

Original Article

Indian Draft DNA Profiling Act: Implications for Institutionalisation and Growth of Forensics

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ABSTRACT

In the present scenario of fast developments in miniaturisation and automation of DNA sequencing/fingerprinting, the DNA-based techniques are phasing out traditional techniques in forensics like serology and microscopy in forensic biology. Although the initial cost of infrastructure and access to technology is a barrier but in long run DNA-based techniques are cost-effective at large scales and also more reliable due to higher stability of DNA compared with protein and other biomolecules. In this context, the law to be soon passed by parliament regarding DNA fingerprinting is very important for streamlining the procedures in sample collection, processing and disposal as well as building an electronic database of DNA profiles. The DNA Profiling Act shall take care of privacy and human rights concerns but its implementation will definitely be a leap forward in robust delivery of justice. Advocacy by academicians for DNA profile act may get it passed by parliament expeditiously and there is also need for more training and promotion of DNA fingerprinting and other DNA Technologies. Many countries around the world has adopted DNA profiling law long back but India is yet to pass such law despite the fact that our country needs it even more due to so many people being reported missing every year and almost equal number of unidentified dead bodies being found.

Keywords: DNA profiling act, Forensics, Implications, Indian, Institutionalisation

DEVELOPMENT OF DNA FINGERPRINTING TECHNOLOGY

Diploid human genome has approximately 6 billion nucleotide base pair^[1]. In this total DNA, there are region with different levels of variability dispersed almost randomly. There are portions which have very high level of conservation and have remained unchanged throughout the course of evolution. Therefore, these sequences are identical even among a class of animals like all mammals

and chordate. Any mutation in these conserved sequences generally becomes lethal for the organism because they code for something that is very crucial for life and development of organism. There are also DNA sequence portions accordingly which are moderately conserved. And there are also the portion of genome which is highly variable and a mutation in these portion of genome has no functional significance. The mutations in these parts of genome are harmless, therefore, over time, so many mutations has accumulated in these portions of genome

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that every human individual is having a unique set of mutations in these highly variable DNA sequences ^[1]. Although 99.9% of genome sequence between two individuals is identical but this 0.1% variation is what makes us genotypically unique. We as individuals are also phenotypically unique which is because of difference in environment as well as genetic influence of a small portion of these 0.1% DNA sequence difference, though most of these 0.1% DNA sequence difference is having no phenotypic significance. This fact also has a very important ethical significance for DNA-based human individual identification, which is; the subpart of this 0.1% highly variable genome which has no phenotypic or functional significance is best suited for keeping as DNA identification record in forensic DNA database. Since these regions are not associated with any disease or personality feature, there will be no danger of misusing forensic DNA data for other purposes like health insurance liability determination, employability and behavioural vulnerability speculation. The modern technique of PCR has enabled it that the signal from only these of few selected highly variable portions of genome is amplified, therefore, without comparing the whole genome, only a small portion of genome can be compared between individuals for identification. Sir Alec Jeffrey in University of Leicester, UK, demonstrated for first time the use of DNA for forensic identification ^[2]. His initial technique was based of restriction fragment length polymorphism (RFLP), in which whole DNA isolated from a sample is subjected to cutting (restriction digestion) with sequence specific enzymes. This will generate DNA fragments of various size which can be observed in agarose gel electrophoresis. The fragment size profile will be always same for DNA from a given individual but it will vary from one individual to another due to few mutation (sequence differences) at positions in genome which is identified by sequence specific restriction enzymes used in this process. The DNA fragments are then transferred onto a nitrocellulose membrane and immobilised. Then radiolabeled complementary DNA probes are hybridised to detect band pattern. This technique required isolation of lot of DNA from human tissue. During the early 1990s, PCR-

based, Amplified fragment length polymorphism (AmpFLP) technique was put into practice. It uses PCR to amplify variable number tandem repeats regions in genome, wherein number of repeats of a DNA sequence (10–50 bp) at a given locus in genome varies from individual to individual. Therefore, the PCR amplicon size distribution will give a unique pattern of bands in agarose gel electrophoresis for an individual. An even more advanced variant of the concept is short tandem repeat (STR) DNA profiling in which the size of repeating sequence unit is even smaller (3–5 bp) ^[3]. Further improvements in technique are that instead of agarose gel electrophoresis, capillary electrophoresis (CE) can be utilised ^[4]. Additionally, many STR can be amplified together in one PCR reaction if the primers for each STR is labelled with fluorescent dye of different colour. This is called multiplex PCR and ‘size multiplexing’ is also often incorporated in it that is if the expected sizes of variants (alleles) of two STR locus in a population is not overlapping then same colour label of fluorescent dye can be used for their primers because anyway, the fragments of DNA can be assigned to different STR locus on the basis of their size range ^[5]. The strength of DNA fingerprinting is that the statistical significance conclusion is very high, not only when the conclusion of results are exclusion but also when results indicate inclusion. Whereas most other forensic methods are reliable for exclusion but not inclusion or match. For example while using a 13 locus combined DNA Index System (CODIS) STR panel for DNA profiling, the probability of match by chance between two unrelated individuals is less than 1 in 10^{13} ^[6,7]. The DNA is also more stable compared to other molecules like protein and glycoprotein, making it a preferred technique over serology and microscopy-based techniques. DNA has been isolated and sequenced even from prehistoric human skeleton remains from thousands years old fossils ^[8]. Another advantage that established DNA fingerprinting as such a robust technique in forensics is feasibility of signal amplification, that is, DNA sequence can be amplified using PCR starting from in principle even one molecule of DNA. DNA fingerprinting of even single cell has been demonstrated ^[9]. Consequently DNA

fingerprinting and DNA barcoding is phasing out respectively other techniques of individual identification and species identification (Table 1). For species identification, DNA sequence of a moderately conserved gene like COI can be taken as standard convention and PCR can be used to amplify this sequence from a forensic sample in question for species identification. This technique is called DNA barcoding and a large reference sequence database Barcode of Life Database (BOLD) is available for matching the barcode DNA sequence from forensic sample^[10]. Since only a minute tissue piece for DNA is required in this technique, it's a preferred technique over other conventional technique of species identification in wildlife crime like comparison with museum specimen, morphology, anatomy and serology^[11,12]. DNA-based identification using single nucleotide polymorphism (SNP) can give more information about individuals involved like their ethnicity, physical characteristics for identification, any genetic or epigenetic disease and subpopulation identity. Next Generation Sequencing techniques enables direct DNA sequencing of single molecules which gives a deeper depth of information on simultaneously from various STRs as well as SNPs This will in future to resolve even more complicated forensic samples and glean more information on crime situation^[13].

DEVELOPMENTS IN MINIATURISATION AND AUTOMATION OF DNA PROFILING

Modern electronics and microfabrication has enabled respectively the automation and miniaturisation of DNA profiling technique also^[14,15]. Like in other techniques, automation brings in more reliability as chances of human error are taken out. The reliability if specifically very important for technique of forensic use and automation

will also help in processing samples in large number which is also very important as lot of DNA profiling sample backlog is piled up even in developed countries. Various techniques of DNA isolation has a varying degree of compatibility with robotic liquid handling systems^[16]. Solid phase affinity column-based DNA isolation and magnetic bead coated with DNA affinity polymer are the most compatible methods with existing robotic liquid handling systems in diagnostic and molecular biology labs^[17]. The complete procedure including data analysis of DNA profiling can be automated. The neural network-based machine learning systems can even identify any artefacts in electropherogram while assigning CE peaks to various STR alleles^[18]. Applied Biosystems software Gene Mapper ID (GMID) can identify peaks, assign them to STR alleles and build a DNA profile matrix. GMID has two components Gene scan and Genotyper which, respectively, identifies peaks and assigns the peaks to STR alleles^[19-21]. Miniaturisation help in decreasing the cost of sample processing as fewer reagents will be consumed, but in forensics it's additionally important because at times the forensic sample to be profiled is also very minute and low in quantity. It also has implications for cost effectiveness, onsite profiling, ease of use and private use of DNA technique. Genebench-FX by Promega is such a DNA profiling instrument that utilises microfluidic systems to do DNA profiling at crime site with full automation yet in a portable small instrument^[22]. National Forensic Science and Technology Center, USA has also field tested portable microfluidic devices for onsite DNA profiling^[23]. ParaDNA instrument developed by LGC Health Science and Innovation group can detect various body fluids at crime site itself, based on mRNA in these tissues like saliva, semen, vaginal fluid, sperm cells, menstrual blood and peripheral blood

Table 1: DNA Identification as an Emerging Alternative to Other Techniques

Forensic Identification	Emerging up	Phasing out
Individual level	DNA fingerprinting	Blood group antigen and haptoglobin-based identification
Species Level	DNA barcoding	Microscopic identification of wood, pollen, diatoms, wildlife trace evidence. Identification of provenance of wildlife crime evidence by morphological features and comparison with museum specimens. Serological identification of species.

[24, 25]. RapidHIT by Invitrogen has also been field tested by government agencies for DNA profiling at site of crime [26].

NEED AND PROGRESS IN INDIA

In India, Lalji Singh pioneered the use to DNA fingerprinting for forensic applications [27]. Lalji Singh worked with Sir Alec Jeffery before returning to India. The first court case solved by DNA fingerprinting in India was a paternity dispute [27]. Since laws of Mendelian inheritance are followed by different variable sequences too, this technique can be applied for parentage testing. Other applications of DNA fingerprinting are various crimes wherein the criminal may leave its DNA sample in form of hair, saliva, semen, blood or even bone. In a case of alleged rape, the spermatozoa from victim's genitals can be collected even after 48 hours and it can be associated with perpetrator with a very high degree of certainty [28, 29]. DNA fingerprinting also has applications in cases of misplaced child in nursing homes, identification of dead bodies after natural disaster or mass murder, recognising extremely mutilated or charred body, human skeletons buried long back etc. Centre for DNA Fingerprinting and Diagnostics (CDFD), Hyderabad was established for research and forensic case works initially in India [30]. Later on various Central Forensic Science Laboratories and state Forensic Science Laboratories has also built facilities for DNA fingerprinting. But its limited to matching a DNA profile from suspect/reference sample to sample found at crime site only. There is no DNA profile databank built yet which will require a separate act to be passed from parliament because DNA data banking requires addressing many ethical and procedural issues.

BUILDING AN ELECTRONIC DATABASE OF DNA PROFILES AND NEED OF A LAW

DNA profiles collected during a case can be stored electronically in a database for future reference. Other than matching the DNA profiles of samples in question and reference samples in a case, a cold search against database of earlier determined DNA profiles of suspects and criminals has solved many complex crimes like serial

murder, serial rapes and other complex crimes. Similarly the DNA sample can be also stored for future reanalysis with additional markers or for re-examination of evidence. Although this type of banking of data and samples has potential for solving very complex crimes but it also brings in potential misuse of this data. The ruling party or people in bureaucracy can systematically collect DNA profile disproportionately from already discriminated minority subpopulation which can lead to systematically more convictions of members of marginalised population. 75% of the young black male population in England and Wales has been entered in NDNAD, by contrast, only 22% of young white males, and 6% of the general population, is on the database. It is due to racial bias of people in police department who discretionary power of collecting DNA sample even for a small crime such as spitting on pavement [31, 32]. To keep everybody equal, DNA profile of everyone shall eventually get into database [33]. But mostly for logistic and risk management reasons various countries are entering the DNA profile of people in database according to criteria of level of offence committed. Health Insurance company or potential employer can try to get access to DNA data for inferring private information which is unethical [34, 35]. Investigation leads can be found in a crime if the DNA profile is not matching completely with any one profile in database but partially its matching with a profile. Such partial match can be indicative of a familial close relation with the actual crime, therefore, DNA profiling of blood relatives of the partially matching individual can get police to actual perpetrator. But there are ethical concerns to using familial DNA search specifically if a community is already overrepresented in DNA database. It goes against an individual's claim over community and right to not turn witness against his/her will [36]. In India human trafficking is very prevalent crime, a DNA databank can solve so many crimes by matching the parents with children found in brothels, homeless children on streets, child labourers in various hazardous industries etc. DNA database of unidentified bodies and relatives of people who are reported missing can relate the two with each other through familial DNA database search. Approximately 40,000 unidentified bodies are reported

every year whereas DNA profile database can solve many of such cases^[37]. On the other hand familial search of DNA database by unauthorised personnel can be misused for unravelling family secrets and family history for criminal public shaming or blackmailing. Therefore, not only DNA databases have to be protected against computer hacking and unauthorised access but also compartmentalisation of information is required so that complete information is not readily available at one place. For example CODIS of USA has a national level profile repository National DNA Index System (NDIS) which has DNA profiles only tagged with coded number without personal identifying information of individuals. The personal identifying information is stored at Local DNA Index System (LDIS) which can provide it through State DNA Index System in case of requirement when a cold hit is found at NDIS data search^[38,39].

INDIAN DRAFT DNA PROFILING ACT

Lokniti Foundation (NGO) filed a public interest litigation (PIL) in supreme court for creating a national DNA profile database through an DNA profiling act so that unclaimed bodies and missing persons can be related^[40].

The Supreme Court then directed the government to make a law accordingly. In this context the law to be soon passed by parliament regarding DNA fingerprinting is very important for streamlining the procedures in sample collection, processing and disposal as well as storing profile in an electronic database. The bill was originally proposed in 2007 and in 2012 drafting of the bill began. The draft bill was prepared by the Department of Biotechnology. The bill proposes to form a National DNA Data Bank and a DNA Profiling Board. The bill has been criticised by human right groups and activist for privacy rights for not addressing the concerns of privacy and arbitrarily assigning wide-ranging discretionary powers. The government of India informed the Supreme Court that it has been preparing to introduce a newer version of the Bill in parliament, titled 'The DNA-Based Technology (Use and Regulation) Bill'. The revised bill proposes storage of DNA profile in databank from five indices (categories) that is crime scene, suspect/under trial, offender, missing person and unknown

deceased person. In older version there were also categories of volunteers and other, which has been removed as the arbitrary discretion provided to director of board regarding these categories could have been misused. The laws of Scandinavian countries are comparatively better at protecting citizens right with more certainty whereas DNA profiling law of UK has more dangers of causing racial discrimination and endangering the privacy of citizens^[42-44]. The Forensic Genetics Policy Initiative (www.dnapolicyinitiative.org) has been started by collaboration of Gene Watch UK, Privacy International, and the Council for Responsible Genetics, with the aim to set human rights standards for DNA databases around the world^[45]. It recommends among other, deletion of DNA profile of innocent people from databases as per European Court of Human Rights' judgement on this issue in 2008. In 2013, following this judgement, in UK, over 1.7 million DNA profiles have been removed from the DNA database and 7,753,000 DNA samples have been destroyed. The number of STR loci proposed for DNA profiling under new bill proposed by Government of India is 13, instead of 17 proposed in older bill^[46]. It has been mandated that a written consent is obtained from an individual before a medical practitioner can obtain a sample of his/her DNA. And a person's DNA profile can be compared to entries in the suspects' and offenders' indices in the databank only if the individual has been designated a suspect or an offender herself^[47]. Until then, his/her profile can be compared only to the crime scene, missing persons and unknown deceased persons indices. However, the consent clause is waived for any person who has been accused of a crime that is punishable either by death or by a sentence of more than 7 years in prison. The new bill is silent about time frame for removal of eligible individuals removal of data, although rules can be framed later on to take care of such obvious procedures. The bill is also silent about quality control and procedures of labs, in this regard international norms of quality check and accreditation are expected to be followed which has been well defined by organisations such as European DNA Profiling Group, European Network of Forensic Science Institutes in Europe and the Federal Bureau of

Investigation's DNA Advisory Board and Scientific Working Group on DNA Analysis Methods (SWGAM) in the United States^[48]. The DNA Profiling Act is primarily to take care of privacy and human rights concerns, additionally its earliest implementation is even more important for robust delivery of justice. Advocacy by academicians for DNA profile act may get it passed by parliament expeditiously and there is also need for more training and promotion of DNA fingerprinting and other DNA Technologies. The act will open way for more streamlined use of DNA fingerprinting in criminal justice system which is required for accommodating and promoting a new technology in legal system^[49, 50]. This will lead to more inflow of funding and popularisation/ advancement of forensics as a discipline. In developed countries, laws on DNA fingerprinting has provided a legal framework for making it robust forensic science evidence, establishment of DNA fingerprinting labs, large scale training programs like president's DNA initiative and institution of quality control boards^[51]. The success of innocence project and data from justice department of USA demonstrates the high impact of DNA fingerprinting technology on robust delivery of justice; therefore, it's certainly an investment worth making for governments^[52-54]. As per a study in USA, individuals' subsequent criminal behaviour is reduced after entry into database of criminal offenders' DNA profiles. In reduction of aggregate crime rate also, DNA databases are most cost effective than traditional law enforcement tools^[55].

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