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Analyzing The Effect Of Technological Advancements In Forensic Odontology On Criminal Trials In India

Gagana. V V

Student, BBA.LL. B, 3rd Year,
Department of Law
Christ (Deemed to be University) Pune, Lavasa, India

ABSTRACT: Forensic Odontology is a branch of Forensic Sciences, which deals with identification of individuals through their dental as well as their palatal structure as it is unique for each individual. Forensic Odontology plays an integral role in the identification of individuals especially in the cases of mass disasters and crimes against humans. The recent advancements in technology as well as Artificial Intelligence have been playing a huge role in the process of identification of individuals through Forensic Odontology. These advancements in the field of Forensic Odontology have not only made the process of identification of individuals much easier and faster but has also been helpful in the faster disposal of cases in criminal trials. This paper deals in detail with the recent technological advancements that have made the process of identification of individuals through the process of forensic odontology easier and quicker as compared to the manual and traditional methods as well as analyse how the technological advancements have changed the viewpoint of the courts in awarding the perpetrators of the offenders their respective punishments. This paper also highlights the various cases in India which have used Forensic Odontology for the identification of offenders as well as cases where the evidence received through the different methods used in Forensic Odontology have been admitted as well as used by the courts in India for the faster disposal of cases and the nature and scope of Forensic odontology in India.

KEYWORDS: **Forensic Odontology, Technological Advancements, Artificial Intelligence, Criminal Trials, Dental Structure**

INTRODUCTION

Forensic odontology is the branch of forensics that deals with human identification based on dental features.[1] This branch of forensic sciences surprisingly, unlike the common conception, does not only deal with the study of the dental structure of an individual, whose identity is to be found but also includes the study of the skull as well as the palatal structure of the body that requires identification.

Hence, a good knowledge for every dentist is necessary about various forensic methods like chronology of primary and permanent teeth, DNA studies, Cheiloscopy, Palatal rugae assessments etc for identification of

[1] A Practical Perspective of Forensic Odontology in Age Estimation: 2 Medico Legal Case Studies, 2021 Indian J. Forensic Med. & Toxicology, 728-732 https://doi.org/10.37506/ijfmt.v15i2.14399.

an individual to assess factors like age, sex, and such, which can be able to play a vital role in practice of Forensic Odontology[2].

1) IMPORTANCE OF FORENSIC ODONTOLOGY

Forensic odontology plays an integral role in analysing not only the age and sex of an individual but also is useful in finding These two conditions play an extremely important role in civil as well as criminal cases.

This field plays a significant role in civil cases like custody battle, malpractice and it is very evident in the cases of paternity identification of a child, when it is in question.

And in case of criminal cases, forensic odontology is used to study the bite mark on the body of the victim of Rape, sexual harassment, child abuse etc.

1.1) Civil case in India where forensic odontology was found to be useful

In one of the cases in India, an abandoned child was taken up by an old childless couple around the age of 3 months, after a couple of years, a man claiming to be the father of the child, demanded the custody of this child claiming that the child was over the age of 6 Years. When this dispute was taken to the court, the court ordered complete physical examination of the child. In this examination the complete dental, palatal as well as joint and skull structure was examined and it was found that the child was under the age of 5 Years which was mentioned in the court by the old couple, who had the custody of the child. The court then granted the custody of the child to the old couple.

2) CRIMINAL CASES IN INDIA WHERE FORENSIC ODONTOLOGY WAS FOUND TO BE USEFUL

2.1 Nirbhaya gang rape

In the Horrific incident of the Nirbhaya rape case in Delhi, in the year 2013, to find out the identity of the rapists, the Delhi police had requested assistance from the forensic odontology department in Dharwad to identify the bit marks found in the victim's body.

A day later, the Sub Inspector of the Vasant Vihar Police Station in New Delhi flew down to SDM college of dental sciences and hospital Dharwad, and shared the photographs of the bite marks found on the victim, as well as dental models of five accused adult men in the case. Bite marks are usually found in crimes related to sexual assault. These bite marks were considered to be as useful and unique as the fingerprints of different individuals.

[2] A Practical Perspective of Forensic Odontology in Age Estimation: 2 Medico Legal Case Studies, 2021 Indian J. Forensic Med. & Toxicology, 728-732 https://doi.org/10.37506/ijfmt.v15i2.14399.

5-6 bite marks were found on the body of the victim. These bite marks were then analysed with the dental structure with the 5 accused. After the analysis and investigation for a period of 2 days, it was found that the bite marks found on the body were similar to the dental structure of the 2 of the 5 accused.[3]

2.2 Age determination of Mohammad Ajmal Kasab

Ajmal Mohammad Amir Kasab, one of the main perpetrators of the 26/11 Mumbai terror attack who was awarded death penalty by the Honourable Supreme Court of India was examined by the process of forensic odontology to determine if he was a minor who should be punished according the Juvenile Justice Act of India.

Once the Forensic odontology department submitted the report, the court held that Ajmal Kasab was not a minor and could be awarded punishments as that of an adult.

3) TECHNOLOGICAL ADVANCEMENTS IN FORENSIC ODONTOLOGY

Now, for the data found through forensic odontology to be accurate, it is extremely necessary that there is a pre-existence of Ante Mortem as well as Post Mortem records.

Before the advent of technology in the Forensic field, the analogy of the AM (Ante- Mortem) and the PM (Post – Mortem) records were done manually, which took a lot of time, as compared to the now used technological methods.

Now, the various technological methods that are used in this field have been extremely helpful in increasing the accuracy of the findings as well as reducing the amount of time in determining the data as well as rechecking and analysing the accuracy of the same.

3.1) Portable Dental X-ray Generator

In recent years, the advance in obtaining postmortem radiographs has led to the invention of NOMAD TM hand held, battery powered X- ray device. The AribexTM NOMADTM portable hand-held dental radiation emitting device was developed in 2004 and received FDA approval as a medical device in July, 2005 and has been used extensively and almost exclusively in the resolution of mass fatality incidents (MFIs) requiring forensic dental identification of numerous victims. "*It weighs 8 pounds, has internal lead shielding and an external lead– acrylic backscatter shield. There is an automatic shut off and Enable feature that minimizes the risk of inadvertent exposure. The NOMADTM uses direct current, operates at a fixed 60 kV, 2.3 mA and has a 0.4 mm focal spot with a 20 cm source-to-skin distance. (Goden et al., 2008). The NOMADTM is easy to set up and use. It meets radiation safety standards and does not require personal dosimetry. NOMADTM presents no risk to the patient or to the operator and the measured doses are well below recommended levels. The image quality of the radiographs is equivalent to that produced with standard X-ray equipment.*" [4]

This portable hand-held radiating device is specifically used to obtain the Post Mortem Radiographs, and is very useful in case of Disaster Victim Identification (DVI) processes.

The biggest advantage of this technological advancement is not only the speed and accuracy but also that it is extremely simple to use by the dental attendees as these devices very accurately accept simple command

[3] *Cases*, Ashith Acharya, http://ashithacharya.com/cases#:~:text=The%20'Nirbhaya'%20Case%20(New%20Delhi)&text=Such%20bite%20marks%20can%20look,of%20the%20five%20accused%20persons. (last visited Nov. 7, 2024).

[4] Smitha S Shetty, Current advances in forensic odontology, 3 Advanced techs. an aid forensic odontology. an update 1615-1620 (2015).

and also follow the X-RAY hygiene protocols that need to be followed while taking up the X-RAY of any object or body.

3.2) Cone Beamed Computed Tomography (CBCT)

A relatively new technique of imaging is CBCT- Cone Based Computer Tomography. The Dentomaxillofacial scanners were introduced in the year 1990, and have resulted in great advancements and positive changes in the field.

This technology uses a specific cone-based laser beam technology, which has a 2D detector which goes around the object once and then leads to the creation of a 2D image. This relatively new technology is cost effective and is extremely useful in creating an XRAY of skeletons and also provides the results in higher resolution as compared to the other XRAY methods.

3.3) Use of phone cameras in bite mark analysis

Phone cameras have started playing a huge role in the field of forensic odontology, just like it plays an integral role in one's life. Phone cameras because of their High-Definition technology (HD), have been extremely useful in documenting evidence, when the technical cameras are not easily accessible at crime scenes.

Because of the current technology, phone cameras can be easily connected to the various forensic apps available, or even to the official forensic apps, to store the data that is found from the crime scenes.

Another requirement in the field of forensic photography is proper lighting, HD cameras, Macro capabilities as well as wide lenses. Without any surprise, the smartphones have all these features inbuilt in them, which make it easier for the practitioners to collect data on the spot, without having heavy equipment to carry with them.

The data that is collected through phone cameras, no differently are used to analyse the AM (Ante Mortem) PM (Post Mortem) dental structure and data, analyse in detail, the bite marks as well as documenting the bite marks or any injuries on the body in case of abuse.

The one thing to keep in mind while using phone cameras to store data and evidence, from Forensic Odontology is to make sure that the evidence is free from data tampering and any form of unethical activities.

4) ARTIFICIAL INTELLIGENCE

Artificial Intelligence can be defined as the machines capacity to perform tasks that would require human intelligence.

Artificial Intelligence is used in almost every field, ranging from education to engineering.

The different Artificial Intelligence methods that are employed in the field of forensic odontology are Artificial Neural Networks, Deep Neural Networks and computational technology, Metaheuristic Algorithm.

This Metaheuristic method coupled with has reported an accuracy of 97.7% when in it coupled with dental Panoramic Radiograph for the personal identification of a body at a crime scene.[5]

Artificial Intelligence can be used in various other aspects including Cheiloscopy, Facial Reconstruction,3D printing and bite Mark analysis.

The most essential aspect while using Artificial Intelligence is to make sure that there is an existence of the Ante Mortem records that be used to analyse the data that is availed from the crime scene.

[5] Smitha T., Artificial Intelligence in Forensic Odontology, 2023 J. Forensic Dental Scis. 01-2, https://doi.org/10.18311/jfds/13/1/2021.659.

Absence of an Ante Mortem record does not mean that the analysis and the identity of an individual cannot be found. Existence of Ante Mortem records make it easier for the relative comparison of the features found at the crime scene with the data that has been entered into the Artificial Intelligence systems.

4.1) Artificial Neural Network clubbed with mandibular morphometric parameters for gender identification.

Gender identification plays an integral role in identification of individuals in the matter of mass victim disasters and in the case of violence. The most reliable source of gender identification are the skeletal bones of the body. These skeletal boned consist of the skull, jaw as well as the. teeth. This structure plays an integral role in identification, even when the body is unidentifiable due to the damage that has been caused to the external mass of the body.

The skeletal structure consists of the mandible, that is an integral and the strongest part of the orofacial framework and is the most resistant part of the body to post mortem changes.

The interesting fact about mandible is that it is the last part of the skeletal structure to complete its growth and is the most sensitive part to the hormonal changes during the puberty or the growth spurt of the individual. Secondly, due to the huge difference in the type of hormones that are released by the brain in males and females, the sensitivity of the mandible to the hormones also assists in the determination of the gender of an individual.

ANN consists of neurons that are connected by links, each of which has a numerical weight associated with it. Each neuron computes the weighted sum of their input links and compares the result with the threshold value. The output of each neuron depends on the activation function used.[6]

4.2) Artificial Intelligence in Facial Reconstruction.

Reconstructing a person's face from bone remains that are unknown to them is known as forensic facial reconstruction[7].

The positive aspect of using Artificial Intelligence is to remove any possible human bias that can come forth while using manual methods of facial reconstruction.

The process of ANN is used to determine the gender of an individual, when the body is mutilated to such an extent where visual analysis cannot be the source of identification. After the gender of the individual is determined, Artificial Intelligence is utilized to create a 3D structure that is approximated to be 97% accurate to the actual facial structure of an individual.

The specific command given to the Artificial Intelligence software is to recreate the dental, skull, jaw structure of the deceased individual.

DANet and DAS- Net are the most prominent Artificial Intelligence software used in facial reconstruction as well as sex determination.

[6] Vathsala Patil et al., Artificial neural network for gender determination using mandibular morphometric parameters: A comparative retrospective study, 7 Cogent Eng'g 1723783, 1-12, (2020), https://doi.org/10.1080/23311916.2020.1723783.
[7] Divya V C & Backiyalakshmi A, Artificial intelligence in forensic odontology: A review, 10 IP Int'l J. Maxillofacial Imaging 6-10, (2024), https://doi.org/10.18231/j.ijmi.2024.002.

5) BITE MARK ANALYSIS

Bite mark analysis, as the name itself suggests is done to analyse the bite marks that are found on a victim's body. This analysis is not only done on the bite marks found on a body but also the bite marks that are found on food, skin as well as other materials. Finding out who created the bite mark and producing evidence that can be used in court are the two main objectives of bite mark analysis.[8]When the bite marks is collected from any crime scene and handed over to the forensic odontologists, it is then submitted into the Artificial Intelligence software, which then use this data to compare it with existing data and provide results.

Artificial Intelligence can be used to improve the quality of the images of the bite marks that are found on a victim's body, which have been captured using mobile phone cameras. These images can then be useful for the practitioners to compare this data with pre-existing data and confirm or rule out the identity of the perpetrator in case of a violent crime. Such analysis done, can be extremely useful as submissions in courts during the criminal trials.

5.1) Role of saliva in Forensic Odontology.

Saliva from bite marks should be extracted as soon as possible for group testing. Saliva samples can be used in conjunction with forensic DNA analysis to determine whether or not there is a relationship between a person and the forensic evidence.[9]

It is essential that as soon as the Forensic Odontologists reach the crime scene, they collect any existing Saliva that is present on the bite mark, as saliva Is one of the best sources to collect DNA from.

Even the age of the offender can be found from the saliva just by measuring the amount of methylation in it, which one the main causes for age related diseases.

6) IMPORTANCE OF ANTE -MORTEM RECORDS

Ante Mortem (AM) records play an extremely essential role in the process of identification of an individual through forensic odontology. Since it is now established that forensic odontology does not include only the analysis of the dental structure, but also the skull as well as the palatal structure of an individual, the pre-existence of data regarding the dental structure, skull structure and the formation of an individual's palatal structure plays an integral role in the quicker identification of any individual.

The term Ante Mortem means 'before death'. Which means the data that is collected of an individual before their death during any of their regular dental checkups etc.

With respect to rural India, the biggest concern with respect to these records is that the importance of the recording of basic data has not been inculcated into the young medical practitioners. Even if the data is collected, there is a high probability that such data will not be collected with the right information and stored in the right way, or such collected data might be disposed of without understanding the relevance of the same.

Multiple births, in rural India do not take place in hospitals, they take place in the homes of their families, which leads to one of the other reasons, why the data of births remain absent. The importance of recording births in the local hospitals is necessary with respect to the storage of Ante Mortem records as in case of the cases of child sexual harassment, the body of the child, as well its dental as well as skull structure, with respect to their stage and rate of growth, can be extremely useful in identifying the age, gender, identity of the child.

[8]Seema Shantilal Pendharkar, Forensic odontology: A new dimension in dentistry, 12 Int'l Dental J. Student's Rsch. 3-6 (2024), https://doi.org/10.18231/j.idjsr.2024.002.

[9] Seema Shantilal Pendharkar, Forensic odontology: A new dimension in dentistry, 12 Int'l Dental J. Student's Rsch. 3-6 (2024), https://doi.org/10.18231/j.idjsr.2024.002.

6.1) Presence of any form of dental treatment

The existence of any form of dental treatment can be analysed using the bite mark that is left behind on the victim's body. Detailed analysis of the bite mark can lead to the conclusion regarding the dental replacement, cavity fillings, tooth removal, smoking habits, Tobacco chewing habits etc.

This also causes a higher need for the presence of Ante Mortem records, which can easily help the investigators find the offender by confirming the same data.

The quality, quantity, and presence or absence of dental treatment can all be used to determine a patient's socioeconomic position.[10]

7) FORENSIC ODONTOLOGY IN INDIA AND IT'S SCOPE IN INDIA

In India, Forensic Odontology still remains at a very primitive stage. Its inclusion in the undergraduate curriculum and formation of The Indian Association of Forensic Odontology (IAFO) has given a major boost to the field but its use still remains limited which has resulted in lack of employment opportunities. A few courses on Forensic Odontology are offered in a couple of universities in India but there is still a lack of a postgraduate degree that would solidify its place as a proper speciality. Persistent efforts by dentists interested in the field, organizations like the IAFO, and the law authorities would help forensic odontology gain the same recognition and importance as it has earned in developed countries[11]

The field has started gaining more recognition due to the constant natural disasters as well, Mass victim Disasters and the commission of Violent crimes. Since, dental evidence are the most reliable source of confirming the identity of an individual, the courts in India have also gradually stated accepting the evidence provided by forensic odontology.

The future of forensic odontology India is pretty bright, but this is not fast enough due to the lack of infrastructure, awareness, specialized courses, and specialized tools. Once these disadvantages are covered up by constant government support, development of well-structured labs and specialized course structure. Forensic odontology will have a pretty bright future in the upcoming years.

8) EFFECT OF TECHNOLOGICAL ADVANCEMENTS IN FORENSIC ODONTOLOGY ON CRIMINAL TRIALS

According to section 45 ,51 and 52 of the Indian Evidence Act[12]. The court can accept expert opinions as evidence during trials. Here, the testimonials by the expert odontologists can play a huge role by providing evidence with regards to the bite mark analysis, Ante Mortem and Post Mortem record analysis and the results arrived at from the 3D facial reconstruction.

In the past forensic odontology would use manual methods to compare the Ante Mortem and the Post Mortem reports, Facial reconstruction and bite mark analysis. These manual methods were prone to errors as well as resulted in human biases.

The results arrived at from forensic odontology using manual methods would not be easily acceptable in courts without the detailed explanation of the process that was used, which included the forensic expert having to explain every single method that was used to arrive at the conclusive result.

[10] Seema Shantilal Pendharkar, Forensic odontology: A new dimension in dentistry, 12 Int'l Dental J. Student's Rsch. 3-6 (2024), https://doi.org/10.18231/j.idjsr.2024.002.

[11] HJ Ali et al., *Scope and relevance of forensic odontology in India - A review*, 44 J. Indian Acad. Forensic Med. 75, (2022), https://doi.org/10.5958/0974-0848.2022.00094.x.

[12] Indian Evidence Act § 45,51,52 (1872).

The technological advancements have made the production of these evidence much quicker, which in turn have made it easier for the forensic experts to give their testimonials in the court, which in turn, makes the disposal of the cases easier as well as faster.

The field of Forensic odontology in itself as some defects, even with the advent of technology which have made is difficult to be accepted as evidence during criminal trials.

The first issue being the lack of standard protocols, especially that there is no specific standard or any uniform method that is commonly used throughout the field. This leads to the procedure used to reach a particular conclusion and it makes it difficult to be accepted as evidence in courts.

Even with the use of various technologies, there is an absence of a particular set of procedure or a particular technology that is a mandate to be used during the identifying processes

The second issue being lack of dental records. One of the primary challenges in forensic odontology is the lack of comprehensive dental records for comparison. Not all individuals have detailed dental records, especially in cases involving victims of mass disasters, unidentified remains, or individuals with poor access to dental care. In case of age estimation, the age of an individual based on dental evidence can be challenging.[13]

The third issue is the lack of resources and funding. As mentioned earlier, forensic odontology as a branch of forensic sciences has a huge scope in the future as well has a bright future in the country. But due to lack of funding not only for the setting up of the institutions but for further research on the topic this field acks the ability to reach the potential it actually has with respect to becoming a well-established branch of forensic science.

The last but not the least, admissibility in the courts. The provisions of the Indian Evidence Act allow the testimonials of the experts in a specific field. Due to the integration of Artificial Intelligence in the field of forensic odontology, there arises questions regarding the credibility of the evidence that has been provided in the courts during the trials.

The acceptance of these evidence is based highly on the judges presiding over the case. To remove such a subjectivity, a specific standard as well as protocol needs to be set up I the field of forensic odontology.

CONCLUSION

Forensic Odontology is a branch of Forensic Sciences, which deals with identification of individuals through their dental as well as their palatal structure as it is unique for each individual. Forensic Odontology plays an integral role in the identification of individuals especially in the cases of mass disasters and crimes against humans. The recent advancements in technology as well as Artificial Intelligence have been playing a huge role in the process of identification of individuals through Forensic Odontology.

The advent of technology in this field has made the process of analysis of data much quicker and has provided the odontologists a method to revise and recheck their data. The advent of technology has surely acted in a positive manner, but there are certain improvements still required in the field to make it a much more prominent branch of forensic sciences.

Once a standardized protocol as well as a standardized set of ethics are set up in the field of forensic odontology, it will become extremely easy for the judges to accept the evidence which used Artificial Intelligence to arrive at results. These few changes can lead to forensic odontology being one of the well know branches of forensic odontology and will lead to more students leaning towards this profession in India.

[13] Sathiya Priya -, *Forensic Odontology and Legality*, 6 Int'l J. For Multidisciplinary Rsch., 11 (2024), https://doi.org/10.36948/ijfmr.2024.v06i01.11823.