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Forensic Genealogy in Solving Age-Old Cases: Review

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Abstract
Forensic genealogy, a revolutionary technique at the intersection of criminal investigations, genetics, and genealogy, has gained recognition for solving mysteries and finding missing persons. This article provides an overview of its approach, highlighting its pivotal role in long-standing cases and the transformative impact of DNA analysis and genealogical research. It also includes case studies that demonstrate the effectiveness of forensic genealogy techniques.

Keywords: Investigative Genetic Genealogy (IGG), Forensic Genetic Genealogy (FGG), Single Nucleotide Polymorphism (SNP), Microarrays

1. Introduction

Forensic genetic genealogy, also known as investigative genetic genealogy (IGG), is a powerful tool in forensic investigations. It utilizes vast genotype datasets containing hundreds of thousands of single nucleotide polymorphisms (SNPs) (Andreas Tillmar, 2021) and public genealogy DNA databases to identify unidentified victims and remains. Researchers use various resources such as vital records, census records, public social media, people search databases, and newspaper archives to construct family trees (Gillam, 2022). Sometimes, a single sample can have two potential genetic matches. By searching publicly available databases and comparing DNA information, investigators can uncover crucial information to solve cold cases. From the candidates identified in the database search, family trees are created, helping to narrow down the list of potential suspects. Traditional and genealogical investigation techniques are then employed, considering factors like location, sex, age, and access to the crime scene (Wickenheiser, 2019). With over 600,000 markers, DNA profiles generated through microarray technologies have been successful in solving murder cases. Genetic genealogy relies on the principle that close relatives share more DNA, while distant relatives share less. However, familial searches using 16-22 autosomal STRs can only establish partial matches to direct or close relatives (Daniel Kling C. P., 2021). Genetic genealogy has the potential to aid law enforcement in identifying criminals when no DNA profiles are available in their databases. It can also provide information on paternity and biogeographical origin. However, issues related to consent and privacy need to be addressed, especially concerning deceased individuals and data security (Jard H. de Vries, 2022).

1.1 Genealogical databases

Direct-to-Consumer Genetic Testing (DTCs) Genetic testing that is sold directly to consumers is known

as 'direct to consumer,' or 'DTC.' After a client submits a DNA sample, they obtain information about their lineage through a secure website or a report. Popular DTC companies include lineage.com, 23andMe, FamilyTreeDNA, and MyHeritage.

Ancestry.com (http://ancestry.com) is the largest direct-to-consumer (DTC) provider with over fifteen million DNA samples in its database. Ancestry requires 'explicit consent' from the person providing the DNA sample. If Ancestry is required by law to disclose a customer's personal information to law enforcement, it will, unless prohibited by law, provide advance notice. A vial of saliva is submitted to the company, which uses it to create an ancestry report (Gillam, 2022), (Lund, 2020).

On 23andme's website, the company says it will "use all practical legal and administrative means to resist requests from law enforcement authorities, and [it] will not disclose a customer data with any public databases or institutions that may put law enforcement access at risk. It could occasionally be necessary to abide by a legitimate subpoena, search warrant, or court order to get genetic or personal data. However, if law enforcement provides a court order, subpoena, or search warrant for genetic or user information, the information will be sent over, and 23andMe may be required by law to comply. Similar to Ancestry, 23andMe asks users to submit a saliva sample for themselves or for someone over whom they have legal authority (Gillam, 2022), (Lund, 2020).

Even while FTDNA makes a point of working with law enforcement, law enforcement officials still need to request that a sample or genetic file be included in the database. On its website, FamilyTreeDNA offers more than a million DNA profiles. Each DNA test kit comes with two cotton swabs that are meant to be used by one person. It will include information on the number of forensic samples and files they have received as well as details on all law enforcement requests for user information that they receive (Gillam, 2022), (Lund, 2020).

MyHeritage is a European company (http://www.myheritage.com). About 1.75 million people used the MyHeritage DNA database as of September 2018. By providing a sample, the customer affirms to MyHeritage that the DNA sample is their own, that of a person for whom they are a legal guardian, or of a person for whom they have secured permission from a court of law to give their DNA to MyHeritage. At the moment, MyHeritage does not release a transparency report (Gillam, 2022), (Lund, 2020).

1.2 GEDmatch

GEDmatch is not a DTC provider, but it assists in forensic genealogy by allowing customers to submit their DNA results from different providers and compare them with other users on the public website. The Golden State Killer was identified using GEDmatch, and the site's administrators made it clear that law enforcement could access the database. In April 2018, GEDmatch informed users that their DNA could be used to identify relatives involved in crimes. Users have the option to not upload their DNA or remove previously uploaded DNA if they are concerned about non-genealogical uses. GEDmatch saw a significant increase in users after assisting with the Golden State Killer case. The company's Terms of Service highlight that DNA may be compared to law enforcement's DNA for identifying perpetrators of violent crimes or the remains of deceased individuals. GEDmatch cooperates fully with law enforcement (Gillam, 2022), (Lund, 2020).

1.3 Genealogical research

DNA analysis and database applications are increasingly being used in investigations when conventional methods fail to find a suspect. One newer technique is genealogy searching, which has proven useful in solving significant cases. If enough DNA matches are unavailable from the crime scene, an extended panel of SNP DNA markers can be compared to publicly available genealogical databases. Family trees are

constructed for close relatives to determine where different branches intersect, indicating a uniting family with both paternal and maternal lineages. Once data, including location and age, is gathered, potential suspects are carefully selected for assessment, with caution taken to avoid raising suspicions. This assessment may involve comparing a known sample from a suspect to the crime scene profile. Genealogical research, which is a crucial step in the investigation, takes time and relies on digitized records and indexed data. It also involves studying historical documents and using social media to gather information on living individuals. Successful genetic genealogy searches require expertise in DNA evidence interpretation, which can be acquired through university courses and qualifications offered by genealogical organizations worldwide (Gillam, 2022), (Lund, 2020).

2.Case studies

The case studies that follow show how investigators have utilized genetic genealogy to help identify a suspect in cold case investigations.

2.1 Snohomish County, Washington; cold case (double homicide) dating back 31 years

This case study demonstrates the effectiveness of genetic genealogy and the importance of thorough investigation. In 1987, a young Canadian couple, Tanya Van Cuylenborg and Jay Cook went missing during a van trip from British Columbia to Washington State. Jay's body and the van were discovered in different locations, while Tanya's body was found in a ditch. DNA evidence was collected from an unidentified suspect.

Using the Gedmatch database, two matches at the fifth-degree relative level were found. By conducting extensive research on both sets of ancestors, investigators discovered an intersection: a son of one match's great-grandmother had married a granddaughter of the other match's great-grandparents. This son had adopted his stepfather's last name, obscuring his true connection to one match. The offspring of this union were second cousins to one match and half-first cousins once removed to the other.

The sole son of this union, William Earl Talbott II, had no criminal record or known link to the victims. However, with the lead from genetic genealogy, investigators obtained a DNA sample from a cup discarded by Talbott. Traditional DNA analysis confirmed a match with the crime site, leading to his arrest. William Earl Talbott II is currently awaiting trial for the murders. This case highlights the power of genetic genealogy in solving complex cases and the importance of considering all potential relationships when analyzing DNA matches (Ellen M. Greytak, 2019).

2.2 Tacoma, WA; 32-year-old cold case (homicide)

This case study highlights the importance of creative thinking skills for genetic genealogists when triangulating matches without documentary sources. In 1986, Michelle Welch, a 12-year-old girl from Tacoma, Washington, went missing and was later found dead. DNA testing suggested that the same person might be responsible for her death and the death of another girl around the same time.

Genetic ancestry analysis revealed that the suspect was predominantly of Northern European descent with a small but significant (10%) admixture of Northern Native Americans. While searching for matches on Gedmatch, it was concluded that the top two matches were likely connected to the suspect through separate branches of the family tree.

Despite extensive research and the construction of family trees tracing back several generations, no direct junction between the two families was found. However, two brothers related to the first match were located near the crime site in 1986 and had Native American ancestry. It was hypothesized that the second match's

relative might be the unrecorded biological father of the brothers, explaining the shared DNA. This would mean that the first match and the brothers were half-cousins.

After conducting genetic genealogy analysis, police identified two potential suspects, including Gary Charles Hartman, who had never provided their DNA to a database. To confirm their involvement, authorities obtained a napkin discarded by Hartman at a restaurant, and the DNA on the napkin matched the DNA found at the crime scene. Hartman has since been arrested and is undergoing trial for Michelle Welch's murder, more than thirty years after the crime occurred (Ellen M. Greytak, 2019).

3. Limitations

Microarrays typically require larger amounts of DNA, but forensic samples often contain lower levels of DNA. These samples also suffer from degradation and enzymatic inhibition, posing challenges for downstream analyses. While the IGG application has shown success, there are concerns about its applicability to law enforcement due to moral and legal questions.

From a technological perspective, two major roadblocks need to be addressed. Firstly, incomplete genotypes of SNPs can affect search results in genealogical databases, leading to inaccurate assessments of relatedness. A low SNP density may also cause shared segments to be overlooked or falsely included (Jard H. de Vries, 2022).

Forensic genealogy not only compromises an individual's privacy but also jeopardizes the privacy of others due to the wealth of family history information contained in DNA data. Autosomal genealogy, commonly used in law enforcement, cannot distinguish between siblings, potentially resulting in wrongful convictions. The lack of regulation and legislation in this area further exacerbates the risks associated with DNA sampling, laboratory errors, contaminated DNA, and potential discrimination in the criminal justice system.

"Genome hacking" can be as simple as collecting someone's saliva without verification and submitting it for DNA analysis. The lack of control over who can access DNA information raises concerns about privacy and security.

Overall, while AI technology can enhance forensic analysis, ethical, legal, and privacy considerations must be carefully addressed to ensure its responsible and effective use in the forensic industry.

4. Conclusion

Public genealogical databases are now aiding investigations by identifying missing persons and donors of bodily stains, potentially exonerating the innocent and solving forensic cases. They also minimize reliance on private DNA databases for sensitive health-related information.

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