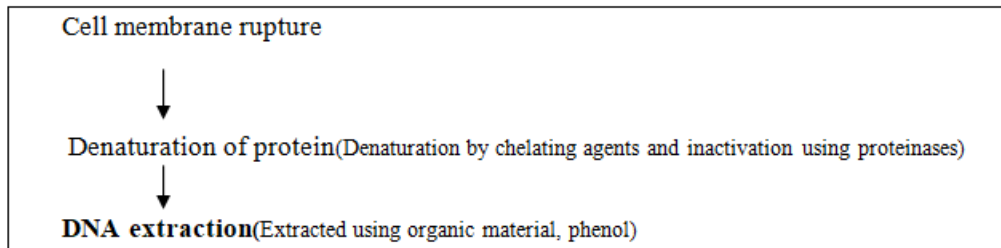
The gene coding for a particular protein is usually found to have 95% non-coding DNA and 2-5% of coding DNA, out of which the junk DNA is usually found to be present in the form of single copy or multiple copies. The variation in the pattern which is usually detected by a probe form, is the basis of DNA profiling system [2,8].

Table 1. History of DNA profiling

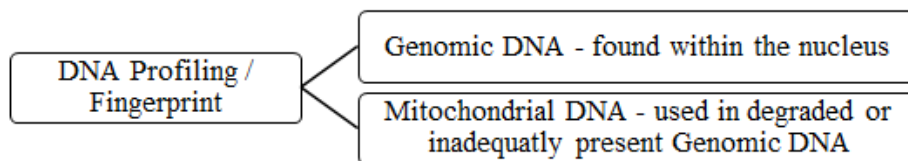
DNA – Isolated from Dental Pulp	Schwartz et al., 1991
Sex identification- Genomic dot blot hybridization for DNA extracted from an unerupted preserved 3 rd molar	Potsch et al., 1992
Conducted PCR after incinerating the extracted pulp at different temperatures.	Sweet., 1995
PCR amplification -stronger in pulp than cementum and dentin.	Tsuchimochi et al., 2002
Microarray in SNP (Single nucleotide polymorphism)	Malaver and Yunis et al., 2003
Massive parallel sequencing	Li et al., 2006
	Tucker et al., 2009

Flow chart 1. Stages in DNA extraction during DNA typing

The DNA can be usually obtained from the tooth from the following steps.



2.5 Types of DNA Used in DNA Fingerprinting



2.6 Methods Used in DNA Fingerprinting

A successful analysis of the genetic makeup can be made by proper DNA isolation and proper quantification. Hence there are various set of methods that are followed.

1. Restriction fragment in length polymorphism method (RFLP)
2. Analysis of Y chromosome
3. Single nucleotide polymorphism (SNP)
4. Polymerase chain reaction (PCR)
5. Short tandem repeat (STR) TYPING
6. Analysis of mitochondrial DNA (mtDNA) [8,9].

Restriction Fragment in Length Polymorphism Method (RFLP): A DNA sample which is collected is fragmented using restriction Endo-nucleases enzymes named as molecular scissors. These, enzymes help to cut DNA sites without the tandem repeats. As a result variable numbers of tandem repeats are produced, which are then separated using gel electrophoresis. A radioactive probe is then used to analyse the DNA fragments.

Analysis of the Y-Chromosome: Y chromosome analysis plays an important role in analysing biological evidence, especially useful in tracing relationship among males, as Y chromosomes are the genetic markers which are passed directly from the father to son. The main criterion of Y chromosome is halo typing that

includes exclusion of the male suspects from the crime scene, which gives a lead in the investigation [3,4,9].

Single Nucleotide Polymorphism (SNP): Any variations in the genome as result of insertions or deletions at single positions are known as single nucleotide polymorphism (SNP). SNP are the emerging markers in the field of forensic medicine. They have an upper hand as they are abundant in human genome and has lower mutation rate [10].

Polymerase Chain Reaction (PCR): PCR is one of the most commonly used techniques in DNA profiling. One of the main significance of PCR is that it is used to amplify the amount of DNA present. Amplification of the original DNA can be done, through standard Polymerase chain reaction which runs through 30 cycles for a couple of hours. DNA primers and special enzymes are used for the reaction [7,8,11].

Analysis of Mitochondrial DNA: It is one of the most expensive techniques as it involves direct sequencing of nitrogenous base. Mitochondrial DNA is usually used when the sample lacks nucleus. Analysis of the mtDNA can be done by obtaining high molecular weight DNA from the teeth. It is a beneficial tool for identification of the missing person by comparing with the maternal relative.

2.7 Use of DNA Profiling in Forensic Dentistry

Biometric identification is one of the tools used for age identification in forensic science. Due to several conditions such as fire and skeletonization, there are difficulties in identification using biometrics. As, teeth have distinctive characteristics and high resistance it plays an excellent source of DNA especially when there is a failure in the conventional method [10,12].

2.8 Drawbacks with DNA Profiling

Even though DNA profiling is considered to be one of the major important tool in Forensic Odontology to solve mysterious cases, DNA profiling has been a matter of question because of its several disadvantages.

The victim cannot be identified in several cases due to the following issues:

- Degradation in case of prolonged exposure to heat and light, samples handled by in experienced technician, instrumental error, incorrect database, and identical twins.
- DNA can be easily implanted at the site of crime [13].

2.9 DNA Database or DNA Data Bank

The idea behind DNA profiling in human identification is the comparison of victim's or suspect's DNA with that of DNA database. Hence it is important to have a proper DNA data collection.

There is lack of DNA collection due to various reasons, out of which the most common issues are privacy issues and in developing countries DNA profiling is not much in common use [6,9,14].

2.10 Privacy - A Matter of Controversy

As DNA analysis is most likely to invade one's own personal information it is considered as invasion of privacy. It gives sensitive information of an individual such as hereditary disease, physical state and ethnic background leading to racial discrimination [15].

2.11 Trace DNA

Trace DNA also known as the touch DNA is considered to be one of the major drawbacks in

DNA profiling technology. Trace DNA are DNA which is obtained from the biological material transferred from a donor to a person during the physical contact. Coincidental matches such as chimera shows a major drawback in DNA profiling [14,15,16].

3. CONCLUSION

Forensic Odontology, especially DNA profiling is an upcoming branch of dentistry. A tooth plays valuable evidence when no other samples are available in crime scenes. Further advancement in DNA profiling can reduce the time factor for the identification of the deceased. Even though DNA profiling has a positive impact in the justice system, there are several disadvantages also. DNA is a unique characteristic feature of every individual, but due to several man-made errors makes it unreliable.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:

The peer review history for this paper can be accessed here:
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