Review Article

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Forensic Odontogenetics

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Abstract

Violence and crimes against human life, such as bomb explosions, wars or plane crashes, as well as cases of carbonized bodies or in advanced stage of decomposition, among other circumstances, highlight the need to employ ever faster and more accurate methods during the process of identification of victims. DNA (Deoxyribonucleic Acid) is frequently used in identifying individuals or determining the origin of certain tissues. Teeth are resistant against extreme circumstances such as temperature, humidity and acidity, which is an important advantage in DNA analysis. Furthermore an abundance of DNA can be extracted from teeth. Saliva can be obtained in a simple, painless and non-radical way. DNA analysis has proven its value in forensic dentistry, but ethical and juridical considerations are still a matter of debate and criticism.

Keywords: Deoxyribonucleic Acid; Genetic Material; Forensic Investigations.

Background

Development of genetics in the1980's allowed innovations to medical field as well to forensic sciences. This was due to discovery of specific mini satellite regions of human genome which had the so called digital impressions". Its analysis led to human individuality information. From that point, genetics research dealing with DNA polymorphism has had a great development [1].

Human beings can be identified by examination of DNA sequences. Every cell of an individual carries a copy of the DNA. Every human being is characterized based on the unique DNA sequence, due to hyper variable regions of DNA, which are specific for an individual. The order of the base pairs in the DNA of every individual is different except in identical twins. The uniqueness is due to the intron regions of the DNA, which contain sequences that are 20 – 100 base pairs in length, and are repeated at different locations along the chromosome, like AGACTAGACATT – AGATTAGGCATT, which are called sequence polymorphisms. The length polymorphism like (AATG) (AATG) (two repeats) and (AATG) (AATG) (AATG) (three repeats) are termed as Short tandem repeats, which are used in forensic identification [2].

Computer aid in several laboratory steps associated to biotechnology and forensic mathematics increase the reliability of examinations to determine sex, age estimation, parenthood and human identification. Therefore it became mandatory that forensic experts in several areas of criminal investigation, forensic medicine and dentistry would associate classical investigation techniques to molecular biology analysis and DNA examination in order to achieve more reliable, objective and specific results facing complex cases [3,4].

Historical Review

In 1985, Jeffreys *et al.* used radioactive probes to identify mini satellites i.e highly variable regions of DNA to define the pattern of the individual. These hyper-variable loci have tandem repeat of nucleotide sequences. According to their size, they are named as

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variable number of tandem repeats (VNTR) or mini satellites having 9–80 base pairs or short tandem repeats (STRs) or microsatellites having 2–7 base pairs. This discovery led to the use of DNA analysis in forensics for identifying human remains and solving disputed parentage issues [5]. In 1991, Schwartz *et al.*, under variable environmental conditions isolated high molecular weight DNA from dental pulp [6,7]. Sweet and Sweet in 1995 identified a human remain from DNA that was extracted from an un-erupted, preserved third molar [8]. Tsuchimochi, *et al.*, in 2002 extracted pulpal DNA by incinerating extracted teeth at temperatures of 100°C, 200°C, 300°C, 400°C and 500°C for 2 min to conduct PCR analysis on them. No PCR product was produced for samples that were incinerated above 400°C whereas samples incinerated for up to 300°C could be amplified [9]. Malaver and Yunis in 2003 found in their study that the pulp produced the strongest PCR amplification signal when compared to dentin and cementum [10].

Human Identification Using DNA

Genetic material can be obtained from several biological sources such as body fluids, soft tissues and mineralized tissues. When dealing with living suspects in parenthood test like father, mother and son, genetic material is preferably obtained from either blood (leukocyte) or buccal mucosa.

On the other hand, if it is necessary to verify genetic relation involving pot-mortem material, time from death and corpse condition are relevant factors to choose which method of DNA extraction is to be used. In a recent death case blood, viscera and soft tissue are the first choice of materials, but as time goes by those sources become inappropriate, leading towards the mineralized tissue sources like bones and teeth. Bones are an important source to obtain genetic material since they are located inside the body and are mineralized also the cortical part protects the medullary part from external factors and micro-organism that may degrade the DNA [11].

Teeth as Genetic Material Source

Teeth also are a good source to obtain genetic material. This is true mainly because of their great tissue resistance against external injuries. Genetic material can be extracted from enamel, dentin, cementum and pulp [12]. Pulp tissue is a loose connective tissue and it degrades easily when compared to others dental tissues. Dental pulp is protected by tooth structures and therefore can present better condition than others soft tissue for DNA extraction. Lessing et al showed that pulp can be a source of DNA in teeth that had been kept or obtained in different conditions [13]. Amelogenin can also be studied from dental material that had been through adverse situations for sex identification. There are several techniques to obtain dental material to extract DNA such as tooth grinding or crushing, tooth horizontal sectioning, pulp extirpation by tooth irrigation and sectioning and nitrogen liquid cryogenic pulverization. Some legal precautions must be followed when dealing with dental material as source to obtain DNA since the process destroys the material used in the examination [14,15].

Applications of Deoxyribonucleic Acid Profiling in Forensic Dentistry The currently performed DNA profile tests are totally reliable and give details about an individual's physical characteristics, ethnicity, place of origin, and sex. These tests are also accepted as legal proofs in courts, for investigation of paternity and human identification [16].

A short tandem repeat can be used for the identification of bodies in mass disasters and old skeletal remains. Even though the DNA present in the ancient remains appear to be very degraded, it is conserved better in the tooth than in the bone samples. The highest success rates for human identification using STR analysis were observed in samples from the dense cortical bone of the weight bearing leg bones like femur and intact teeth also exhibited high success rates. On the basis of STR, the Combined DNA Index System (CODIS) was established by the Federal Bureau of Investigation. It was developed specifically for enabling the public forensic DNA laboratories to create searchable DNA databases of authorized DNA profiles. At times it is difficult to perform genetic identification with nuclear DNA due to the long time interval between the time of death and examination of tissues. Usually in such cases only bone and teeth may be available for analysis. Teeth provide an excellent source for high molecular weight mitochondrial DNA, which offers several unique advantages for the identification of human remains [17].

Mitochondrial Dna (mtDNA)

Mitochondrial Deoxyribonucleic acid is a powerful tool for forensic identification as it possesses high copy number, maternal inheritance, and high degree of sequence variability. Each offspring has the same mtDNA as their mothers, as the mitochondrion of each new embryo comes from the mother's egg cell and the nuclear DNA is contributed by the father's sperm. In investigations involving missing persons, comparing the mtDNA profile of the unidentified

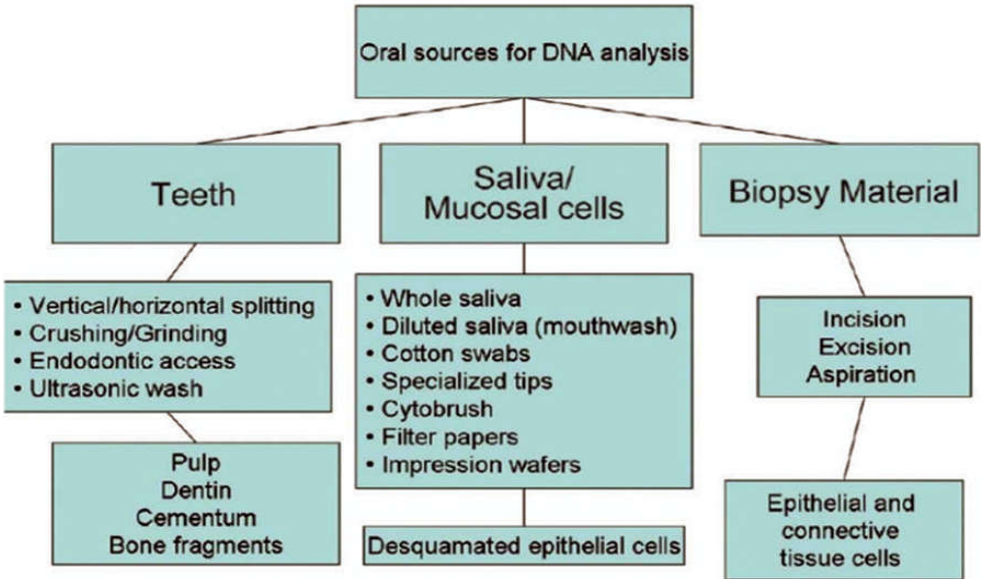
remains with the profile of a potential maternal relative can be an important technique. However, mtDNA analysis is a slightly time-consuming technique and is exclusively matrilineal, and hence, less informative. Thus, this analysis is not usual in all forensic laboratories directed at resolution of crimes and identification of persons.[18]

Y-Chromosome Analysis

Deoxyribonucleic acid polymorphisms on the human Y chromosome are valuable tools for understanding human evolution, migration, and for tracing relationships among males.The majority of the length of the human Y chromosome is inherited as a single block in linkage from father to male offspring, as a haploid entity. Hence, Y chromosomal DNA variation has been mainly used for investigations on human evolution and for forensic purposes or paternity analysis. Y-chromosome STR (Y-STR) polymorphisms are used in deficiency paternity testing, cases of physical assault, murders, sexual assault, and child abuse, where bite marks are frequently found on the skin.[19]

Gender Typing

The enamel proteins that are required for the development of normal tooth enamel are encoded by the amelogenin genes. The amelogenin gene is a single copy gene, homologs of which are located on Xp22.1 – Xp22.3 and Yp 11.2. The variation of length in the X-Y homologous amelogenin gene i.e AMELX and AMELY, are used for gender identification. The gender may also be identified from the dental pulp DNA through the analysis of the peaks of X and Y loci by capillary gel electorphoresis [20].



Conclusion

DNA examinations and Molecular Biology analysis became an essential tool to help or solve investigation matters that had been considered irresolvable in crime investigation and Forensic medicine. Therefore it is mandatory that those who are in forensic investigations must acquire knowledge about forensic genetics to provide greater justice and benefit the society.

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