JOURNAL OF

Punjab Academy of Forensic Medicine & Toxicology

ISSN: 0972-5687

Volume: 24, Number: 02 July to December Publication: Half Yearly

2024

Editor-in-Chief

Prof. (Dr.) Ajay Kumar

A Peer Reviewed Journal on

Forensic Medicine, Toxicology, Analytical Toxicology, Forensic Science, Environmental Pollution, Forensic Pathology, Clinical Forensic Medicine, Identification, Legal Medicine, State Medicine, Medical Jurisprudence, Medical Ethics, Forensic Nursing, Forensic Odontology, Forensic Anthropology, Forensic Psychiatry and other Allied branches of Medicine and Science dedicated to administration of Justice.

OFFICIAL PUBLICATION OF

PUNJAB ACADEMY OF FORENSIC MEDICINE & TOXICOLOGY

Place of Publication: Bathinda (Punjab) India

• Indexed with Index Copernicus (Poland), Scopus (Elsevier Products), IndMed (ICMR New Delhi), Safetylit, Worldcat Library & WHO Hinari

• JPAFMAT is also having PubMed/NLM catalogue number (NLM Unique ID: 101232466).

• Available online at Indian Journals.com, pafmat.org and pafmat.com

• UGC Approved (as per UGC care list)

J Punjab Acad Forensic Med Toxicol 2024;24 (2) ISSN : 0972-5687

PUNJAB ACADEMY OF FORENSIC MEDICINE AND TOXICOLOGY

(Registration No. 139 / 1998-99, Chandigarh)

HO: Department of Forensic Medicine, Govt. Medical College, Patiala (Punjab) 147001

FOUNDER GOVERNING COUNCIL OF PAFMAT

Patron

Dr Jagdish Gargi

Advisors

Dr J.S. Dalal

Dr Harish Tuli

Dr Maj. Gen (Rtd.) Ajit Singh

President

Dr. R.K. Gorea

Vice President

Dr. D.S. Bhullar

Secretary

Dr. Sat Pal Garg

Treasurer

Dr. Nirmal Dass

Executive Members

Dr A.S. Thind

Dr Jagjiv Sharma

Dr Kuldeep Kumar

Dr I.S. Bagga

Dr Baljit Singh

GOVERNING COUNCIL (2023 - 2025)

President
Dr. Rajiv Joshi

General Secretary
Dr. Satinderpal Singh

Joint Secretary
Dr. Ravdeep Singh

Finance Secretary
Dr. Jatinderpal Singh

Vice President
Dr. Vishal

Joint Editor
Dr. Harwinder Singh Chhabra

Editor-in-Chief
Dr. Ajay Kumar

Executive Members

Dr. Ashwini Kumar
Dr. Varinder Pal Singh
Dr. Kunal Khanna
Dr. Anju Gupta
Dr. D.S. Walia
Dr. Nikhil Mehta
Dr. Malvika Lal

Advisors

Dr. O.P. Aggarwal
Dr. S.S. Oberoi
Dr. Balbir Kaur
Dr. D.S. Bhullar
Dr. Gurmanjit Singh
Dr. K.K. Aggarwal
Dr. Jagdish Gargi
Dr. R.K. Gorea
Dr. Ashok Chanana
Dr. Rajiv Joshi

From the Desk of Editor-in-Chief

It is with great excitement and gratitude that I extend a warm welcome to each of you as we continue our journey together. As the Editor-in-Chief, I am honored to be at the helm of this publication, where our collective passion for research, reviews, and case reports takes the shape of the journal. In this ever-evolving landscape, we remain committed to bringing you new, original research, reviews, and unique case reports. Our team is dedicated to curating the best articles, covering a diverse range of topics, and providing fresh perspectives that reflect the world around us.

I am thankful to the editorial team and the members of the Academy for supporting me in this publication. My special thanks go to Joint Editor Dr. Harvinder Singh Chhabra and Assistant Editor Dr. Sahil Thakral for their unwavering support and sincere efforts in the publication and release of this issue. The Journal publishes original research papers, review articles, case reports, and book reviews on Forensic Medicine and Toxicology. It also highlights the achievements of the Academy and its members. This journal is designed to help achieve the aims and goals of the Academy: to expand academic activities, spread knowledge, and present the latest research in the field of Forensic Medicine and Toxicology. Any suggestions or advice for further improving the standards and quality of the journal will be highly appreciated and may be sent to the editorial team.

Each issue of the journal reflects the hard work, commitment, and dedication of our talented contributors, reviewers, and editors. Their commitment to excellence is truly remarkable. Your support and feedback help shape the direction of our content, and for that, we are deeply appreciative.

Thank you for being a part of this journey.

ISSN Numbers:
ISSN-L: 0972-5687, p-ISSN: 0972-5687, e-ISSN: 0974-083X.

Indexed with:
IndexCopernicushttp://journals.indexcopernicus.com/karta.php?id=4715

Scopus (SCI):
http://www.scimagojr.com/journalsearch.php?q=19900194914&ip=sid&clean=0

Volume of Distribution:
200 copies.

Funding Bodies: Punjab Academy of Forensic Medicine & Toxicology, Donations from Philanthropists and manuscript handling charges

Address for submission of articles Online (Soft Copy):
iamdrajay@gmail.com, indianjournals.com

Prof. (Dr.) Ajay Kumar
Professor (Forensic Medicine)
Associate Dean (Examination)
Chair Person Recruitment Cell
All India Institute of Medical Sciences, Bathinda
Editor in Chief, Journal of Punjab Academy of Forensic Medicine and Toxicology (JPAFMAT)

JOURNAL OF
Punjab Academy of Forensic Medicine & Toxicology
ISSN: 0972-5687

Volume: 24, Number: 02 **July to December** **Publication: Half Yearly**

Contents

JOURNAL OF
Punjab Academy of Forensic Medicine & Toxicology
ISSN: 0972-5687

Volume: 24, Number: 02 **July to December** **Publication: Half Yearly**

Contents

JOURNAL OF
Punjab Academy of Forensic Medicine & Toxicology
ISSN: 0972-5687

Volume: 24, Number: 02 **July to December** **Publication: Half Yearly**

Contents

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00030.3

Editorial

Forensic Microbiology : Reveal the Microbial Signatures in Criminal Investigations

1. **Ajay Kumar,** Professor, Department of Forensic Medicine and Toxicology, AIIMS, Bathinda
2. **Kamla Kant,** Associate Professor, Department of Microbiology, AIIMS, Bathinda

ABSTRACT

Forensic microbiology is a nascent field that utilizes the distinguishing features of microorganisms to assist in criminal investigations. Through the examination of microbial communities and their DNA, forensic microbiologists can make significant contributions to different elements of a crime, such as human identification, estimation of the post-mortem interval, and detection of agents of bioterrorism. This editorial observes the applications, techniques, challenges, and future directions of forensic microbiology within the criminal justice system.

Corresponding Author :
Dr. Kamla Kant, Associate Professor,
Department of Microbiology, AIIMS, Bathinda
E-mail: drkamlakant@gmail.com
Contact : +919968230968

Article History:
Received: 30 November 2024
Received in revised form: 18 January 2025
Accepted on: 18 January 2025
Available online: 15 April 2025

Keywords: Identification; Microbiome; Bioterrorism; Metagenomics; Bioinformatics.

INTRODUCTION

Microorganisms pervade all possible environments, even the human body. Every person carries a unique microbiome - a diverse collection of microorganisms-that can be used as a microbial fingerprint. Forensic microbiology takes advantage of this uniqueness to aid legal investigations, providing new avenues for evidence gathering and analysis. Forensic microbiology has acquired increased relevance with progress in sequencing technologies and bioinformatics, allowing more accurate description of microbial communities.

Different applications of forensic microbiology in forensic investigations[1-2] include:

Human Identification: The specific makeup of a person's microbiome can be used for personal identification. For example, skin bacteria and the microbiome linked to hair or body fluids can be used as microbial signatures, possibly connecting a suspect to a crime scene. This method is especially helpful when conventional DNA evidence is degraded or lacking.[3]

Post-Mortem Interval Estimation: Once deceased, the human body decomposes, and in this process, certain microbial populations, referred to as the thanato-microbiome, are activated. From the pattern of succession of these microorganisms, forensic experts can estimate the post-mortem interval. This is an alternative to conventional methods, particularly when environmental factors render other methods ineffective.[4]

Bioterrorism and Epidemiology: Forensic microbiology has a central function in tracing the origin of biological agents employed in bioterrorism. By analysing the genetics of pathogens, researchers can distinguish between naturally caused outbreaks and intentional releases. A good example is the case of the 2001 anthrax attacks in the United States, where genomic investigation traced the origin of the anthrax spores.[5]

Sexual Assault Investigation: It is recommended in new studies that bacteria carried from sex could be applied to forensic testing for identifying suspects, particularly if sperm cannot be found. The bacteria from genitals are different between persons and will leave particular markings which can be identified on their sex partners following intercourse. It could prove quite useful in circumstances when sperm may not be detected owing to condom usage, vasectomy, or non-ejaculation.[6]

Geolocation and Trace Evidence: Soil and water samples have unique microbial communities that can connect a suspect or object to a location. Soil microbes on a shovel, for instance, can tell where the shovel was last used, offering useful information in criminal investigations.[7]

Methodologies in Forensic Microbiology

Molecular biology advances have armed forensic microbiologists with an array of tools to examine microbial evidence:

- **DNA Sequencing:** Next-generation sequencing (NGS) high-throughput sequencing technologies enable

profiling of microbial communities in detail. These methods provide the ability to identify bacterial species in a sample, including challenging-to-culture bacteria.[8]

- **Polymerase Chain Reaction (PCR):** PCR amplifies defined DNA sequences and makes it easy to detect certain microorganisms or genes of interest. PCR is sensitive and may be used in degraded samples.[9]
- **Metagenomics:** This method entails direct examination of genetic material extracted from environmental samples, giving insights into microbial community functional potential. Metagenomics comes in handy when handling complex or unknown microbial communities.[10]
- **Bioinformatics:** With the generation of a huge amount of data through sequencing, bioinformatics computational tools come into play to analyse the data. Bioinformatics pipelines help with genome assembly, gene annotation, and comparison of microbial communities among samples.[11]

Challenges in Forensic Microbiology

Though forensic microbiology has tremendous potential, some challenges still exist:

- **Standardization:** Standardized methods of sample collection, analysis, and interpretation are essential to make microbial evidence acceptable in a court of law. Differences in methodology can cause varied results, diluting the validity of the evidence.[12]
- **Environmental Factors:** Temperature, humidity, and soil structure can affect microbial communities, possibly making results confusing. Knowledge of such variables is critical for the interpretation of accurate data.[7]
- **Ethical Considerations:** The application of microbial information has privacy implications, which necessitate ethical standards to safeguard people's rights. For example, the comparison of individual microbiomes might inadvertently expose sensitive health data.[13]
- **Legal Acceptance:** The comparatively recent use of microbial evidence in criminal trials implies that its acceptance in courts is still in development. The establishment of credibility and reliability of forensic microbiology is vital for its incorporation in the justice system.[13]

Though there are challenges, with the help of updated technology and the vast microbial genetic information there are huge opportunities to explore the role of the microbes in supporting the forensic evidences, also with emerging of the AI tools the possibilities are tremendous.

REFERENCES

1. Ventura Spagnolo E, Stassi C, Mondello C, Zerbo S, Milone L, Argo A. Forensic microbiology applications: A systematic review. Leg Med (Tokyo). 2019;36:73-80
2. Arora A. Contemporary forensic medicine. J Indian Acad Forensic Med. 2023 ;46 (1):2
3. Franceschetti L, Lodetti G, Blandino A, Amadasi A, Bugelli V. Exploring the role of the human microbiome in forensic identification: opportunities and challenges. Int J Legal Med. 2024;138(5):1891-1905
4. Dash HR, Das S. Thanatomicrobiome and epinecrotic community signatures for estimation of post-mortem time interval in human cadaver. Appl Microbiol Biotechnol. 2020;104(22):9497-9512
5. Khan AS, Amara PS, Morse SA. Forensic public health: epidemiological and microbiological investigations for biosecurity. Microbial Forensics. 2020;105-122
6. Dixon R, Egan S, Payne M, Mullally C, Chapman B. Bacterial transfer during sexual intercourse as a tool for forensic detection. iScience. 2025;28(2):111861. Published 2025 Feb 12
7. Jillian E. Malbrough, Kelly M. Elkins,Chapter 19 - NGS profiling of water and soil microbial DNA in forensic science,Editor(s): Hirak Ranjan Dash, Kelly M. Elkins, Noora Rashid Al-Snan,Next Generation Sequencing (NGS) Technology in DNA Analysis,Academic Press,2024, 375-385
8. Hu T, Chitnis N, Monos D, Dinh A. Next-generation sequencing technologies: An overview. Hum Immunol. 2021;82(11):801-81
9. Khehra N, Padda IS, Swift CJ. Polymerase Chain Reaction (PCR). In: StatPearls. Treasure Island (FL): StatPearls Publishing; March 6, 2023
10. Zhang L, Chen F, Zeng Z, et al. Advances in Metagenomics and Its Application in Environmental Microorganisms. Front Microbiol. 2021;12:766364
11. Pereira R, Oliveira J, Sousa M. Bioinformatics and Computational Tools for Next-Generation Sequencing Analysis in Clinical Genetics. J Clin Med. 2020;9(1):132
12. Nodari R, Arghittu M, Bailo P, et al. Forensic Microbiology: When, Where and How. Microor-ganisms. 2024;12(5):988
13. Cecile Melisse Ponce de Leon-Derecho, Genevieve Dable-Tupas,Chapter 13 - Ethical considerations in microbiome research,Editor(s): Genevieve Dable-Tupas, Rohini Karunakaran, Peter Paul C. Lim, Maria Catherine B. Otero,Human Microbiome Drug Targets,Elsevier,2025,Pages 179-188

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00032.6

Original Research Paper

Deaths Due to Hanging – A Two-year Retrospective Study of Cases from North India

1. **Ankita Dhull,** PG JR1*
2. **Amandeep Singh,** Professor*
3. **Nikhil Mehta,** Assistant Professor*
4. **Dasari Harish,** Professor and Head*

*Department of Forensic Medicine & Toxicology, Government Medical College & Hospital, Chandigarh

ABSTRACT

Introduction: Hanging is one of the most common methods used for suicide throughout the world. In this study we did a comprehensive analysis of the cases of death due to hanging, brought to a tertiary care center, for postmortem examination. A 2-year retrospective study was conducted at our institute using the actual data of the post-mortem reports from 1st January 2022 to 30th 31st December 2023. All the cases which presented with a ligature mark were chosen for the present study. A total of 1758 postmortems were conducted during the study period, of which cases of hanging were 87. Of these, most were of age group of 21 – 30 years (42.5%). Males were involved in almost two thirds of the cases. Most of the victims were in private service (28.7%), followed by laborers (19.5%). In most of the cases, the deceased preferred his/ her own residence, & closed space was preferred over open area. In most of the cases, ligature material used was a 'chunni' (35.6% and the ceiling fan was the favored point of suspension (78 %). Postmortem examination of the cases was performed within 24 hours in 57.5 % of cases. Married males preferred suicide by hanging, as compared to unmarried males. In all the cases, hyoid bone was found to be intact. Complete hanging was seen in almost 80 % of the cases. Viscera was sent in all the cases to rule out any concomitant intoxication, but reports are still awaited in most cases. The incidence rate of hanging was 4.9% in our study.

Corresponding Author :
Dr. Amandeep Singh, Professor
Department of Forensic Medicine & Toxicology,
Government Medical College & Hospital, Chandigarh
E-mail: dramandeep@gmail.com
Contact : +919646121610

Article History:
Received: 29 November 2024
Received in revised form: 15 January 2025
Accepted on: 15 January 2025
Available online: 15 April 2025

Keywords: Hanging, Suicide; Postmortem Examination; Ligature Mark; Ligature Material; Retrospective Study.

INTRODUCTION

Hanging is a form of violent asphyxia death caused by suspension of the body by a ligature encircling the neck such that the constricting force is the weight of the Indumal's body or a part of it.[1] It is the method of capital punishment in India. Hanging is one of the most common methods used for suicide, throughout the world. While there are other ways to end one's life, hanging oneself is preferred because it causes pain for a very short interval of time. Hanging is considered to be suicidal, until the contrary is proved.[2] Homicide by hanging is very rare in adults, unless the victim is under influence or unconscious due to some other reason. However, hanging may be simulated after a murder to confuse the investigative agencies. Accidental hanging may occur in infants (crib deaths) or in children during certain 'role play' games or in cases of autoerotic hanging, in adults.

The cause of death could be asphyxia, venous congestion, cerebral ischemia or fracture of cervical vertebra, etc. In our study, it was asphyxia in all the cases.

History of the incident is very important especially to know: Type of hanging - complete/ partial, location (indoor or outdoor), ligature material (such as chunni, turban fabric, rope, steel wire, muffler, etc.); other circumstantial evidence found, etc. The reasons for suicide are numerous, however the important ones are: personal issues, fight with spouse, or friends, relationships issues, depression, alcoholism, or other addictions, financial issues, unemployment, etc.

MATERIAL AND METHODS

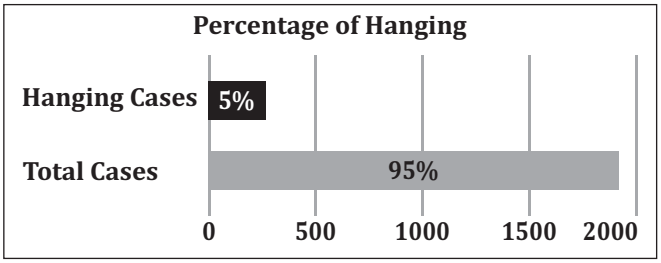
A 2-year retrospective study was performed at the

mortuary of GMCH, Chandigarh by perusing the post-mortem reports from 1st January 2022 to 31st December 2023. Data regarding the incident, type of ligature material used, circumstances, demography, type of hanging, dribbling of saliva, suspension point, whether hanging was typical/ atypical, level of ligature mark, reasons for hanging, time between death and post-mortem examination etc, were noted from the reports and the police papers. Care was taken to peruse the available documents thoroughly so as not to confuse the artefact with the antemortem finding. A total of 1758 dead bodies were received for postmortem examination at the mortuary of the department, of which 87 cases presented with a ligature mark. Usually ligature mark represents both strangulation and hanging but after considering the detailed history, findings, and the opinions given in each report, we concluded that all the cases were of hanging.

OBSERVATIONS AND RESULTS

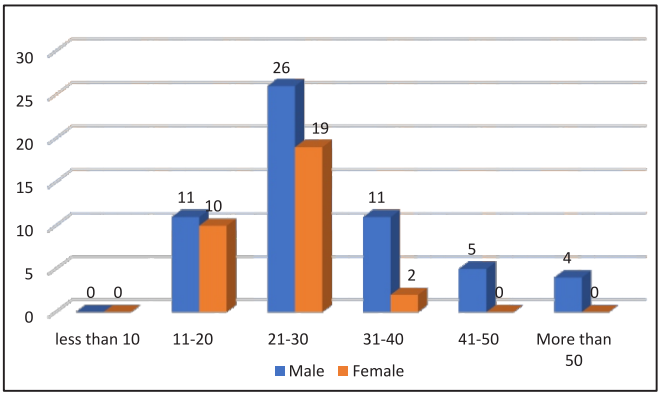
A total of 1758 postmortems were conducted during the study period, of which, the cases of hanging concluded to be 87 as shown in the given chart **(Figure No 1)**.

Figure 1: Percentage of Hanging Cases Conducted During the Study Period



As shown above **(Figure No. 2)**, majority of the cases were of the age group 21 to 30 years (42.5 %), followed by 11 to 20 years (22.9%); least cases were from the > 50 years group (2 cases).

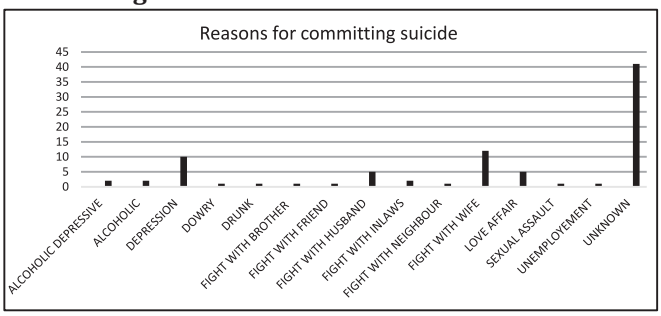
Figure 2: Showing Distribution of Cases According to the Age Groups



The most common occupation among the cases of death due to hanging was private service (30, 34.4%), followed by students (14, 16%) laborers (13,14.94%), house wives/ unemployed (9 each, 20.6%), etc.; while the occupation of 12 (13.7%) victims was not known.

Our study shows that the majority of the victims committed suicide because of personal issues 34%; followed by fight with spouse, 14%; depression, 12%; alcoholism/ financial issues, 10% each; relationship issues, 7% **(Figure 3)**.

Figure 3: Showing Number of Reasons for Committing Suicide

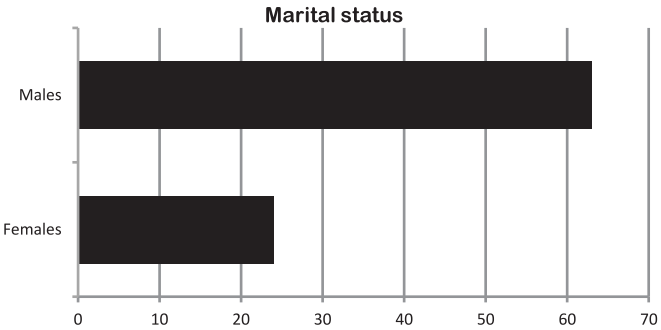


Majority of the cases of hanging taken up for postmortem examination at the mortuary of the institute were from Chandigarh, (62 cases,71.26 %), followed by Punjab (20 cases, 22.9%) and Uttar Pradesh (5 cases,5.74%).

Advance decomposition changes were present in only two cases whereas it was absent in rest of the cases.

Married males were involved in almost two third of the cases, 63.7% and females in 24.3%. **(Figure No. 4)**

Figure 4: Showing Distribution of Cases According to Marital Status



In majority of the cases, ligature material used was a 'Chunni', in 55.6% cases, Rope, 13% cases, Saree, 6 % cases and Parna, in 1% cases. **(Figure No. 5)** the ligature material was soft in 85 % cases.

The most common place chosen by the deceased, for hanging themselves was their own residence 94.3%. Again, the most common suspension point chosen for hanging was the ceiling fan, 78% cases; followed by the grill of the

window, 6%; iron rod, 5%; and tree in 3% of the cases. **(Figure 6)**

Figure 5: Ligature Material Used by the Deceased

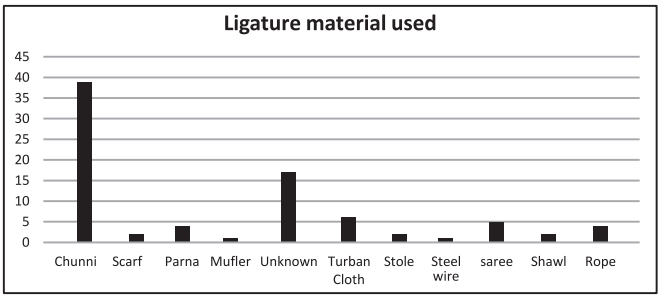
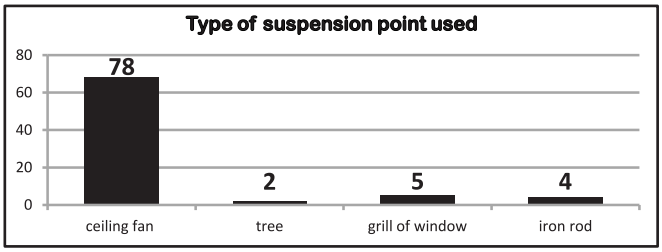


Figure 6: Suspension Point used for Hanging



In our study it was observed that the post-mortem examination was conducted within 24 hours of the death, 85% cases.

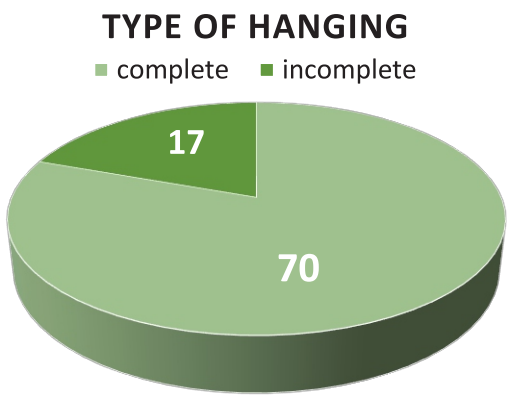
The ligature mark was above the level of thyroid in 56% of the cases; and at the level of the thyroid in 34% of the cases.

The material preferred was soft material such as chunni in 84.5% of the cases as compared to hard material like rope in 16.5%. The ligature mark was found to be the thickest below the level of mastoid (59% cases) and thinnest and deepest, below the chin (31% cases) whereas in rest of the 10% cases it was found on the other landmarks.

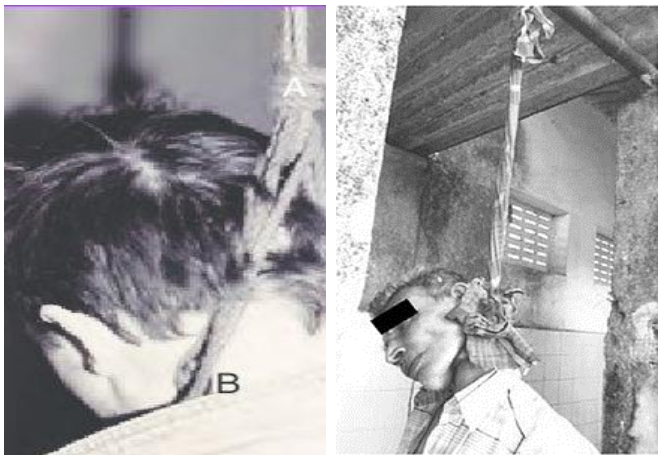
Complete hanging was seen in 80.4% of the cases, and incomplete/ partial in the rest, 19.6%. **(Figure: 7)**

Among the cases of partial hanging, feet were found touching the ground in 7 cases (8%), deceased was sitting/ lying down prone in 6 cases (6.89%) and kneeling in 4 cases (4.59%).

Figure 7: Distribution of Cases Depending Upon Type of Hanging



Typical hanging was seen in 71.3% and atypical in 28.7% of the cases. **(Figure 8)**



The condition of hyoid bone and thyroid cartilage was noted to be intact in 52 (60%) cases. Petechial haemorrhages in the eyes, lining of the mouth (lower lip) in Platysma and Sternomastoid muscle were also present, indicating asphyxia. Ecchymosis of neck was present in 10 cases (11.49%). Larynx and trachea were congested in all the cases.

Routine viscera were sent in all the cases to rule out the concomitant intoxication and the reports are still awaited.

DISCUSSION

Suicide is a self-directed action with a lethal result.[3] Hanging is, usually, a highly spontaneous act in which the victim catches hold of whatever ligature material, point of suspension, etc. is available to him or her in order to complete the act. Asphyxia fatalities resulting from constriction of the neck are widespread worldwide; nonetheless, a detailed structural assessment of the neck is crucial to verify whether the case is actually of hanging or not. This is so because the difference between hanging and strangulation is minimal. If we cannot differentiate, then ligature strangulation, which is homicidal, can be passed off as hanging, which is suicidal.

Along with asphyxia and cerebral anoxia, vagal inhibition and carotid sinus pressure, or a combination of both, have been reported as the causes of death in complete suspension, while, in the majority of partial suspension cases, the mechanism of death appears to originate from airway/ vascular blockage.

In our study, the incidence of hanging is 4.9 % of the total medicolegal postmortem examinations conducted by the department during the period of study, which is in consonance with the study by Patel A P, 4.7%.[3] Majority of the victims were in the age group of 21 to 30 years, 42.5%, while Amandeep et al. observed it to be 59.2%, in the age group of 15 to 25 years,[4] and Azmak D. et al. reported that the maximum cases, 20.8% in their study, were within the 30 to 39 year age group.[5]

Nearly 94 % victims in our study preferred closed places, mainly their own homes, with their family members often at home. In 71.3 % of the cases in the study by Sharija et al. closed spaces, with only 5% of the victims committing suicide by hanging themselves from the braches of a tree.6 In the present study, complete hanging was seen in 81.5% of the cases, in accordance with the study conducted by T. Saisudheer and M Ahmed.[6-7]

As regards the breadth of the ligature mark below the mastoid region, in our study, in 59 % cases it was 4cm, while in the observations of the other researchers,[8-10] the breadth was found to be 1-2cm. The breadth of the ligature mark depends on the material used and how many times it is wrapped around the neck also matters.

Our study revealed that most of the victims committed suicide due to personal issues, 34%; depression, 12 %; alcoholism, 10%; and relationships issues, 7 %. Similar observations were made by Patel AP.3 In present study, Chunni was most commonly used soft ligature material 35.6%, as it is easily available in all Indian households, but the study done by Naik S k et al found that scarf was the most common ligature material used.[11-12]

CONCLUSION

The incidence of hanging is 4.94% in our present study. Hanging remains a significant method of suicide, often chosen spontaneously with readily available ligature materials. The incidence of hanging in our study aligns with previous research, with a notable prevalence among young adults aged 21 to 30 years. The majority of hangings occurred in closed environments, predominantly within the victims' homes, mirroring findings from other studies. The breadth of ligature marks varied, with our study noting broader marks compared to others, likely due to the different materials used. The primary motivations for hanging included personal issues, depression, alcoholism, and relationship problems. This study underscores the need for enhanced mental health support and intervention strategies to address the underlying causes of suicide in the population. Internal neck findings in hanging cases often include crucial indicators that help distinguish between suicidal hanging and homicidal strangulation. Typical injuries includes haemorrhages in the neck muscles, which result from the constriction of the neck. Petechial haemorrhages in the eyes and lining of the mouth can also be present, indicating asphyxia. These internal findings, along with the external ligature marks, provide critical forensic evidence to accurately determine the cause and manner of death. Additionally, there is a critical need for thorough forensic examinations to accurately distinguish between suicidal hanging and homicidal strangulation as in suicidal hanging history of previous attempts would be present and is usually partial in nature.

REFERENCES

1. Guhraj PV. Forensic Medicine. Ed: Chandran MR. Orient Longman, New Delhi. 2nd Ed. 2003: 175-81.
2. Modi JP. Medical jurisprudence and toxicology. Matiharan K & Patnaik KP Eds. Lexis Nexis Publishers. New Delhi 23rd Ed. 008:555-614
3. Patel, AP, Bansal A, Shah J, Shah KA. Study of hanging cases in Ahmedabad. Jour Ind Acad Forensic Med 2012;34:342-5.
4. Singh A, Gorea RK, Dalal JS, Thind AS, Walia D. A study of demographic variables of violent asphyxial death. Jour Punjab Acad Forensic Med Toxicol 2019;3:22-5.
5. Azmak D. Asphyxial deaths: a retrospective study & review of the literature. Am J Forensic Med Pathol 2006;27(2):134-44.
6. Sharija J. Epidemiological profile of suicide by hanging in southern parts of kerala: an autopsy based study. Jour Ind Acad Forensic Med 2023;(5):233-6.
7. Ahmad M, Hossain M. Hanging as a method of suicide: retrospective analysis of postmortem cases. Jour Armed Forces Medical College, Bangladesh 2011;6(2):37–9.
8. Ambade VN, Tumram N, Meshram S, Borkar J. Ligature material in hanging deaths: neglected area in forensic examination. Egyptian Jour Forensic Sciences 2015;5(3):109-13.
9. Uche NA. Suicide or homicide? forensic investigation of death of a 19 year old female by hanging. Int J Community Res 2020;9(1):27-32.
10. James R, Silcocks P, Suicidal hanging in Cardiff, a 15-year retrospective study, Forensic Sci Intl 1992;(56)2:167-75.
11. Raghavendra BR, Chavan KD, Devadoss S, Vijayanath V. Study of Ligature Mark in hanging cases in Bangalore East Region. J Indian Acad Forensic Med. 2016;38(1):18-20.
12. Naik SK, Patil DY. Fracture of hyoid bone in cases of asphyxial deaths resulting from constricting force round the neck. Jour Ind Acad Forensic Med 2005;27(3):149-53

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00033.2

Original Research Paper

Effect of Buccal Swab Storage Duration on DNA Levels and Purity Through STR-Codis Locus Examination

1. **Wiwin Ida Nur Sri Wahyuni,** Department of Forensic Medicine and Medicolegal, Faculty of Medicine Universitas Airlangga, Surabaya, Indonesia
2. **Ahmad Yudianto,** Department of Forensic Medicine and Medicolegal, Faculty of Medicine Universitas Airlangga, Surabaya, Indonesia & Forensic Science Study Program, Graduate School of Universitas Airlangga, Surabaya, Indonesia
3. **Galih Endradita,** Department of Forensic Medicine and Medicolegal, Faculty of Medicine Universitas Airlangga, Surabaya, Indonesia
4. **Meivy Isnoviana,** Faculty of Medicine Wijaya Kusuma University, Surabaya, Indonesia

ABSTRACT

Introduction: Specimens for DNA examination are venous, arterial and capillary blood, in addition to sperm, vaginal swabs, buccal swabs and bones. Buccal swab examination can be a good option, comfortable, and relatively easier to perform. The FBI published 13 loci for DNA identification test. Among STR markers, tetranucleotide repeats are more popular.

Materials and Method: This is a laboratory experimental research using times series method, from March 2022 to April 2022 at the Forensic Medicine Installation of Dr Soetomo Hospital and the Human Genetics Laboratory of the Tropical Disease Institute, Airlangga University, Surabaya. Population were samples of buccal swab from bodies caused by natural causes death from inpatient installations. The research samples were stored in the refrigerator on the 7th, 20th and 40th day. Kruskal Wallis and the Mann Whitney test were used.

Results: The highest and lowest mean of DNA purity was found on day 40 (1.62 µg/dl) and day 1 (1.52 µg/dl), respectively. The highest and lowest mean of DNA quantity was found on the 7th day (158.12 µg/dl) and 20th day (112.53 µg/dl). There is no significant difference in the DNA quantity ($p = 0.761$) and DNA purity ($p = 0.483$) based on the storage time. There was no influence on the length of storage on the quality of DNA according to CODIS STR locus. In this study, D12S391, D2S441, D10S1248, D1S1656, D22S1045, and D2S1338 loci were evaluated.

Discussion: DNA amplification requires DNA purity (λ260 / λ280 ratio 1.5 – 2), DNA content, and adequate quality of the DNA. The six loci were chosen as recommended by the FBI with their high discriminatory power. DNA degradation is mostly caused by environmental exposure. Other causes are short chromosome loci and the telomerase process.

Conclusion: There was no association between the duration of buccal swab storage on the quality of DNA according to the STR locus examination.

Corresponding Author :
Dr. Wiwin Ida Nur Sri Wahyuni, Department of Forensic Medicine and Medicolegal, Faculty of Medicine Universitas Airlangga, Surabaya, Indonesia
E-mail: wiwinidans@gmail.com
Contact : +6281234308969

Article History:
Received: 27 December 2024
Received in revised form: 25 December 2024
Accepted on: 25 December 2024
Available online: 15 April 2025

Keywords: Buccal Swab; Short Tandem Repeat; DNA Content; DNA Purity.

INTRODUCTION

Deoxyribonucleic acid (DNA) is a nucleic acid that stores all information about genetics. Every human has 23 pairs of chromosomes. DNA profiling or DNA fingerprinting is a method of evaluation for tissue or body fluids that identifies DNA from a certain individual, which is proven capable to distinguish individuals objectively.[1-2] Every nucleated cells can be used to test nuclear DNA (nDNA) and cells without nuclei can be used to test mitochondrial DNA (mtDNA). Nuclear DNA is the most accurate for DNA profiling.[3]

In general, specimens for DNA examination are venous, arterial and capillary blood, in addition to sperm, vaginal swabs, buccal swabs and bones.[4] Buccal swab examination can be a good option, comfortable, and relatively easier to perform. The identification process according to the 2009 Disaster Victim Identification (DVI) guidelines includes primary methods (fingerprints, dental comparison, DNA

analysis) and secondary methods (property methods, medical examination). Someone's identity is confirmed by at least 2 methods that provide positive results.[5]

The FBI published 13 loci for DNA identification test.[6] Short Tandem Repeats-Combined DNA Index System (STRs-CODIS) is a DNA repeat marker that is widely used because STR loci have small alleles.[7] Among STR markers, tetranucleotide repeats are more popular compared to dinucleotides or trinucleotides due to their narrow allele range.

Masjkur et al showed a decrease in DNA levels on days 1, 3, 5 and 7 when storing buccal swab samples at room temperature and in a refrigerator at 4°C. DNA damage causes irreversible damage to DNA hydrogen bonds, in addition to purine and pyrimidine bonds. DNA profiling is still possible to perform.[8] In a research by Hakim et al, buccal collector swab storage can be used as a storage medium for genetic DNA for 4 years at room temperature.[9]

Buccal swab is the easiest and most non-invasive method. Buccal swab DNA samples are expected to survive the storage process during the law enforcement process.[2] This research was aimed to determine the quality of buccal swab specimens for DNA examination during the storage process in the refrigerator. We hypothesize that there is an influence on the length of storage of buccal swabs on DNA quality based on CODIS STR locus.

MATERIALS AND METHOD

This is a type of laboratory experimental research using times series, which is a method used to determine the effect after treatment in a study. The research was conducted from March 2022 to April 2022 at the Forensic Medicine Installation of Dr Soetomo Hospital and the Human Genetics Laboratory of the Tropical Disease Institute, Airlangga University, Surabaya.

The population of this study consisted of buccal swab samples collected from bodies of individuals who died of natural causes in inpatient installations. The samples were obtained in the forensic examination room at Dr. Soetomo Hospital, Surabaya, between March and April 2022. The research samples were taken from buccal swabs from bodies which were stored in the refrigerator on the 1st, 7th, 20th and 40th day. Meanwhile, samples from lysed tissues and bodies that died due to COVID-19 or other infectious diseases were excluded. According to sample calculations, a minimum of nine samples was required.

The independent variables consist of refrigerator temperature, storage time for buccal swabs, and bodies that died due to natural causes. Meanwhile, the dependent variable is DNA purity, DNA content, and STR-CODIS. Bodies that died due to natural causes are deaths that are related to disease and is not caused by accident, poisoning, suicide, or murder according to medical records. Refrigerator temperature is described in Celsius and storage time in hours. The quality of DNA isolation is measured by DNA content using a UV Visible Spectrophotometer. STR-CODIS is a DNA sequence, which is included as a DNA analysis locus by the FBI in 2017, which was measured by Gene Ampr. PCR System 9700 thermal cycle, Promega Corp 2001.

Swabs were performed on buccal of both sides and collected in DNAzol buffer solution. Samples were sent to the Human Genetic Institute Tropical Disease Laboratory, Airlangga University. DNA extraction was carried out using a UV spectrophotometer and then DNA quality was measured. PCR process was then carried out using STR primers on 7 new DNA loci. DNA amplification using PCR with an instrument inspection protocol using the gene ampr PCR system 9700 Thermal Cycler. Then electrophoresis was conducted with silver staining. Calculation of DNA quality using the DNA Levels table is based on the temperature and storage time of the buccal swab sample in the refrigerator. Calculation of buccal swab DNA detection using STR PCR is based on temperature, storage time in the refrigerator and detection of loci D1S1656, D2S441, D2S1338, D10S1248, D12S391, D19S433 and D22S1045.

An ANOVA analysis was done to evaluate the effect of storage time (days 1, 7, 20 and 40) at refrigerator temperature on the DNA quality of buccal swabs through examination of the CODIS STR locus. Initially, normality test was carried out using Shapiro Wilk statistics. However, as data was not normally distributed, Kruskal Wallis and the Mann Whitney test were used instead.

RESULTS

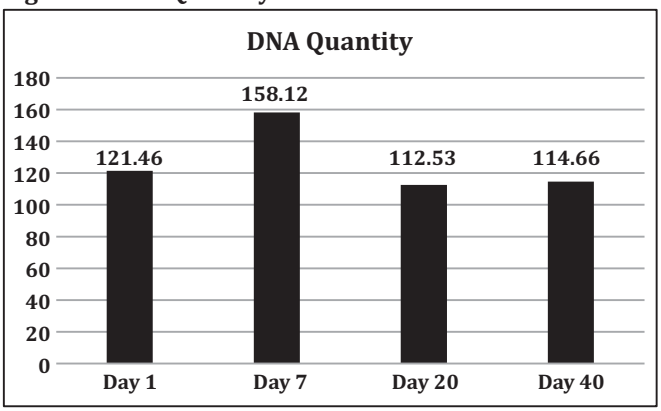
The highest average DNA quantity of buccal swab was found on the 7th day of storage with 158.12 µg/dl while the lowest average DNA quantity on the 20th day of storage with 112.53 µg/dl **(Table 1)**. There was an increase in terms of average DNA quantity on day 7, followed by a decrease on day 20, then increase again on day 40 **(Figure 1)**.

The highest mean DNA purity was found on day 40 of storage, namely 1.62 µg/dl and the lowest mean DNA purity was found on day 1 of storage, namely 1.52 µg/dl

Table 1: Mean of DNA Quantity in Buccal Swabs of Bodies at Refrigerator Temperature

Storage Time	Mean DNA Quantity (µg/dl) ± SD
Day 1	121.46 ± 79.30
Day 7	158.12 ± 173.08
Day 20	112.53 ± 108.76
Day 40	114.66 ± 81.72

Figure 1: DNA Quantity

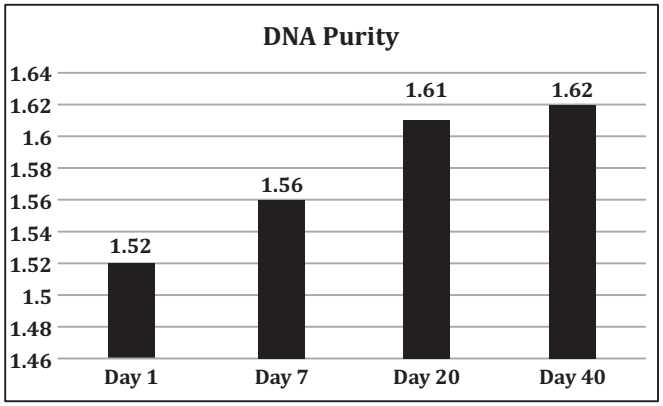


(Table 2). There was an increase in the average DNA purity from day 1 to day 40 and there was no decrease **(Figure 2)**.

Table 2: Mean of DNA Purity in Buccal Swabs of Bodies at Refrigerator Temperature

Storage Time	Mean DNA Purity (µg/dl) ± SD
Day 1	1.52 ± 0.14
Day 7	1.56 ± 0.18
Day 20	1.61 ± 0.11
Day 40	1.62 ± 0.11

Figure 2: DNA Purity



Shapiro-Wilk normality test on the DNA quantity data on day 1 showed a normal distribution, while the DNA quantity on days 7, 20 and 40 had an abnormal distribution. DNA purity on days 1, 7 and 40 had a normal distribution, while DNA purity data on day 20 had an abnormal distribution. This research data is homogeneous.

The p value for DNA quantity was 0.761, which indicated that there was no significant difference in the DNA quantity of buccal swab based on the storage time on days 1, 7, 20 and 40 with refrigerator temperature. There was a slight mean difference which was not significant, where the highest levels were on the 7th day of storage while the lowest levels were on the 20th day of storage.

On the other hand, the p value of the DNA purity was 0.483, indicating that there was no significant difference in the DNA purity of buccal swabs based on the length of storage on days 1, 7, 20 and 40 with the refrigerator temperature. The highest mean was found on the 1st day of storage, while the lowest level was on the 40th day of storage. This difference was also not significant statistically.

According to Mann Whitney test, there is no significant difference in DNA quantity and DNA purity between each storage group on days 1, 7, 20 and 40. So it was concluded that there was no influence on the length of storage of buccal swabs on the quality of DNA by examining the CODIS STR locus.

Table 3: Mann-Whitney U Test for DNA Quantity

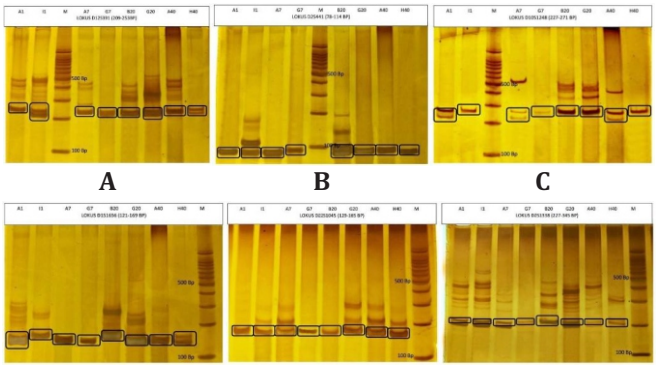
Comparison (Days)		Sig	Conclusion
	7	0.508	There is no significant difference
1	20	0.354	There is no significant difference
	40	0.965	There is no significant difference
7	20	0.825	There is no significant difference
	40	0.627	There is no significant difference
20	40	0.354	There is no significant difference

Table 4: Mann-Whitney U Test Output for DNA Purity

Comparison (Days)		Sig	Conclusion
	7	0.452	There is no significant difference
1	20	0.250	There is no significant difference
	40	0.184	There is no significant difference
7	20	0.723	There is no significant difference
	40	0.596	There is no significant difference
20	40	0.288	There is no significant difference

Examination of several loci using the STR method is required to identify individuals. In this study, D12S391, D2S441, D10S1248, D1S1656, D22S1045, and D2S1338 loci were evaluated because they have high discriminatory power and have not been explored much. Figure 3 shows

the results of PCR amplification of the six loci tested (A-F) on buccal swab samples of the bodies through examination of the STR locus with storage periods of 1, 7, 20 and 40 days with a refrigerator temperature ranging from 4 to 12 degrees Celsius. There is different size of the DNA band seen every sample **(Figure 3A-F)**.



A B C

D E F

DISCUSSION

DNA purity is one of the requirements for PCR amplification. DNA is considered to be pure if the λ260 / λ280 ratio ranges from 1.5 – 2 (ideally 1.8 – 2). When the DNA purity is less than 1.5, it means that DNA isolation contains more protein, while if the result is more than 2, it means that DNA isolation contains more RNA.[10]

Our findings which are obtained from sample buccal swab of the bodies through examination of the STR locus with storage periods of 1, 7, 20 and 40 days with a refrigerator temperature ranging from 4-12°C with DNA purity ranges from 1.27 – 1.85. With these results, the DNA purity requirements for DNA amplification have been met. DNA purity in this study keep increasing each day, on day 1, 7, 20, and 40 was 1.52; 1.56; 1.61; and 1.62, respectively.

The following requirement is DNA content. Amplification process using STR PCR requires DNA levels of 0.5-2.5 ng/µL.[11] In this study, the average levels were obtained from buccal swab sample of the bodies with storage time on day 1, 7, 20 and 40 ranges between 112.53 –158.[12] ng/µL. There was a significant increase in DNA levels and purity. This is influenced by storage in the refrigerator temperature of 4-12°C. Low temperatures may inhibit DNA degradation thus it can be stored for examination at a later date.12 Imran Tarique et al explains that samples stored at -20°C for 24 hours had higher DNA concentration compared to samples stored at -4°C which is stored for 48 hours. This research suggested that the role of temperature is strongly affecting DNA levels and purity. [13]

DNA amplification using PCR will produce adequate DNA bands if the level and purity of the DNA is of good quality. DNA quality defined as adequate if the DNA is not completely degraded. Another influencing factor was the sampling method which was not performed simultaneously which may lead to different results.

Factors that Influence DNA Degradation Include:[14]

a. Endogenous (factors originating from within the cell): Cell damage begins with the process of autolysis and decay, followed by process of aerobic decomposition.

b. Exogenous (factors originating from the environment): These include temperature and humidity.

Due to the influence of external factors, DNA damage can be classified into 2 types as follows:[15]

a. Type 1: DNA degrades longer and more slowly and generally due to chemical processes.

b. Type 2: DNA degrades more quickly and generally due to humidity, high temperatures, and sunlight.

In addition to DNA content, the adequate quality of the DNA is also necessary to consider. Adequate quality is a condition where DNA is not degraded. DNA that is severely degraded will result in failed primer attachment (annealing) to the DNA target which is going to be amplified.[16] High levels of DNA do not necessarily produce good visualization of PCR amplification. Where DNA quality is poor, DNA bands are short and produce unclear visualization PCR products.

The PCR visualization results were analyzed descriptively, by looking at the presence of DNA bands that matched the size of the STR PCR product for each locus. The STR loci used in this study were D12S391, D2S441, D10S1248, D1S1656, D22S1045, and D2S1338. These six loci were chosen because these are new loci found on autosomal chromosomes and are recommended by the FBI in STR examinations and have high discriminatory power **(Table 5)**.[17]

Table 5: Size of PCR Product

Locus	PCR product size (bp)	Frequency of appearance of DNA bands (%)
D12S391	209-253 bp	100
D2S441	78-114 bp	100
D10S1248	227-271 bp	100
D1S1656	121-169 bp	100
D22S1045	129-165 bp	100
D2S1338	227-345 bp	100

PCR visualization results from the six loci above show the appearance of all DNA bands. However, there are some PCR visualizations that are unclear or thin due to degradation. DNA degradation is mostly caused by environmental exposure, including high temperature and humidity.[18] Other causes are short chromosome loci and the telomerase process. It is a natural process of shortening of the chromosomes ends. The ends of these chromosomes are non-coding nucleoprotein structures called telomeres.[19] Telomeres consist of hexanucleotide sequences rich in guanine (TTAGGG in vertebrates).[20]

Telomeres are important for the maintenance of chromosome stability by protecting chromosome ends from recombination, fusion, and degradation. Therefore, loss of telomere function is likely to have profound effects on chromosome maintenance and integrity. Several studies suggest that telomere length is related to the replication capacity of eukaryotic cells. It has been proven that there is a cause-and-effect relationship between telomere shortening and human cell replication due to the aging process, namely that the life span of fibroblasts and epithelial cells can be extended by lengthening telomeres. In contrast to normal somatic cells, cancerous cells have delayed cellular aging by lengthening telomeres and thereby having unlimited replication capacity. The natural process of telomerase in autosomes causes chromosome shortening, so that the coding area also shortens. This can cause the primer to not attach because the DNA template size does not match the amplicon size.[20]

DNA damage due to high temperatures can break hydrogen bonds between pairs of nitrogen bases (purines and pyrimidines) in the DNA chain. Purines and pyrimidines are the main components of the chemical structure of DNA, where adenine pairs with thymine and guanine always pairs with cytosine. The destruction of this hydrogen bond is irreversible. This results in the visualization of damaged DNA being PCR amplified with poor visualization of the PCR product.[21]

CONCLUSION

DNA isolation from buccal swab of bodies through evaluation of the STR locus with storage times of 1, 7, 20 and 40 days with refrigerator temperatures ranging from 4-12°C showed varying DNA levels and purity. The level and purity of DNA increases as refrigerator storage stabilize the sample, therefore not easily degraded. After reviewing all the factors, it was concluded that there was no association between the duration of buccal swab storage on the quality of DNA according to the STR locus examination.

REFERENCES

1. Manasatienkij C, Ra-ngabpai C. Clinical Application of Forensic DNA Analysis: A Literature Review. J Med Assoc Thai. 2012 Oct 1;95(10):1357.
2. Aflanie I, Prastowo W, Roselina, Yudianto A, Koesbardiati T. Genetic variation analysis and kinship relationship between Dayak Ngaju tribe and Dayak Bukit tribe through examination of core DNA of Bukit CODIS STR Locus (combine DNA index system) 13 for the purpose of Forensic Identification. Indian J Forensic Med Toxicol. 2020 Jul 30;14(3):1094–7.
3. Yudianto A. DNA Touch dalam Identifikasi Forensik [Internet]. Scopindo Media Pustaka; 2020 [cited 2023 Dec 17].
4. Woo JS, Lu DY. Procurement, Transportation, and Storage of Saliva, Buccal Swab, and Oral Wash Specimens. Methods Mol Biol Clifton NJ. 2019;1897:99–105.
5. Emanuela DD, Dhanardhono T, Saebani S. PERBEDAAN KUANTITAS DNA YANG DIEKSTRAKSI DARI BUCCAL SWAB DENGAN JUMLAH USAPAN YANG BERBEDA. J Kedokt Diponegoro Diponegoro Med J. 2017;6 (2):443–50.
6. Karantzali E, Rosmaraki P, Kotsakis A, Le Roux-Le Pajolec MG, Fitsialos G. The effect of FBI CODIS Core STR Loci expansion on familial DNA database searching. Forensic Sci Int Genet. 2019 Nov; 43: 102129.
7. Hares DR. Selection and implementation of expanded CODIS core loci in the United States. Forensic Sci Int Genet. 2015 Jul;17:33–4.
8. Masjkur IN, Arfianti E, Yudianto A, Furqoni AH, Aâ€TMyun Q. The effect of temperature and storage time of cuccal swabs on FGA and D13S317 loci with the STR PCR method. J Teknol Lab. 2020 Dec 31;9(2): 192–8.
9. Hakim HM, Lalung J, Khan HO, Ismail SA, Aziz MY, Ishak AR, et al. Evaluation of long-term storage effects on buccal cell DNA from untreated cards for STR profiling. IOP Conf Ser Earth Environ Sci. 2020 Dec;596(1): 012009.
10. Tang W, David FB, Wilson MM, Barwick BG, Leyland-Jones BR, Bouzyk MM. DNA extraction from formalin-

fixed, paraffin-embedded tissue. Cold Spring Harb Protoc. 2009 Feb;2009(2):pdb.prot5138.

11. Sosiawan A, Yudianto A, Furqoni AH, Nzilibili SMM, Nuraini I. Full-sibling allelic frequency and sharing among Madurese: STR technique by 12 locus and the sex-typing amelogenin gene. Egypt J Forensic Sci. 2019 Dec;9(1):38.
12. Alrokayan S. Effect of Storage Temperature on the Quality and Quantity of DNA Extracted from Blood. Pak J Biol Sci. 2000 Mar 1;3.
13. Samoo IT, Khatri P, Bhutto B, Tariq M, Chandio I, Soomro M, et al. Effect of Temperature and Storage Time on DNA Quality and Quantity from Normal and Diseased Tissues. J Basic Appl Sci. 2017 Jan 5;13:203–6.
14. Karni M, Zidon D, Polak P, Zalevsky Z, Shefi O. Thermal degradation of DNA. DNA Cell Biol. 2013 Jun;32(6):298–301.
15. Yudianto A, Sispitasri YE, Margaret N. Analysis of Earphone Swab Mitochondrial DNA as an Alternative Material For Identification Examination. Folia Medica Indones. 2016;52(3):169–73.
16. Kusumadewi A, Kusuma SE, Yudianto A. Analisis DNA Jaringan lunak manusia yang terpapar formalin dalam interval waktu 1 bulan selama 6 bulan pada lokus D13S317 dengan metode STR-PCR. J Biosci. 2012;14(2):7.
17. Feng X, Li S, Liu H, Liu C, Zhang X, Wang H, et al. Validation of the PowerPlex Fusion 6C system: a six-dye STR system for forensic case applications. Aust J Forensic Sci. 2019 May 4;51(3):280–308.
18. Coble MD, Butler JM. Characterization of new miniSTR loci to aid analysis of degraded DNA. J Forensic Sci. 2005 Jan;50(1):43–53.
19. Hayflick L. The Future of Ageing. Nature. 2000 Dec 1;408:267–9.
20. Chakravarti D, LaBella KA, DePinho RA. Telomeres: history, health, and hallmarks of aging. Cell. 2021 Jan 21;184(2):306–22.
21. Abdel Hady RH, Thabet HZ, Ebrahem NE, Yassa HA. Thermal Effects on DNA Degradation in Blood and Seminal Stains: Forensic View. Acad Forensic Pathol. 2021 Mar;11(1):7–23.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00034.9

Original Research Paper

Age Estimation Using Orthopantomogram of Mandibular and Maxillary Second and Third Molars by Modification of Nolla's Method

1. **Ankita Dhull,** PG JR*
2. **Amandeep Singh,** Professor*
3. **Dasari Harish,** Professor and Head*
4. **Ajay Kumar,** Professor**

* Department of Forensic Medicine & Toxicology, Government Medical College & Hospital Chandigarh
**Department of Forensic Medicine & Toxicology, AIIMS Bathinda

ABSTRACT

Introduction: Dental age estimation is a crucial tool in forensic medicine used to determine an individual's approximate age based on dental development. It is particularly useful in legal cases, including rape, criminal abortion, and determining the eligibility of minors for specific activities. Orthopantomogram (OPG) is a non-invasive, cost-effective technique used to assess dental age. While Nolla's method has been widely used for individuals aged 17 years and below, our study extends its application to individuals above 17 years, focusing specifically on the 2nd and 3rd molars.

Materials and Methods: In this study, we assessed dental age using OPG among individuals above 17 years. Unlike Nolla, who analysed all eight teeth on either side of the jaw, we concentrated on the 2nd and 3rd molars of both jaws, preferably on the left side.

Results: Our findings revealed that chronological age closely matched the estimated age in the 17–23-year age group, showing minimal standard deviation (SD). However, greater SD was observed in individuals aged 12–17 years and 24–30 years. This indicates that our method is most accurate within the 17–23-year range.

Conclusion: The study validates the effectiveness of OPG-based dental age estimation, particularly for individuals aged 17–23 years. The preference for the 2nd and 3rd molars provided reliable age estimation even when the number of analysable teeth was limited.

Corresponding Author :
Dr. Amandeep Singh, Professor
Department of Forensic Medicine & Toxicology, Government Medical College & Hospital Chandigarh
E-mail: dramandeep@gmail.com
Contact : +919646121610

Article History:
Received: 11 January 2025
Received in revised form: 25 January 2025
Accepted on: 25 January 2025
Available online: 15 April 2025

Keywords: Nolla Staging; Orthopantomogram (OPG); Maxillary; Mandible; Teeth, Chronological Age.

INTRODUCTION

Dental age estimation is a process of assessing one's approximate age with the help of teeth and is a key research area in medical forensics. Age estimation is typically required by the court of law for legal purposes.[1] According to forensic viewpoints, environmental disturbances can change bone growth, which makes the approach of estimating age based on the maturity of the arm and wrist rather prone to error.[2] Among forensic clinicians, the most popular technique for determining age based on tooth growth is the panoramic X-ray or Orthopantomogram.[2] The Study Group on Forensic Age Diagnosis (AGFAD) recommended that three tests - a physical examination, an X-ray of the left hand, and an assessment of the dental development3 to be combined and carried out independently to improve diagnoses and increase the accuracy of age estimation. Permanent mandibular and maxillary second and third molars were chosen for this study, as they appear in the chosen age group. The method involves assessing the development of specific teeth, particularly the molars, which have well-defined stages of eruption and root development. Nolla identified several key stages that can be used to estimate the age of children and adolescents, typically ranging from birth to 16 years. Each stage corresponds to specific chronological ages, making it possible to generate a reliable age estimate based on dental morphology. Nolla's method has several advantages. Firstly, dental structures are often preserved even in degraded skeletal remains, allowing for analysis when other methods may fail. Secondly, teeth are less affected by environmental factors

that can alter the integrity of bones, leading to more reliable age estimates.

MATERIAL AND METHODS

This was a one-year Retrospective Study starting from 1st May 2023 to 30th April 2024 done on the patients who came to the dental OPD for regular oral checkup and have got their OPG's done. Study was done after taking due permission from Institutional Ethical Committee vide letter no. GMCH/IEC/2024/1162.

Inclusion Criteria:

- Patients who require OPG for any diagnostic or therapeutic purposes in the age group 12-30 years
- Patients giving valid age proof (Driving License, Birth certificate, 10th certificate, or Passport).

Exclusion Criteria:

- Patients with a history of dental caries, tooth extraction, previous dental repair, missing molar, or ectodermal dysplasia.
- Any OPGs showing pathology or deformity or previous dental procedure were not included in study

Sample Size: The sample size taken was 100.

Sample size calculation Sample size is calculated based on anticipated 50 percent accuracy of dental age estimation using Nolla's method with OPG. Based on confidence coefficient and 10 percent absolute precision sample size comes out to be 96. Keeping in view, unclear OPG's and impacted teeth, etc, a 10% extra sample size will be considered, making it 105. It will be a prospective, cross-sectional Study, conducted on patients coming to dental OPD for regular oral checkups. Written informed consent from the patients/ legal heirs of the patient or the guardian (Children) will be taken.

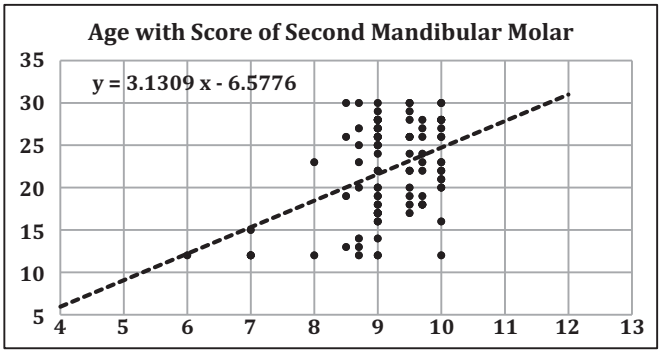
MATERIALS AND METHOD

With the help of Nolla's Staging using OPG only for second and third mandibular and maxillary molars scoring of various stages was done. As the developmental stage of the tooth falls between any of the two consecutive stages, 0.5 was added to the calculated score. As the radiograph showed a reading that was slightly greater than the illustrated grade but not as much as halfway between the stage and the next, the value 0.2 was added and as the development is slightly less than the grade indicated the value 0.7 was added. The total score was calculated by adding the stages for second and third mandibular and maxillary molars and regression curves for each was created from which, a regression formula was derived by plotting the total score on x- axis and Chronological age on y- axis. Then the estimated dental age was calculated by putting the corresponding values in the Regression Formula. Followed by the derivation of mean standard deviation of each molar.

OBSERVATION AND RESULTS

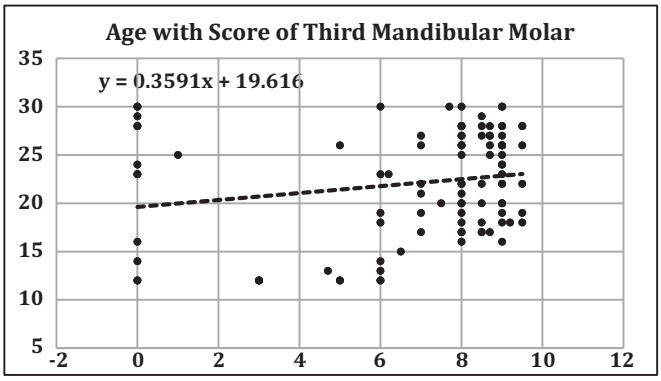
In our study, male to female ratio was 1:1. Distribution of cases according to age groups. According to sex. The results of the study are as follows: Mean score of second mandibular molar was 9.1 with mean chronological and calculated age of 22.12 years and mean standard deviation of +/- 2.18. **(Graph 1)**

Graph 1: Chronological Age is Plotted on the y Axis and Score is Plotted on the x Axis.



Mean score of third mandibular molar is 6.8 with mean chronological and calculated age of 22.12 years and mean standard deviation of +/- 2.4. **(Graph 2)**

Graph 2: Chronological Age is Plotted on the y Axis and Score is Plotted on the x Axis.



Mean score of second maxillary molar is 8.8 with mean chronological and calculated age of 22.2 years and mean standard deviation of +/-2.2 . **(Graph 3)**

Mean score of third maxillary molar is 6.0 with mean chronological and calculated age of 22.12 years and mean standard deviation of +/- 2.3. **(Graph 4)**

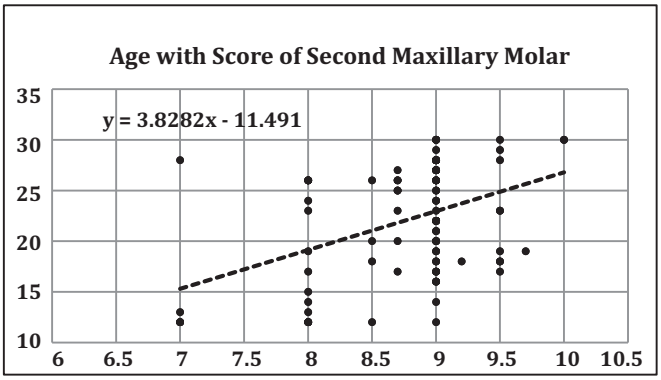
Mean score of total molars is 30.8 with mean chronological and calculated age of 22.2 years and mean standard

deviation of +/- 2.32. **(Graph 5)**

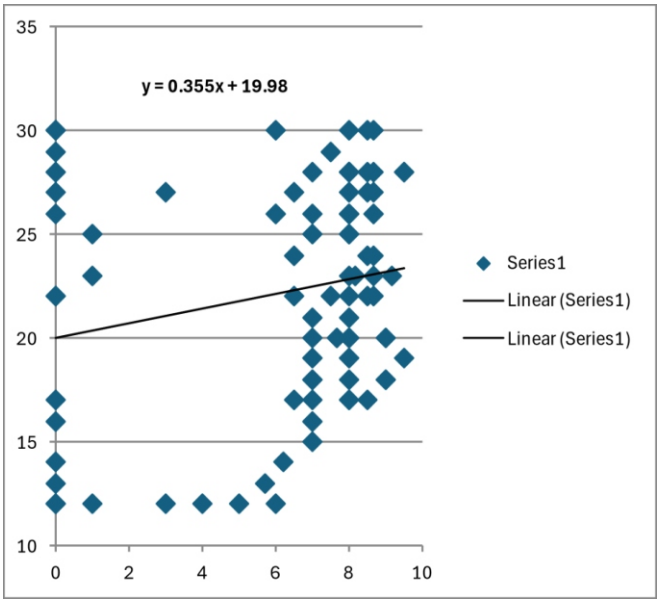
Mean score of total Maxillary molar is 14.7 with mean chronological and calculated age of 22.12 years and mean standard deviation of +/- 2.37. **(Graph 6)**

Mean score of total Mandibular molar is 15.9 with mean chronological and calculated age of 22.12 years and mean standard deviation of +/- 2.3. **(Graph 7)**

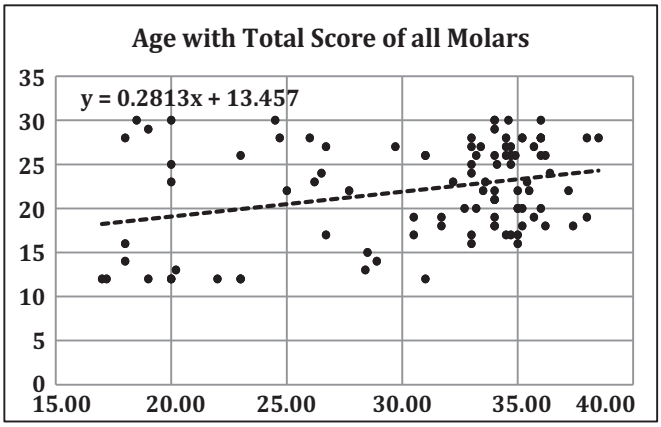
Graph 3: Chronological Age is Plotted on the y Axis and Score is Plotted on the x Axis.



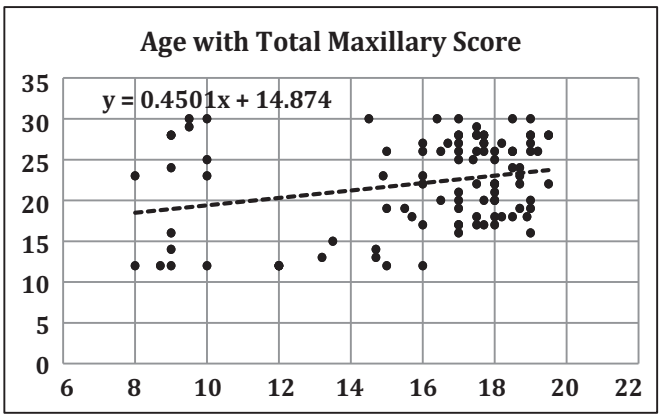
Graph 4: Chronological Age is Plotted on the y Axis and Score is Plotted on the x Axis.



Graph 5: Chronological Age is Plotted on the y Axis and Score is Plotted on the x Axis.



Graph 6: Chronological Age is Plotted on the y Axis and Score is Plotted on the x Axis.



Graph 7: Chronological Age is Plotted on the y Axis and Score is Plotted on the x Axis.

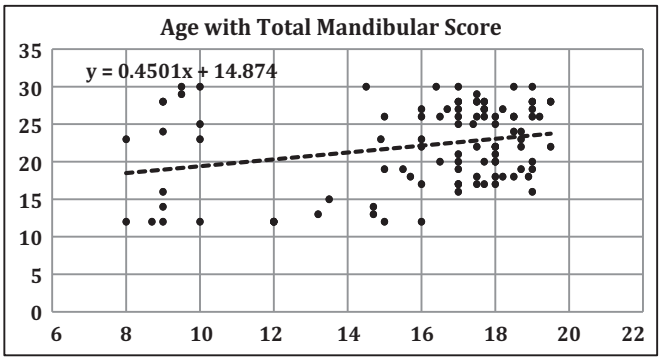


Table 1: Comparison between the Calculated Age and Actual Age of Various Teeth

Tooth	Mean Actual Age	Mean Score	Mean Calculated Age	Mean SD
2nd Mandibular	9.1	22.12	22.12	2.1
3rd Mandibular	6.8	22.12	22.12	2.4
2nd Maxillary	8.8	22.12	22.12	2.2
3rd Maxillary	6.0	22.12	22.12	2.3
Both Mandibular	16.0	22.12	22.06	2.3
Both Maxillary	14.7	22.00	22.12	2.3
Total	**30.8**	**22.12**	**22.12**	**2.3**

According to the above-mentioned table, least standard deviation is shown by second Mandibular tooth and maximum deviation is shown by third mandibular. Whereas, total deviation shown by both the Molars is 2.3 as compared to the actual age.

DISCUSSION

In our study, the relationship between chronological age and dental maturity was assessed through the scoring of second and third mandibular and maxillary molars. The male-to-female ratio was balanced at 1:1, minimizing potential sex-based bias, which ensures the representativeness of our findings.

For the second mandibular molar, the mean score was 9.1, corresponding to a chronological and calculated age of 22.12 years, with a standard deviation of +/- 2.18 years. This is consistent with findings from Singh et al. (2020),[3] who used Nolla's method for dental age estimation in North Indian children and found comparable results for mandibular second molars. The second mandibular molar is one of the first permanent molars to emerge, and its development has been well-documented in the context of age estimation.[3]

The third mandibular molar had a mean score of 6.8, with a standard deviation of +/-2.4 years, reflecting a later developmental stage and higher variability in eruption time. This variability in third molar development is consistent with studies by Paz Cortés et al. (2020)[4] and Demirjian et al. (1973),[5] who noted that third molars often exhibit more variation in their eruption times compared to earlier-erupting molars. The higher standard deviation observed in our study is likely due to genetic factors and nutritional differences influencing molar eruption patterns (Farhadian et al., 2019).[6]

For the second maxillary molar, the mean score was 8.8, corresponding to a mean chronological age of 22.2 years with a standard deviation of +/- 2.2 years. Maxillary molars tend to exhibit a slightly delayed eruption compared to mandibular molars, a pattern corroborated by Chaillet et al. (2005),[7] who found that maxillary teeth typically develop later than their mandibular counterparts. Additionally, the third maxillary molar showed a mean score of 6.0, with a standard deviation of +/- 2.3 years, suggesting a similar delayed eruption, which aligns with findings from Paz Cortés et al. (2019)[4] and Nandlal et al. (2014)[8] in Spanish and rural populations, respectively.

When considering the total scores for both mandibular and maxillary molars, we found that the total mandibular molar score was 15.9, and the total maxillary molar score was 14.7, with corresponding chronological ages of approximately 22.12–22.2 years. These findings reflect a trend in which mandibular molars are slightly more advanced in their development compared to maxillary molars, which is consistent with earlier research (Demirjian et al., 1973).[4] This pattern is significant, as it highlights the reliable use of molar scoring, especially mandibular molars, for age estimation in forensic contexts, as emphasized by Marques et al. (2015)[9] and Peiris et al. (2009).[10]

Moreover, the observed standard deviations (+/- 2.32 years for total molars and +/- 2.37 years for total maxillary molars) indicate substantial individual variation, underlining the complexity of dental age estimation and the need for methods that account for these differences. The slight variations observed in the results align with the findings of Yassin et al. (2020),[11] who also reported considerable variability in age estimation using Nolla's method across different populations. The results suggest that while there is a general trend in dental maturity corresponding to chronological age, factors like ethnicity, genetics, and environment contribute to the differences seen in individual cases (Nur et al., 2012).[12]

Our study supports the established understanding that molars, particularly mandibular molars, serve as reliable indicators for estimating chronological age. However, individual variations, as reflected in the observed standard deviations, emphasize the importance of considering both population-specific factors and the inherent variability of dental development. As noted by Maret et al. (2010)[13] and Mualla et al. (2020)[14], advancements in imaging techniques, such as cone beam computed tomography (CBCT), can further enhance the accuracy of age estimation methods. These findings underscore the critical role of dental age estimation in forensic science, highlighting the need for continued refinement of these methods to accommodate the diverse factors influencing dental maturation

CONCLUSION

In our study, we applied a regression formula derived from molars to estimate chronological age. For total molars, the formula used was $y = 0.28138x + 13.457$, where x represents the total score of both the second and third molars. The estimated age variation ranged from 0.2 to 11 years. This formula facilitates age estimation based on

dental development, with a primary focus on molars. Our findings revealed that the estimated chronological age predominantly fell within the 17 to 23 year age group, which exhibited the lowest standard deviation (SD). Conversely, the highest SD was observed in the 12 to 17-year and 24 to 30-year age groups. The analysis primarily considered the second and third molars from the left side of the jaw. However, in cases of caries or ectodermal dysplasia, the right-side molars were used instead to ensure the accuracy of the developmental scores. The mean standard deviation of Nolla's score across the sample was approximately ±2.3 years. Additionally, the mean estimated age was 22.12 years, closely aligning with the mean chronological age of 22 years, reinforcing the reliability of Nolla's method for age estimation within this range.

Overall, our results highlight the effectiveness of Nolla's method in estimating age based on dental development while also identifying areas of variability. Future research with larger sample sizes and diverse populations could further enhance the accuracy and applicability of this method across different demographic groups.

REFERENCES

1. Kashyap RR, Kashyap RS. Forensic odontology: Is India emerging as a potential contributor to literature. J Punjab Acad Forensic Med Toxicol. 2020;18(2):30-5.
2. Kushdeep Kumar Gupta, Abraham Johnson A morphological and radiological assessment of teeth in variable incinerated temperature. J Punjab Acad Forensic Med Toxicol 2020;20 (1): 47-51
3. Singh HV, Kalra N, Tyagi R, Khatri A. Dental age assessment of North Indian origin children using Nolla's method in mandibular second molar. Egypt J Forensic Sci. 2020;10(1):1-7.
4. Paz Cortés MM, Rojo R, Alía García E, Mourelle Martínez MR. Accuracy assessment of dental age estimation with the Willems, Demirjian and Nolla methods in Spanish children: Comparative cross-sectional study. BMC Pediatr 2020;20(1):361.
5. Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol 1973:45(2):211-27.
6. Farhadian M, Salemi F, Saati S, Nafisi N. Dental age estimation using the pulp-to-tooth ratio in canines by neural networks. Imaging Sci Dent 2019;49(1):19-26.
7. Chaillet N, Nyström M, Demirjian A. Comparison of dental maturity in children of different ethnic origins: international maturity curves for clinicians. J Forensic Sci 2005;50(5):1164-74.
8. Nandlal B, Patil K, Ravi S. Estimation of dental age by Nolla's method using orthopantomographs among rural free residential school children. IJMRHS. 2014;3(2):273-7.
9. Marques MR. Pereira MdL, Caldas IM. Forensic age estimation using the eruption of the second permanent mandibular molar: determining age over 14 years-old. Aust J Forensic Sci 2015;47(3):306–12.
10. Peiris TS, Roberts GJ, Prabhu N. Dental Age Assessment: a comparison of 4- to 24-year-olds in the United Kingdom and an Australian population. Int J Paediatr Dent 2009;19(5):367-76.
11. Yassin S, Alalmai BM, Huaylah SA, Althobati M, Alhamdi FA, Togoo R. Accuracy of Estimating Chronological Age from Nolla's Method of Dental Age Estimation in a Population of Southern Saudi Arabian Children. Nigerian journal of clinical practice 2020;23(12): 1753-8.
12. Nur B, Kusgoz A, Bayram M, et al. Validity of demirjian and nolla methods for dental age estimation for Northeastern Turkish children aged 5-16 years old. Med Oral Patol Oral Cir Bucal 2012;17(5):e871-7.
13. Maret D, Molinier F, Braga J, Peters OA, Telmon N, Treil J, Inglèse JM, Cossié A, Kahn JL, Sixou M, et al. Accuracy of 3D reconstructions based on cone beam computed tomography. J Dent Res. 2010;89(12):1465-9.
14. Mualla N, Houssein EH, Hassan MR. Dental age estimation based on x-ray images. CMC 2020;62(2): 591-605.
15. Nolla CM. The development of the permanent teeth. J Dent Child 1960;27:254-66.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00035.5

Original Research Paper

Determination of the Sex of An Individual From Finger Print Ridge Density

1. **Sanchit Narang,** Junior Resident*
2. **Amandeep Singh,** Professor*
3. **Dasari Harish,** Professor & Head*
4. **Ajay Kumar,** Professor**

* Department of Forensic Medicine & Toxicology, Government Medical College & Hospital, Chandigarh
** Department of Forensic Medicine & Toxicology, AIIMS Bathinda

ABSTRACT

Introduction: Identification is the determination of the individuality or personality of a person, based on certain physical characteristics. Determination of sex is vital in establishing the identity of human remains and has always been a challenge for forensic investigation, particularly when a fingerprint recovered from crime scene does not match with any of those available in the records. Determination of the sex of an individual from fingerprint ridge density.

Materials and Method: The present study was conducted on 400 individuals (201 males and 199 females) of Chandigarh population, aged above 18 years, to study the possibility of differentiation of gender using fingerprint ridge density. For calculating the finger print ridges, a square of 5mm was drawn on radial end, ulnar end and lower end of fingerprint. The number of ridges of the fingerprints of each square were noted and mean value for total ridges of both thumbs from each individual was determined.

Results: Results showed that women have a significantly higher fingerprint ridge density than men. Fingerprints having ridge density of < 14/25mm2 are more likely to be that of a male, and one having ridge density of >14/25mm2 are more likely to be that of a female.

Conclusion: It was concluded that fingerprint ridge density can be used as a tool for sex determination.

Corresponding Author :
Dr. Amandeep Singh, Professor
Department of Forensic Medicine & Toxicology,
Government Medical College & Hospital Chandigarh
E-mail: dramandeep@gmail.com
Contact : +919646121610

Article History:
Received: 11 January 2025
Received in revised form: 27 January 2025
Accepted on: 27 January 2025
Available online: 15 April 2025

Keywords: Identification; Sex Determination; Fingerprint; Ridge Density.

INTRODUCTION

The determination of the individuality of a living or dead person is called Identification.[1] No two people are identical in any way that can be measured, and no amount of control can equalise all the cells/make them absolutely identical. Even identical twins differ from one another in various ways. This difference is influenced by hormonal factors, particularly testosterone, as well as genetic and environmental factors. Understanding these variations is crucial in the field of forensic investigation, as they can aid in sex determination from fingerprint evidence, which is vital in various forensic contexts.[1] However, the applicability of these findings is limited by population-specific characteristics, necessitating further studies across diverse ethnic groups.

Fingerprint Ridge Density (FPRD) is defined as the number of ridges per unit area, with males typically having lower FPRD due to larger body surface areas. Previous research indicates that ridge density varies across different areas of the fingerprint, with the radial area showing the highest density.[2] This further emphasizes the need for robust methodologies in data collection and analysis to ensure accuracy in forensic applications.[2]

Various techniques for fingerprint collection have been outlined, including traditional inked prints, digital scans, and optical methods like Total Internal Reflection Fluorescence Microscopy (TIRFM). Advanced algorithms and machine learning techniques are suggested to enhance the precision of ridge density measurements.[3] Additionally, methods for collecting fingerprints from crime scenes, such as dusting, chemical development, and high-resolution photography, are described, underscoring

the importance of meticulous evidence handling. The current study involves measuring ridge density in 400 consenting individuals to determine sex based on thumbprints from both hands.

MATERIALS AND METHOD

The present study was undertaken after approval from the Institutional Research and Ethics Committee (GMCH/IEC/751R/2022/155). It was a prospective, cross-sectional study conducted over 18 months, focusing on the adult population of Chandigarh, with a sample size of 400 individuals (201 males and 199 females).

The sample size was calculated to ensure a 95% confidence level and a 5% significance level, estimating that 50% of cases would be correctly identified. Inclusion criteria required parti-cipants to be over 18 years of age, regardless of gender, while exclusion criteria eliminated individuals who had conditions affecting fingerprints (e.g., psoriasis, leprosy, burns). Materials used included soap and tissue for hand cleaning, a blue ink stamp pad, non-glossy A4 white sheets, a camera with a minimum resolution of 16 megapixels, and a computer for data storage.

After obtaining informed consent, fingerprints from both thumbs were collected, following hand washing. Thumbprints were taken on white paper using the ink pad, with specific squares (5mm) marked for analysis. High-resolution photographs of the prints were captured, and ridge counts were performed in the marked areas to estimate ridge density. The mean ridge count for both thumbs was calculated, and differences between sexes were analysed using data from each thumb separately and combined.

RESULTS

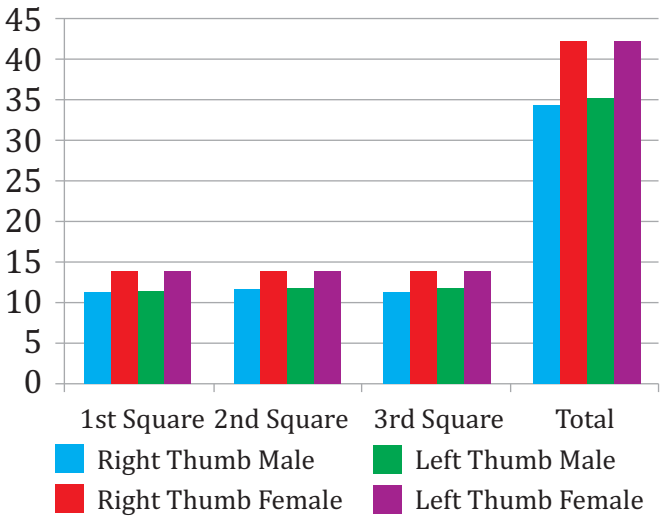
A total of 400 cases were taken, of which 201 were male and 199 were female. Majority of the study population comprised of the age group of 21-25 years (74%) and the mean age was 21.64 years for males and 21.53 years or females. The mean age of the whole study sample was 21.58 years.

Descriptive statistical analysis and results of unpaired t-test for the Ridge Density (RD)in the right and left thumbs are shown in figures1. Statistical analysis was done to find out the association between ridge density and sex of an individual. Mean values of all measurements were found to be highly significant with p=0.0001.

The analysis revealed that the mean value of RD of the right thumb was 42.312, with a standard deviation of 2.818 among females, whereas among males, it was 34.423 (SD-3.355). **(Figure 1)**

For the left thumb, the mean value for RD was 35.139 for males and 42.327 for females with a standard deviation of 2.843 and 3.319 respectively. P value was found to be statistically significant at 0.0001. **(Figure 1)** The combined ridge density of the right and left thumb was 69.562 in case of males and 84.638 in case of females with SD 5.787 & 5.426, respectively. Female mean RD was statistically higher than male mean RD (p =0.0001). For the Right thumb, mean value of 1st, 2nd and 3rd squares was found to be 11.408, 11.667 and 11.48 respectively, for males, while it was 13.945, 14.231and 14.136 respectively, for females. For the left thumb, mean value of 1st, 2nd and 3rd squares was found to be 11.468, 11.741 and 11.930, respectively, for males, while it was 13.940, 14.080 and 14.307, respectively, for females. **(Figure 1)**

Figure 1: Bar Diagram Showing Mean Ridges of Right and Left Thumb in Males and Female



The statistical analysis of the Right Thumb RD (RTRD) showed that, 91% of males & 87.9% of females were correctly identified. Overall, 89.5% of cases were correctly identified, based on Statistical analysis of RTRD. **(Table 1)**

Table 1: Categorisation (male and female) based on Statistical analysis of RTRD

Sex			Predicted Group Membership		Total
			Male	Female	
Original	Count	Male	183(91%)	18(9%)	201
		Female	24(12.1%)	175(87.9%)	199
89.5% of original grouped cases correctly classified.					

Table 2: Categorisation (male & females) based on statistical analysis of LTRD

Sex			Predicted Group Membership		Total
			Male	Female	
Original	Count	Male	183(91%)	18(9%)	201
		Female	29(14.6%)	170(85.4%)	199
88.2% of original grouped cases correctly classified.					

Table 3: Categorisation (male &females) based on statistical analysis of both thumb RD

Sex			Predicted Group Membership		Total
			Male	Female	
Original	Count	Male	187(93%)	14(7%)	201
		Female	22(11.1%)	177(88.9%)	199
91.0% of original grouped cases correctly classified					

The statistical analysis of the Left Thumb RD(LTRD) showed that, 91% of males and 85.4% of females were correctly classified. In total 88.2 % of the study sample was classified correctly. **(Table 2)**

When the analysis was done using the combined RD of both thumbs, 93% of the males were correctly categorised, whereas, for females, it was 88.9%. Overall, 91% of study sample were correctly classified. **(Table 3)**

DISCUSSION

The determination of an individual's gender is crucial for establishing identity, particularly in forensic contexts. This process can help narrow down the population by excluding half of it. Most studies on fingerprint analysis have utilized ink staining and the rolling method, which captures all regions of the fingerprint-radial, ulnar, and proximal. This method is especially important in identifying individuals in scenarios such as natural disasters, terrorist attacks, or cases involving decomposed bodies.

Significant variations in fingerprint ridge density (FPRD) across different populations and genders are:

General Trends: Across various studies, males consistently exhibit lower ridge densities compared to females. For instance, African-American males have a mean radial ridge density of 10.9/25mm[2,4] while Egyptian males show a higher mean of 20.50/25 mm.[2,11] Conversely, females have higher ridge densities, with values ranging from 12.81/25 mm^2 to 21.36/25 mm^2 among different populations.[4-12]

1. Variability: The standard deviations of ridge densities also vary significantly. For males, the standard deviation ranges from 0.92/25 mm^2 in Sudanese males[14] to 2.71/25 mm^2 in Argentine males.[7] For females, it ranges from 0.634/25 mm^2 in Indian females8 to 2.652/25 mm^2 in Egyptian females.[11]

2. Ulnar Ridge Density: In the ulnar area, males show ridge densities from 13.02/25 mm^2 in Sudanese males[14] to 16.54/25 mm^2 in Argentine males,[7] while females range from 14.22/25 mm^2 to 17.75/25 mm^2. Males exhibit greater variability in ulnar ridge density.

3. Proximal Ridge Density: Similar patterns are observed in the proximal area, where males have ridge densities from 9.75/25 mm^2 in Sudanese males[14] to 14.33/25 mm^2 in Argentine males,[7] and females range from 10.80/25 mm^2 to 16.13/25 mm^2.

4. Comparative Studies: The study by Rivalderia et al.[12] found a mean thumb ridge density of 14.27 for females, aligning closely with the current study's finding of 14.10. For males, the current study's mean of 11.59 is comparable to Gutiérrez-Redomero et al.'s[4] finding of 11.87.

In our study, 400 individuals were enrolled and their fingerprint ridge density from the thumbs of both hands was used to determine the sex. Majority of the study population comprised of the age group of 21-25 (74%) and the mean age was 21.64 years for males and 21.53 years or females. The mean age of the whole study sample was 21.58 years. **(Table 4)**

The above research makes it clear that there were notable disparities in the FPRD across people from different ethnic backgrounds and geographical areas. While all studies revealed that the ridge densities of males were substantially lower, African-Americans had a mean radial ridge density of 10.9/25 mm^2, whereas Egyptian population had a mean radial ridge density of 20.50/25 mm^2. In contrast, the mean ridge density was shown to be greater in females in all investigations; the radial ridge density varied across African-Americans and Egyptians, ranging from 12.81/25 mm^2 to 21.36/25 mm^2 **(Table 4)**

From the interpretations of the analysis and results above, it can be concluded that, finger print ridge density can be used as a useful criterion to determine the sex of an individual.

CONCLUSION

The analysis of fingerprint ridge density indicates notable differences between males and females, with males generally exhibiting lower ridge densities. Specifically, the ridge densities of both the right and left thumbs are

Table 4: Mean and Standard Deviation for FPRD in Radial Area

No.	Author/ Year/ Population	Male		Female	
		Mean	SD	Mean	SD
1	Acree - 1999 - African American-Alabama, USA[4]	10.9	1.15	12.61	1.43
2	Acree - 1999 - Caucasian-Alabama, USA[4]	11.14	1.31	13.32	1.24
3	Gutiérrez-Redomero et al. - 2008 - Madrid, Spain[5]	16.23	1.39	17.91	1.47
4	Nayak et al. - 2009 - Udupi, India[6]	11.05	1.111	14.2	0.634
5	Nayak et al. - 2010 - Chinese-Udupi, India[7]	11.73	1.066	14.15	1.038
6	Nayak et al. - 2010 - Malaysian-Udupi, India[6]	11.44	0.988	13.63	0.906
7	Gutiérrez-Redomero et al. - 2011, Argentina[7]	16.62	2.71	17.82	2.87
8	Nithin et al. - 2011 - Mysore, India[8]	12.57	1.493	14.14	1.684
9	Krishan et al. - 2012 - Kangra, India[9]	15.84	1.231	17.94	1.232
10	Gutiérrez-Redomero et al. - 2013 - Argentina[7]	17.04	1.68	19.08	1.84
11	Gutiérrez-Redomero et al. -2013- Puna, Argentina[7]	16.67	1.78	18.47	1.56
12	Gutiérrez-Redomero et al. - 2014 - Madrid, Spain[10]	16.85	1.76	19.11	1.79
13	Eshak et al. - 2013 - Minya, Egypt[11]	20.5	1.974	21.36	2.652
14	Rivalderia et al. - 2015 - Buenos Aires, Argentina[12]	15.56	1.49	17.82	1.36
15	Rivalderia et al. - 2015 - Chubut, Argentina[12]	16.08	1.47	18.36	1.83
16	Soanboon et al. - 2016 - Khon Kaen, Thailand[13]	15.97	1.16	17.23	1.17
17	Ahmed and Osman - 2016 - Khartoum, Sudan[14]	12.8	0.92	14.5	1.18
18	Taduran et al. - 2016 - Quezon City, Philippines[18]	14.57	1.43	15.89	1.69
19	Kumar et al. - 2017 - Belgaum, India[15]	13.56	1.38	16.92	1.48

effective for gender identification, with the right thumb showing slightly higher accuracy. Combining the ridge densities from both thumbs further enhances this accuracy.

This trend is consistent across various finger regions, including proximal, radial, and ulnar squares. Overall, these findings suggest that fingerprint ridge density is a reliable method for gender determination, and utilizing multiple fingerprint characteristics can improve accuracy, offering valuable insights for forensic and biometric applications.

Conflict of Interest: None Funding: Nil

REFERENCES

1. K S Narayan Murty O P Reddy. Essentials of forensic medicine and toxicology. Jaypee; 2017
2. Acree MA. Is there a gender difference in fingerprint ridge density? Forensic Sci Int 1999;102(1):35-44.
3. National Forensic Science Technology Center. A simplified guide to fingerprint analysis. 2009.
4. Nayak SB , Velan J , Shern NL , Zoung LF , Jeyarajan A , Aithal AP. The Relationship between Dermatoglypic Pattern of Right Thumb and Physical Health of Medical Students: A Cross-sectional Study. J Punjab Acad Forensic Med Toxicol 2017; 17 (1):17-21
5. Gutierrez-redomero E, Alonso C, Galera V. Variability of fingerprint ridge density in a sample of spanish-caucasians and its application to sex determination. Forensic Sci Int 2008;180(1):27-32
6. Nayak VC, Rastogi P, Kanchan T, Lobo SW, Yoganarasimha K, Nayak S, et al. Sex differences from fingerprint ridge density in the indian population. J Forensic Leg Med 2010;17(2):84-6
7. Gutiérrez-Redomero E, Quirós JA, Rivaldería N, Alonso MC. Topological variability of fingerprint ridge density in a sub-saharan population sample for application in personal identification. J Forensic Sci 2013;58(3):592-600.
8. Nithin MD, Manjunatha B, Preethi DS, Balaraj BM. Gender differentiation by finger ridge count among South Indian population. J Forensic Leg Med. 2011;18(2):79-81
9. Krishan K, Kanchan T, Ngangom C. A study of sex differences in fingerprint ridge density in a north Indian young adult population. J Forensic Leg Med. 2013;20(4):217-22.
10. Gutiérrez-Redomero E, Rivaldería N, Alonso-Rodríguez C, Sánchez-Andrés Á. Assessment of the methodology for estimating ridge density in

fingerprints and its forensic application. Science & justice. 2014;54(3):199-207.

11. Nayak VC, Rastogi P, Kanchan T, Yoganarasimha K, Kumar GP, Menezes RG. Sex differences from fingerprint ridge density in Chinese and Malaysian population. Forensic Sci Int. 2010;197(1-3):67-9
12. Rivalderia N, Sánchez-Andrés Á, Alonso-Rodríguez C, Dipierri JE, Gutiérrez Redomero E. Fingerprint ridge density in the Argentinean population and its application to sex inference: a comparative study. Homo. 2016;67(1):65-84
13. Singh G. Determination of gender differences from fingerprints ridge density in two northern Indian population of Chandigarh region. J. Forensic Res. 2012;3(3):3.
14. Ahmed AA, Osman S. Topological variability and sex differences in fingerprint ridge density in a sample of the Sudanese population. Journal of Forensic and Legal Medicine. 2016;42:25-32.
15. Gutiérrez-Redomero E, Quirós JA, Rivaldería N, Alonso MC. Topological variability of fingerprint ridge density in a sub-saharan population sample for application in personal identification. J Forensic Sci. 2013;58(3): 592-600.
16. Kapoor N, Badiye A. Sex differences in the thumbprint ridge density in a central Indian population. Egyptian Journal of Forensic Sciences 2015;5(1):23-9.
17. Htun KS, Hlaing KH, Zaw T, Hlaing TM. Stereomicroscopic gender determination from fingerprint ridge density and fingerprint patterns. In24th Myanmar Military Medical Conference 2017
18. Taduran RJ, Tadeo AK, Escalona NA, Townsend GC. Sex determination from fingerprint ridge density and white line counts in Filipinos. Homo. 2016;67(2):163-71

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00036.1

Original Research Paper

Demographic Study of Pattern of Medicolegal Cases in Almora, Uttarakhand: A 2-Year Retrospective Study

1. **Preet Inder Singh,** Assistant Professor*
2. **Alwin Abraham Varghese,** Assistant Professor*
3. **Chandra Prakash,** Dean & Principal*
4. **Shiduti Sharma,** Junior Resident*

* Department of Forensic Medicine & Toxicology, SSJGIMS&R, Almora, Uttarakhand- 263601

ABSTRACT

Introduction: Medicolegal cases play a crucial role in the intersection of law and public health. Almora, located in Uttarakhand, has seen a variety of such cases over the past few years. Understanding the demographic and injury patterns of these cases can provide valuable insights for health and law enforcement systems in the region.

Objective: This study aims to analyze the demographic distribution, types of injuries, and the manner of medicolegal cases reported in Almora, Uttarakhand, from January 2022 to December 2024.

Materials and Method: A retrospective study was conducted, analyzing 434 medicolegal cases from hospital records. Data collected included patient age, sex, type of injury, nature of injury, body site affected, manner of injury, type of vehicle involved, and the season of occurrence. Descriptive statistics were used to summarize these variables, and trends were observed across different demographic groups.

Result: A total of 434 medicolegal cases were included in the study. The most affected age group was 26-35 years (23.70%), with males comprising 75.98% of the total cases. Lacerations were the most common type of injury (50.23%), followed by contusions (22.12%) and abrasions (15.91%). Accidental injuries dominated the cases, accounting for 74.26%, while homicidal and suicidal injuries made up 10.35% and 5.31%, respectively. The most frequently affected body sites included the forehead (5.67%), knee (2.09%), and shoulder (1.49%). Most of the cases occurred during the spring (36.59%) and summer (35.37%) months. Two-wheelers were involved in 74.26% of the vehicular accidents.

Conclusion: This study highlights significant trends in the occurrence of medicolegal cases in Almora, with a predominance of male victims and a high incidence of accidental injuries, particularly those involving two-wheelers. The findings stress the need for targeted public health campaigns focusing on accident prevention, especially road safety, and the enhancement of emergency services in the region to address the high frequency of injuries.

Corresponding Author :
Dr. Preet Inder Singh, Assistant Professor
Department of Forensic Medicine & Toxicology, SSJGIMS&R, Almora, Uttarakhand- 263601
E-mail: planetinder@yahoo.co.in
Contact : +919779100027

Article History:
Received: 30 November 2024
Received in revised form: 08 January 2025
Accepted on: 08 January 2025
Available online: 15 April 2025

Keywords: Medicolegal Cases; Almora; Uttarakhand; Demographic Study; Injury Patterns; Road Safety; Retrospective Study.

INTRODUCTION

Medico-legal cases coming to the Casualty department of a hospital play a pivotal role in reflecting the social, economic, and administrative conditions of a particular region. These cases are usually documented through reports prepared by a doctor at the request of an Investigating Officer, providing vital information to guide the legal process. Such reports often involve criminal cases like injury, postmortem, rape, pregnancy, abortion, and delivery, and are collectively known as medico-legal reports. If a Casualty doctor suspects any foul play, or if there is uncertainty about the case, the attending doctor has the discretion to classify the case as medico-legal. If it is thought that there may be a criminal investigation or legal authorities involved, this choice is taken regardless of the patient's permission.

Road traffic accidents, falls from heights, physical assault, burns, sexual assault, poisoning, injuries, instances of the brought dead or unconscious, and animal attacks are examples of common medico-legal case categories.[1] As the initial point of contact for such occurrences, the Casualty department is responsible for registering all medico-legal

cases. As a vital link between medical care and the law, the casualty department is essential in any hospital since it helps distinguish between medical and medico-legal matters. It also serves as an Outpatient Department (OPD) outside of regular OPD hours.

With an emphasis on demographic patterns, injury kinds, and causes, the current study attempts to examine the pattern of medico-legal cases at a tertiary care facility in Almora, Uttarakhand. The results of this study will help clarify the common trends in the area and support the creation of road safety and public health initiatives that are specific to Almora's requirements.

MATERIALS AND METHOD

This is a retrospective study of medico-legal cases registered in a casualty of Casualty Department and Medicolegal Section of the District Hospital in Almora, Uttarakhand, over a period of two years, from January 2022 to December 2024. A total of 434 medico-legal cases. During the study period a total of 434 medico-legal cases were registered. The collected data was analysed and represented in form of tables by mentioning various parameters and compared with other resembling studies Individuals from both genders and all age groups were included and people with no medico-legal perspective were excluded from study

The study reviewed various parameters, including age, gender, type of injury, manner of injury, body site affected, seasonal variation, and vehicle involvement in the cases. The collected data was analysed and represented in form of tables by mentioning various parameters and compared with other resembling studies Individuals from both genders and all age groups were included and people with no medico-legal perspective were excluded from study.

RESULTS

There was a notable male preponderance in the gender distribution, with 329 male cases (75.78%) and 105 female cases (24.02%) out of total of 434 subjects.

With 103 instances (23.70%), the age group of 26–35 years old was the most often impacted, followed by the 36–45 age group with 77 cases (17.78%). This implies that injuries needing medico-legal treatment are more common among younger and middle-aged persons, especially those who work or engage in leisure activities. **(Table 1)**

Type of Injury

The majority of cases in this study were related to lacerations, accounting for 50.23% of the total medicolegal injuries. The next most common injuries were contusions (22.12%) and abrasions (15.91%). Other injuries, such as fractures (3.92%), poisoning (5.75%), and burns (2.07%), were less frequent. **(Table: 2)**

Table 1: Age Group Distribution

Age Group (Years)	Number of Cases N=434	Percentage (%)
0-15	35	8.08%
16-25	64	14.81%
26-35	103	23.70%
36-45	77	17.78%
46-55	71	16.30%
56-65	51	11.85%
66-75	29	6.67%
76-85	4	0.69%
Total	**434**	**100%**

Table 2: Injury Type Distribution

Type of Injury	Number of Cases	Percentage (%)
Laceration	218	50.23%
Contusion	96	22.12%
Abrasion	69	15.91%
Fracture	17	3.92%
Poisoning	25	5.75%
Burn	9	2.07%
Total	**434**	**100%**

Manner of Injury

Accidental injuries formed the largest category, accounting for 74.26% of the cases. This was followed by homicidal cases (10.35%), suicidal cases (5.31%), and assault cases (6.46%). **(Table 3)**

Seasonal Distribution of Cases

The highest frequency of medicolegal cases occurred during the spring (36.59%) and summer (35.37%) seasons. These periods typically have more outdoor activities, contributing to the higher number of incidents. Winter, with fewer outdoor activities, saw fewer cases (9.33%). **(Table 4)**

Table 3: Manner of Injury Distribution

Manner of Injury	Number of Cases	Percentage (%)
Accidental	323	74.26%
Homicidal	45	10.35%
Suicidal	23	5.31%
Assault	28	6.46%
Total	**434**	**100%**

Manner of Injury Distribution

In this study, the manner of injury was predominantly accidental, accounting for 74.48% of cases (323 cases). Homicidal injuries followed with 19.81% (86 cases), while suicidal injuries represented 5.06% (22 cases). A small percentage (0.69%, 3 cases) were due to assault. This distribution highlights that accidental injuries were the most common cause, while homicidal injuries were also notably present. **(Table 5)**

Type of Vehicle Involved

Two-wheelers accounted for 79.27% of the medicolegal cases (344 instances), making them the most often involved vehicle type. Cars accounted for 1.22% of the incidents (5 instances), whilst four-wheelers were involved in 7.32% of the cases (32 cases). The kind of vehicle was not stated in 53 occurrences, or 12.19% of cases. This implies that two-wheelers are the most common vehicles engaged in these kinds of situations, most likely because they are more prone to be involved in accidents than other vehicle types. **(Table 6)**

Body Site Involved in Injuries

The study found that the most common injuries were to the forehead (23.25%), followed by occipital, nose, and head (9.91% each). Other frequent injuries involved the knee, eyebrow, and neck (8.75% each). Injuries to the back and parietal regions were observed in 7.37% of cases, while shoulder injuries were the least frequent at 6.22%. These findings suggest that head and upper body injuries are most prevalent in medicolegal cases, likely due to the nature of accidents like falls and road traffic incidents. **(Table 7)**

Table 4: Seasonal Distribution

Season	Number of Cases	Percentage (%)
Spring	159	36.59%
Summer	154	35.37%
Autumn	81	18.71%
Winter	40	9.33%
Total	**434**	**100%**

Table 5: Manner of Injury Distribution

Manner of Injury	Number of Cases	Percentage (%)
Accidental	323	74.48%
Homicidal	86	19.81%
Suicidal	22	5.06%
Assault	3	0.69%
TOTAL	**434**	**100%**

Table 6: Type of Vehicle Involved

Type of Vehicle	Number of Cases	Percentage (%)
Two-wheeler	344	79.27%
Four-wheeler	32	7.32%
Car	5	1.22%
Not Specified	53	12.19%

Table 7: Body Site Involved in Injuries

Body Site	Number of Cases	Percentage (%)
Forehead	101	23.25%
Occipital	43	9.91%
Nose	43	9.91%
Head	43	9.91%
Knee	38	8.75%
Eyebrow	37	8.51%
Neck	38	8.75%
Back	32	7.37%
Parietal	32	7.37%
Shoulder	27	6.22%

DISCUSSION

In our study, it was observed that most of the victims were males (75.98%), which is consistent with the findings of previous studies such as those conducted by Trangadia MM et al.,[2] Hussaini SN et al.,[3] and Yatoo GH et al.[4]

The predominance of males over females may be attributed to societal factors, where males are more likely to engage in outdoor and risk-related activities, and tend to be more involved in work and travel compared to females, who often stay at home. Our results show a male-to-female ratio of 75.98% and 24.02%, respectively, highlighting the significant male dominance in medicolegal cases.

The age distribution showed that the majority of victims were between the ages of 26 and 35 (23.70%), followed by those between the ages of 36 and 45 (17.78%). This is consistent with research showing that younger persons were more likely to be engaged in such incidents (Trangadia MM et al.[2], Yatoo GH et al.[4] ,Garg V[5]).

These people are more vulnerable to accidents and injuries since they are in the peak of their careers and leisure activities. The high incidence among those aged 16–25 years (14.81%) and 46–55 years (16.30%), with a declining frequency observed as age increases, further supports this pattern. It implies that those who are more active and engage in a variety of outdoor activities, such as work and leisure, are more susceptible to accidents that call for medicolegal care.

Road traffic accidents (RTAs) accounted for 74.26% of all cases in the current study, which is consistent with research by Trangadia MM et al.[2] and Yatoo GH et al[4], Srivastava V[6] ,. that found RTAs to be the primary cause of medicolegal cases.

Poor road conditions, traffic congestion, and an increase in vehicle traffic are some of the variables that contribute to the high frequency of RTAs and increase the number of accidents. This is also supported by the study of Yadav A et al.[7], Tariq SA [8], which shows that RTAs make up the majority of cases.

Additionally, our analysis found that falls (15.91%) and poisoning (5.75%) were major contributors to the overall number of medicolegal cases. This contrasts with research where poisoning cases were more prevalent, such as that done by Yadav A et al.[7]

Nonetheless, poisoning accounted for 5.75% of all cases in our survey, indicating that it is still a major problem for medico-legal documentation. Even though assault instances were less common in our sample (6.46%), they are nonetheless important since they frequently affect criminal investigations.

The majority of victims (78.40%) were released following treatment, according to the case outcomes in our study. This is a good sign of how well emergency care and intervention work. This aligns with related research, such as those conducted by Hatwal rt al,[9] Yadav A et al.[7] and Siddappa SC [10] and Trangadia[2] Malik Y et al.[11]. 4.69% of the cases were sent to higher facilities for further treatment, while 6.32% of the cases absconded or took departure against medical advice (LAMA).

Overall, 9.59% of patients ended in death while receiving treatment, which is consistent with results from earlier research when fatalities were reported in a comparable percentage range. These results reflect the importance of timely medical intervention, the availability of sophisticated medical facilities, and public health awareness.

CONCLUSION

This study offers important new information about the seasonal patterns and demography of medico-legal cases. The findings emphasize the necessity of focused public health education, particularly for young individuals aged 26 to 35, who are more susceptible to traffic accidents. The results also point to the significance of seasonal safety campaigns by indicating that healthcare systems should be ready for increased case volumes in the spring and summer.

While the frequency of poisoning indicates the need for continuous public awareness campaigns, the preponderance of unintentional injuries highlights the need for stronger road safety regulations. Additionally, the very low rate of homicidal and suicidal injuries emphasizes the need of domestic safety and mental health programs.

Overall, this study underscores the vital role of emergency medical services and highlights the necessity for proper medico-legal training for healthcare professionals to ensure accurate documentation and reduce the risk of negligence. Our observations highlight the significant role that emergency services play in providing medical care in medicolegal cases and the importance of prompt treatment in reducing mortality.

The findings also underscore the need for continuous health education to prevent injuries, particularly related to road traffic accidents and poisoning.

REFERENCE

1. Aggarwal A. Textbook of Forensic Medicine and Toxicology; 2014. p. 636
2. Trangadia MM, Mehta RA, Rada NH, Gupta BD. Profile of medicolegal cases in tertiary care hospital in Jamnagar, Gujarat: Retrospective study of one year. J Res Med Dent Sci. 2014;2(4):57–62.
3. Hussaini SN, Kulkarni CS, Batra AK. Profile of medico-legal cases coming to casualty of Government Medical College. J Forensic Med. 2013;22(2):1–5.
4. Yatoo GH, Jalali S, Malik A, Khan A. Profile and pattern of medicolegal cases attending tertiary care hospital in North India. Int J Med Pharm Sci. 2015;5(5):1–8.
5. Garg V, Verma S.K. Profile of Medico-legal Cases at Adesh Institute of Medical Sciences and Research, Bathinda, Punjab J Indian Acad Forensic Med, 2010. 32(2); 150-52.
6. Srivastava V, Najan A, Markam PK, Shukla S. Profile of Medico Legal Cases at Netaji Subhash Chandra Bose Medical College Jabalpur, Madhya Pradesh.
7. Yadav A, Singh NK. Pattern of medico-legal cases in rural area of Fridabad. J Indian Acad Forensic Med. 2013;35(1):60–2.
8. Tariq SA, Qasim AP, Naeem M. Pattern of female medicolegal cases attending the casualty department

of a teaching hospital. Journal of University Medical & Dental College. 2014 Jun 3;5(1):20-5.

9. Hatwal P, Devassy S, Pandey K, Bhaisora CP. SOCIO-DEMOGRAPHIC PROFILES OF VICTIMS OF ROAD TRAFFIC ACCIDENTS IN KUMAON REGION OF UTTARAKHAND. International Journal of Medical Toxicology & Legal Medicine. 2022 Jul;25(3-4).
10. Siddappa SC, Datta A. A study pattern of medico-legal cases treated at a tertiary care hospital in central Karnataka. Indian J Forensic Comm Med. 2015 Jan 1;2(4):193-7.
11. Malik Y, Chawla R, Sharma G, Malik P, Singh R, Tripathi A. Profile of medico legal cases in causality of a rural medical college of Hariyana. J Indian Acad Forensic Med. 2013;35(4):367–75.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00037.8

Original Research Paper

Otologic Findings in Medicolegal Autopsies : A Prospective Study

1. **Anu B,** Post Graduate, Department of Forensic Medicine and Toxicology, AIIMS Raipur
2. **Krishnadutt Chavali,** Professor and HoD, Department of Forensic Medicine and Toxicology, AIIMS Raipur
3. **Ripu Daman Arora,** Professor, Department of ENT & Head & Neck Surgery, AIIMS Raipur

ABSTRACT

Introduction: This study explores the significance of otologic findings in medico-legal autopsies, particularly examining the tympanic membrane and middle ear.

Materials and Method: A total of 221 cases were evaluated at AIIMS Raipur to determine whether these findings correlate with causes of death.

Results: Hemotympanum and middle ear haemorrhage were predominantly associated with asphyxial deaths, suggesting their potential role as indicators in such cases. Tympanic membrane perforations were notably observed in blast injuries, emphasizing the impact of explosive trauma on ear structures.

Conclusion: The study highlights the importance of incorporating otologic examinations in routine autopsies to enhance forensic investigations. Despite certain limitations, such as a small sample size and procedural challenges, the findings contribute valuable insights to the field of forensic pathology.

Corresponding Author :
Dr. Krishnadutt Chavali, Professor and HoD, Department of Forensic Medicine, AIIMS Raipur
E-mail: drkhchavali@aiimsraipur.edu.in
Contact : +919340169290

Article History:
Received: 22 January 2025
Received in revised form: 22 January 2025
Accepted on: 22 January 2025
Available online: 15 April 2025

Keywords: Forensic Medicine; Otologic Findings; Hemotympanum; Tympanic Membrane; Medico-Legal Autopsy.

INTRODUCTION

Forensic medicine plays a critical role in criminal investigations, particularly in determining causes of death through postmortem examinations. A medico-legal autopsy is conducted with the intent of resolving queries on the identity of the deceased, the cause of death, the time of death, the factors underlying the death, etc., aiding law enforcement in solving the crime. Autopsies, whether clinical or medico-legal, provide essential insights into disease processes and forensic evidence that aid in the administration of justice. While comprehensive examinations are standard, certain anatomical regions, such as the ear, were often overlooked due to perceived difficulties in accessing and interpreting findings.

The ear, specifically the middle ear and tympanic membrane, holds potential forensic significance, particularly in cases involving traumatic and asphyxial deaths. Otoscopy is a clinical procedure that is used to evaluate the middle ear, tympanic membrane (TM), and external auditory canal, among other parts of the ear.[1] The otoscopy may give crucial forensic evidence by revealing a variety of diseased and traumatic alterations in the middle and outer ears. Otoscopy is also strongly advised when looking into young people's unexpected deaths.[2] Despite this, routine examination of the ear in medico-legal autopsies is not commonly performed, largely due to inadequate facilities and the perceived complexity of the dissection and therefore their importance in routine autopsies were seldom reported. This study was conducted to address this gap by systematically examining otologic findings in a series of medico-legal autopsies, aiming to determine their relevance in establishing causes of death.

OBJECTIVE

The primary objective of this study was to investigate the presence of various otologic findings in medico-legal autopsies. By testing association of these findings with specific causes of death, the study aimed to enhance the forensic utility of otologic examinations.

MATERIALS AND METHOD

Study Design: This study was an observational analytical study conducted at the All India Institute of Medical Sciences (AIIMS), Raipur, over a period of one year.

Study Population: The study population consisted of cases brought to the mortuary of AIIMS Raipur for medico-legal autopsies.

Inclusion Criteria:

- All cases brought to AIIMS, Raipur mortuary for medico-legal autopsy.

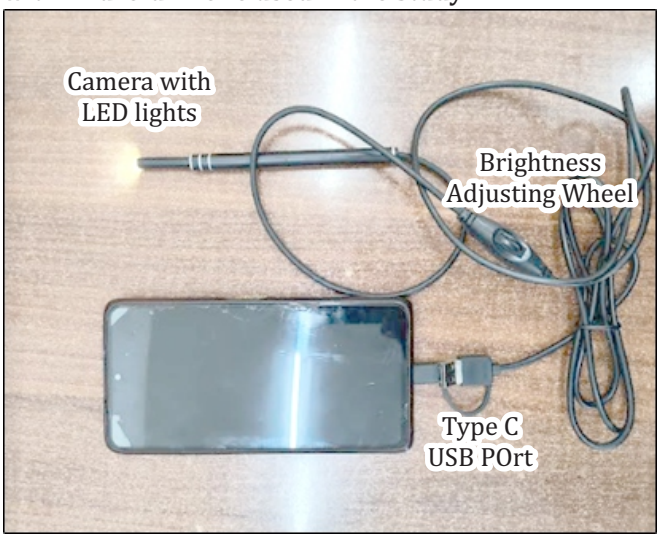
Exclusion Criteria:

- Cases with gross mutilation of both ears.
- Advanced decomposition involving both ears.
- Cases where a definite cause of death could not be established after postmortem.

Sample Size and Sampling Technique: Sample size was calculated to be 186 at α- 5% and population proportion 50%. Purposive sampling was employed to select cases meeting the eligibility criteria and 221 cases were studied in total.

Otologic Examination: The otologic examination was conducted using a digital otoscope (Glaceon® USB Ear Endoscope) with adjustable LED lighting, attached to an Android phone (Redmi Note 10 Pro) for capturing images and videos **(Figure 1)**.

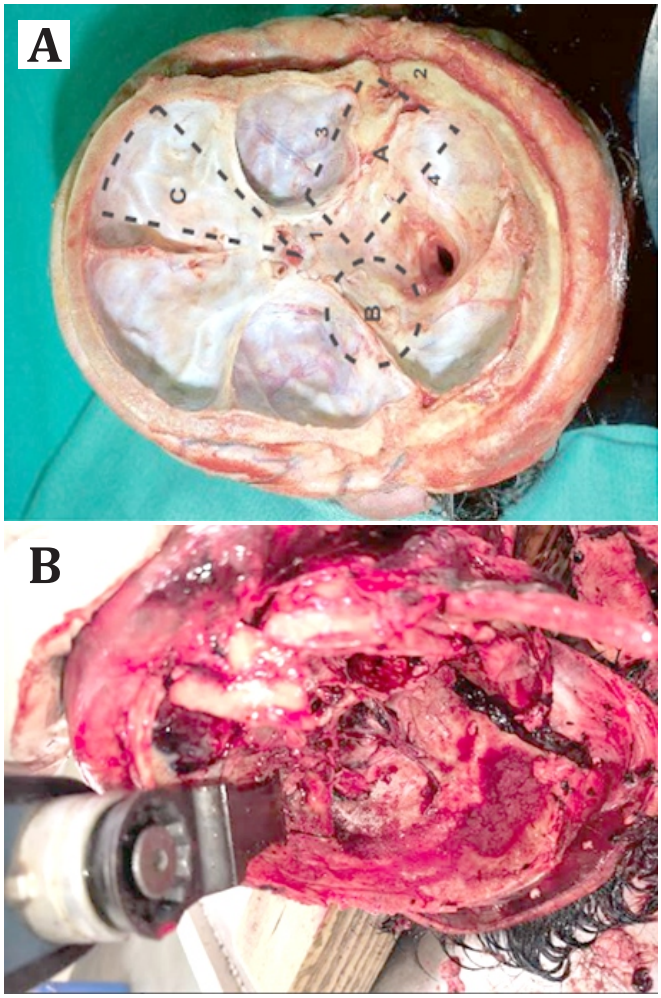
Figure: Image of the Digital Otoscope Attached with Android Phone used in the Study



The following steps were taken during the examination:

1. **External Ear Examination:** The external ear canal was examined for any signs of trauma, perforation, or other pathological conditions.
2. **Tympanic Membrane Inspection:** The tympanic membrane was assessed for integrity, colour changes, and any signs of haemorrhage or perforation.
3. **Middle Ear Dissection:** Middle ear dissection was performed using a Bosch Multi Cutter GOP oscillating saw to remove the temporal bone and expose the middle ear cavity **(Figure 2A** and **2B)**.

Figure 2: A. (Top) Image Showing Middle Ear Dissection (marked as A)[3],
B. (Bottom) Image Showing Dissection in the Study



Data Collection: Data was collected using a structured case record form, documenting the condition of the tympanic membrane, presence of hemotympanum, perforations, and other otologic findings. The cause of death was recorded based on the full autopsy results, and the time since death was estimated during the autopsy.

Data Analysis: The collected data was entered into Microsoft Excel and analysed. Findings were represented in the as frequencies and percentages. Association between otologic findings and the cause of death were explored to identify potential forensic indicators.

Ethical Clearance: Necessary approval from institutional ethical committee had been obtained before commence-

ment of the research work.

RESULTS

Demographics: The study included 221 cases, with a majority (85.5%) being male and the most represented age group being 19-30 years (32.1%)**(Table 1)**.

Table 1: Demographic Distribution of Cases

Variable (Age in Years)	Frequency (n=221)	Percent (%)
<18	13	5.9
19-30	71	32.1
31-40	49	22.2
41-50	43	19.5
>50	43	19.5
Unknown	2	0.9
Sex		
Male	189	85.5
Female	32	14.5

Table 2: Distribution of Attributes of Death

Variable (Cause of Death)	Frequency (n=221)	Percent (%)
Craniocerebral damage	44	19.92
Asphyxia due to hanging	34	15.39
FSL pending	26	11.77
Polytrauma	16	7.20
Asphyxia due to drowning	13	5.89
Hemorrhagic shock	13	5.89
Septicemia	13	5.89
Others	62	28.05
Time Since Death		
<6 hour	20	9
6-12 hour	60	27.1
12-18 hour	80	36.2
18-24 hour	37	16.7
>24 hour	24	10.9

Table 3: Otologic Findings

Variable	Yes	No
Tympanic Membrane		
Perforated	2	219
Retracted	1	220
Granulation	0	221
Ossicular Injury	0	221
Color of Tympanic Membrane		
Blue	52	169
Congested	7	214
Hemorrhage of Tympanic Membrane		
Petechial hemorrhage	0	221
Diffuse hemorrhage	0	221
Middle ear hemorrhage	52	169

The causes of death were varied, with road traffic accidents (RTA) being the most common, followed by hanging and drowning.

1. Hemotympanum

- Hemotympanum, characterized by blood in the middle ear, was observed in 52 cases (23.5%).
- This finding was predominantly associated with asphyxial deaths, including 32 cases of hanging (61.5%) and 12 cases of drowning (23.1%).
- A few cases of craniocerebral damage following RTA also showed hemotympanum, suggesting its potential as an indicator in such cases.

2. Tympanic Membrane Perforation:

- Tympanic membrane perforations were noted in 2 cases (0.9%), both associated with severe trauma.
- One case involved craniocerebral damage, and the other was due to a blast injury. The presence of perforations in these cases highlights the impact of explosive and traumatic forces on the ear structures.

3. Tympanic Membrane Colour:

- The majority of cases (73.3%) exhibited a normal tympanic membrane.
- Blue discoloration, indicative of hemotympanum, was noted in 23.5% of cases, predominantly in asphyxial deaths.
- Congestion of the tympanic membrane was found in 7 cases (3.2%), primarily associated with septicaemia and electrocution.

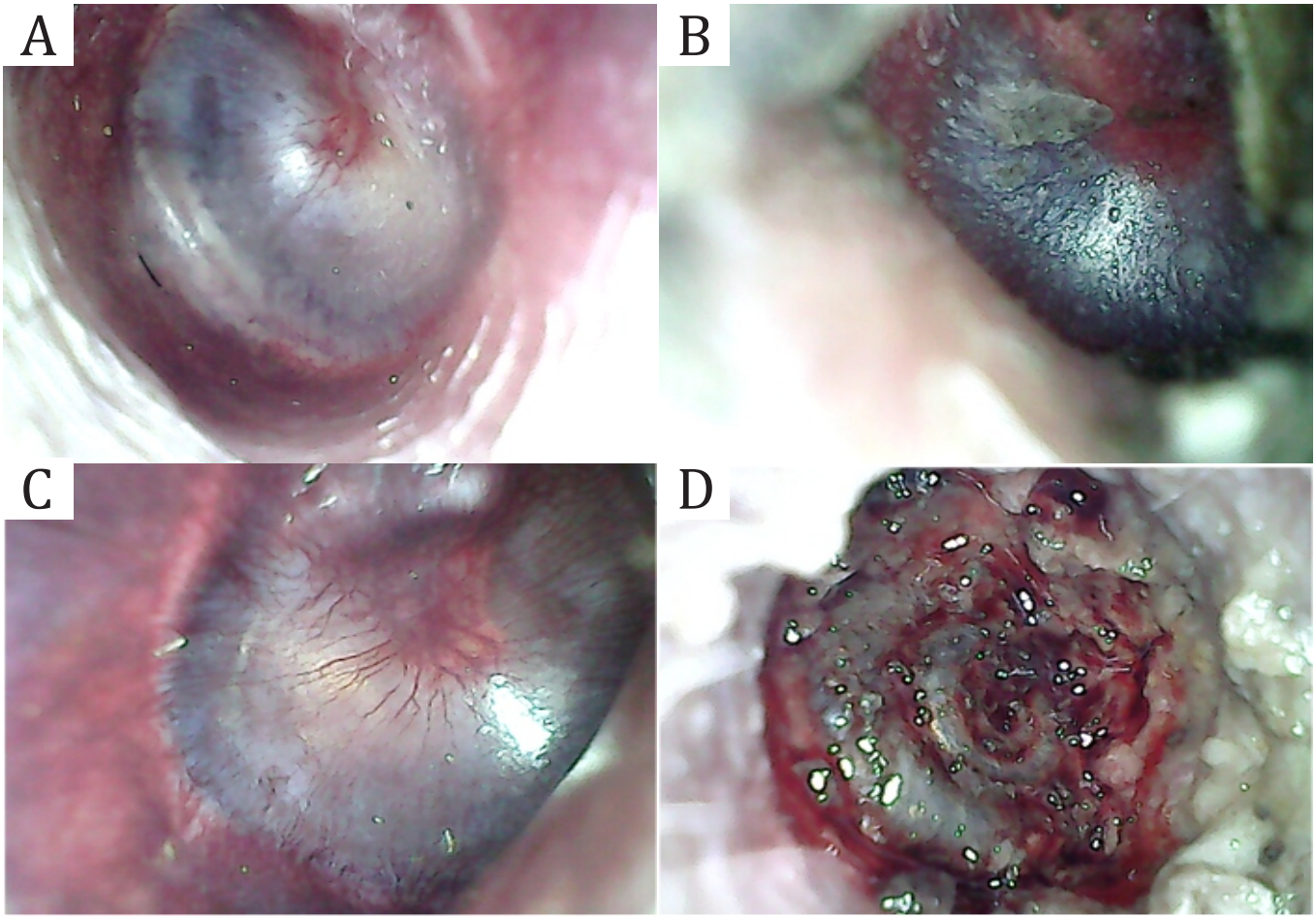
4. Middle Ear Hemorrhage:

- Middle ear hemorrhage was present in 52 cases (23.5%), with a strong association with asphyxial deaths.
- This finding was absent in the majority of other causes of death, highlighting its potential forensic relevance in specific scenarios.

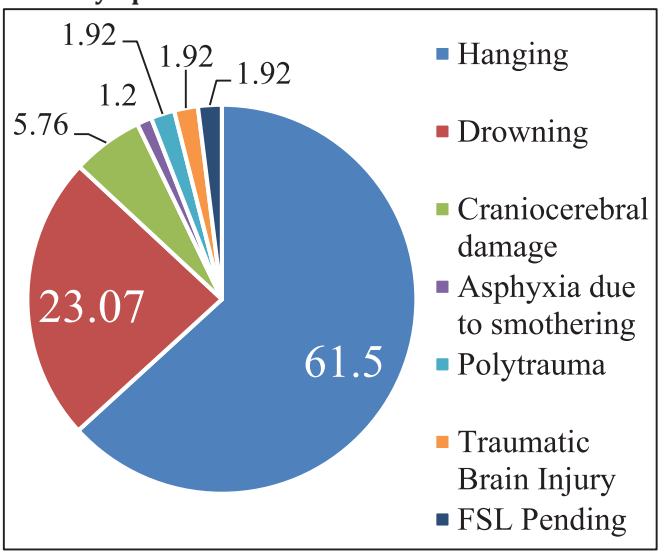
Correlation with Cause of Death:

- Hemotympanum and middle ear hemorrhage were predominantly associated with asphyxial deaths (hanging, drowning) and some cases of craniocerebral injury.
- Perforations of the tympanic membrane were closely linked to traumatic deaths, particularly those involving blast injuries.

Figure 3: Otologic Findings. A. **and** B. **Haemotymophanum.** C. **Haemotyphanum with Congestion.** D. **Perfortion**



Graph 1: Distribution of Cause of death and Haemotymphanum

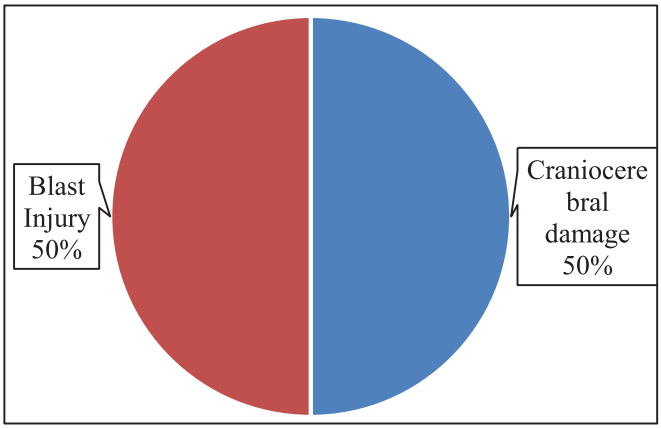


- Tympanic membrane congestion was observed in cases of electrocution and septicemia, suggesting a potential role in identifying these conditions.

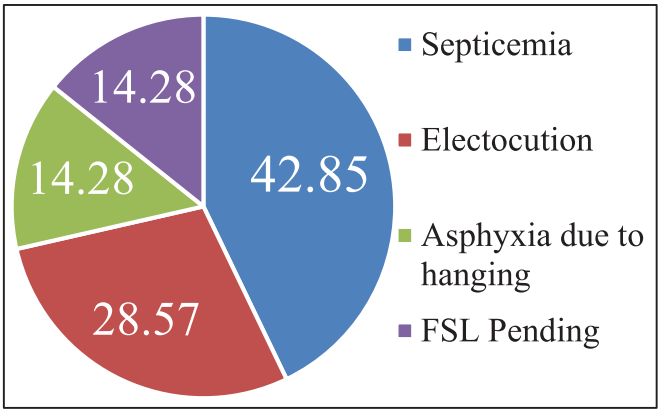
DISCUSSION

The results of this study demonstrate the forensic value of otologic investigations in medico-legal autopsies, especially when establishing the cause of death in traumatic injury and hypoxia cases. Tympanic membrane perforations in blast injuries and the regular occurrence of hemotympanum and middle ear bleeding in asphyxial deaths highlight the potential of otologic findings as useful

Graph 2: Distribution of Cause of Death and Tympanic Membrane Perforation



Graph 3: Distribution of Cause of Death and Tympanic Membrane Congestion.



indications in forensic investigations.

As a Sign of Asphyxial Deaths: Hemotympanum was found in 23.5% of the cases and was highly correlated with asphyxial deaths, especially drowning and hanging. This result is in line with earlier research by Duband S et al[4] R Amberg et al[5] which have proposed a connection between hemotympanum and asphyxial mechanisms, where increased intracranial pressure and vascular congestion result in bleeding within the middle ear.

According to Rasmussen et al. (2013), petechial hemorrhages of the tympanic membrane may really be the only indication of potentially fatal pressure on the neck, such as hanging.[6] As previously noted by Niles N.R., the development of hemotympanum in drowning cases is also consistent with the theory that vascular alterations in the middle ear may be exacerbated by the hypoxic environment and the struggle for air during submersion.[7] According to these results, hemotympanum can be a useful forensic marker for identifying asphyxia death, especially when there are no or unclear outward indications.

Tympanic Membrane Perforation in Traumatic Deaths: The effect of traumatic forces on the ear structures is highlighted by the tympanic membrane perforation that occurs in cases of blast injuries and craniocerebral injury. High-pressure shockwaves produced by blast injuries are known to quickly displace air in the ear, rupturing the tympanic membrane.Katz E et al[8] and Wolf SJ et al.[9] In these situations, the existence of tympanic membrane perforations helps to recreate the events leading up to death in addition to confirming exposure to severe traumatic pressures. This research highlights how crucial it is to perform thorough otologic tests during autopsies, particularly when there is a suspicion of trauma or explosion exposure. Tympanic membrane rupture is nearly invariably linked to blast lung injury.[10]

Hemorrhage in the middle ear and color changes in the tympanic membrane: When middle ear hemorrhage and hemotympanum are seen together, it further supports the forensic value of otologic findings. The observation of middle ear hemorrhage, especially in asphyxial deaths, lends credence to the theory that vascular compromise and elevated intracranial pressure play a key role in the emergence of such findings.(Wankhade AG (2021).[11]

Further layers of diagnostic information that can be crucial in identifying the cause of death are provided by the color changes in the tympanic membrane, such as the blue staining that indicates hemotympanum and the congestion seen in cases of septicemia and electrocution.

The mechanism of injury, according to an analysis of the cases examined by Redleaf MI and McCabe BF in "Lightning injury of the tympanic membrane," is direct electrical conduction from the scalp to the soft tissues of the external auditory canal to the tympanic membrane.[12] However, Modayil et al. (2013) noted in their assessment of the literature that the mechanism of harm after a lightning strike might differ from that after an electrical injury at home or at work.[13]

Shortcomings and Future Directions: Although the study offers valuable insights, it is crucial to recognize some of its shortcomings. The results may not be as broadly applicable as they may be because of the small sample size and the fact that the study was only carried out at one institution. Additionally, certain cases-such as those with advanced decomposition or impacted earwax-were disqualified because otologic investigations could not be performed.

To get around these obstacles, future studies should try to use a bigger, more varied sample and investigate the application of cutting-edge imaging and diagnostic methods. Additionally, more research is required to determine the frequency and seriousness of otologic abnormalities in various causes of death as well as to create uniform guidelines for their analysis in medico-legal autopsies.

CONCLUSION

This study emphasizes how crucial otologic results are for forensic purposes in medico-legal autopsies, especially when traumatic injuries and asphyxial deaths are involved. Tympanic membrane perforations in blast injuries and hemotympanum and middle ear bleeding in asphyxial deaths demonstrate the potential of these findings as

important markers of the cause of death. The findings support the regular inclusion of otologic tests in autopsy procedures since they can offer important information that might otherwise go unnoticed.

Forensic pathologists can improve the precision and thoroughness of their investigations and ultimately help determine the cause of death more precisely by incorporating otologic evaluations into routine autopsy procedures. The results of this study set the stage for further forensic otology research with the goal of improving diagnostic standards and deepening our knowledge of ear-related findings in diverse medico-legal settings.

The study's shortcomings, such as its limited sample size and procedural difficulties, emphasize the necessity of more research to confirm and broaden these conclusions. Notwithstanding these drawbacks, the study highlights the importance of otologic results in the larger framework of forensic pathology and offers a solid basis for their forensic application.

Conflict of interest\Source of funding: Nil

REFERENCES

1. Otoscopy - Statpearls - Ncbi Bookshelf [internet]. [cited 2023 Oct 21].
2. Pohlová Kučerová, Štěpánka & Hejna, Petr & Dobiáš, Martin. (2016). Význam Otoskopie V Soudnělékařské Diagnostice: Prospektivní Studie Benefits Of Otoscopy In Forensic Autopsy Practice: A Prospective Study. Soudní Lékarství / Casopis Sekce Soudního Lékarst.
3. Finkbeiner, W. E., Ursell, P. C., & Davis, R. L. (2009). Autopsy Pathology: A Manual And Atlas. Philadelphia, Pa: Saunders/elsevier.
4. Duband S, Timoshenko Ap, Morrison Al, Prades Jm, Debout M, Peoc'h M. Ear Bleeding: A Sign Not To Be Underestimated In Cases Of Strangulation. Am J Forensic Med Pathol [internet]. 2009 Jun;30(2): 175–6.
5. Amberg R, Strutz J. [differential Diagnosis Of Hematotympanum In Forensic Autopsy]. Laryngorhinootologie. 1995 May;74(5):312–6.
6. Rasmussen Er, Larsen Pl, Andersen K, Larsen M, Qvortrup K, Hougen Hp. Petechial Hemorrhages Of The Tympanic Membrane In Attempted Suicide By Hanging: A Case Report. J Forensic Leg Med. 2013 Feb;20(2):119–21.
7. Niles Nr. Hemorrhage In The Middle-ear And Mastoid In Drowning. Am J Clin Pathol [internet]. 1963 Sep;40:281–3.
8. Katz E, Ofek B, Adler J, Abramowitz Hb, Krausz Mm. Primary Blast Injury After A Bomb Explosion In A Civilian Bus. Ann Surg. 1989 Apr;209(4):484–8.
9. Wolf Sj, Bebarta Vs, Bonnett Cj, Pons Pt, Cantrill S V. Blast Injuries. The Lancet. 2009 Aug;374(9687): 405–15.
10. Avidan V, Hersch M, Armon Y, Spira R, Aharoni D, Reissman P, Et Al. Blast Lung Injury: Clinical Manifestations, Treatment, And Outcome. The American Journal Of Surgery. 2005 Dec;190(6): 945–50.
11. Wankhede Ag. Potential Usefulness Of Otoscopy In The Evaluation Of Hanging Deaths: A Report Of Two Cases. J Forensic Sci [internet]. 2021 Oct 29;
12. Redleaf Mi, Mccabe Bf. Lightning Injury Of The Tympanic Membrane. Ann Otol Rhinol Laryngol [internet]. 1993 Nov;102(11):867–9.
13. Modayil Pc, Lloyd Gw, Mallik A, Bowdler Da. Inner Ear Damage Following Electric Current And Lightning Injury: A Literature Review. Eur Arch Otorhinol-aryngol. 2014 May;271(5):855–61.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00038.4

Original Research Paper

Prevalence and Grading of Coronary Artery Stenosis: Correlation with Associated Risk Factors – An Autopsy Based Study

1. **Monika Sharma,** PG JR III*
2. **Amandeep Singh,** Professor*
3. **Uma Handa,** Professor & Head, Department of Pathology, Government Medical College & Hospital Chandigarh, India
4. **Dasari Harish,** Professor & Head*

* Department of Forensic Medicine & Toxicology, Government Medical College & Hospital Chandigarh, India

ABSTRACT

Introduction: Atherosclerosis, a major cause of cardiovascular mortality, involves plaque formation in arterial walls, leading to their narrowing and hardening. This chronic inflammatory process begins with endothelial dysfunction and low-density lipoproteins (LDL) accumulation, progressing to fatty streaks, fibrous plaques, and complicated lesions. Coronary artery stenosis (CAS), a consequence of atherosclerosis, can cause angina, myocardial infarction, heart failure and sudden death. This study investigates CAS prevalence, severity, and associated risk factors in a population of Northern India.

Materials and Method: This prospective, cross-sectional autopsy study (n=100, age ≥20) examined CAS. Hearts were examined grossly and microscopically. Coronary arteries were sectioned, processed, embedded, further sectioned and stained with haematoxylin and eosin. The compiled data was analysed using SPSS 26.0 Software

Results: Of the 100 cases studied, CAS was prevalent in 79%; 29% mild, 24% moderate, and 26% showed complicated changes. Males had higher smoking and alcohol consumption rates. Sedentary lifestyles correlated with severe atherosclerosis. Smoking, diabetes, and hypertension increased vessel involvement.

Conclusion: This study found a high CAS prevalence (79%), with severity linked to lifestyle (sedentary behaviour) and comorbidities (smoking, diabetes, hypertension). These findings emphasize the interplay of lifestyle, demographics, and comorbidities in CAS, influencing clinical practice and future research.

Corresponding Author :
Dr. Amandeep Singh, Professor, Department of Forensic Medicine & Toxicology, Government Medical College & Hospital Chandigarh, India
E-mail: dramandeep@gmail.com
Contact : +919646121610

Article History:
Received: 11 November 2024
Received in revised form: 13 January 2025
Accepted on: 13 January 2025
Available online: 15 April 2025

Keywords: Atherosclerosis; Coronary Artery Stenosis; Cardiovascular Disease; Heart Disease; Cardiac Health; Atheroma; Ischemic Heart Disease.

INTRODUCTION

Atherosclerosis, a leading cause of cardiovascular mortality, is characterized by the thickening and hardening of arterial walls due to the formation of atheromatous plaques.[1] These plaques, composed of lipids, connective tissue and inflammatory cells, primarily affect the tunica intima and media of medium-sized and large arteries, most commonly the coronary, cerebral, and aortic arteries.[2] Once considered a simple lipid accumulation disorder, atherosclerosis is now recognized as a complex, chronic inflammatory process.[3] This inflammation plays a crucial role in all stages of the disease - from initial endothelial dysfunction to plaque progression and eventual thrombotic complications.[4] Elevated inflammatory markers, such as C-reactive protein, have been shown to predict adverse cardiovascular events.[5]

The pathogenesis of atherosclerosis begins with endothelial dysfunction - loss of the endothelium's normal protective functions.[6] This dysfunction is triggered by various factors, including modified low-density lipoproteins (LDLs), which accumulate in the intima (inner layer of the artery).[7] These modified LDLs stimulate endothelial cells, leading to monocyte recruitment and differentiation into macrophages.[8] These macrophages, along with vascular smooth muscle cells (VSMCs) engulf lipids, becoming foam cells, a hallmark of early atherosclerotic lesions, known as fatty streaks.[9] This process is further fuelled by various inflammatory signalling pathways, leading to a significant build-up of lipids, both within the cells and in the extracellular matrix.

The clinical manifestations of atherosclerosis depend on the location and severity of the arterial blockage and whether the narrowing occurs acutely or gradually.[10] Gradual narrowing may allow the development of collateral circulation, but this may not always provide sufficient blood flow. Numerous modifiable and non-modifiable risk factors contribute to atherosclerosis, including age, sex, genetics, family history, smoking, obesity, physical inactivity, alcohol consumption, hypertension, dyslipidemia, diabetes mellitus, inflammation, and environmental factors. These risk factors often have a multiplicative effect on disease risk.[11]

The progression of atherosclerosis is typically described in stages: the fatty streak, characterized by lipid-laden foam cells; the fibrous plaque, where white blood cells, foam cells, and VSMCs accumulate, narrowing the arterial lumen; and the complicated lesion, which occurs when the plaque ruptures, leading to thrombus formation and potential complete occlusion of the artery.[12]

Coronary artery stenosis (CAS), the narrowing of the coronary arteries due to atherosclerotic plaque, is a major contributor to ischemic heart disease (IHD), the leading cause of death globally. The World Health Organization (WHO) estimates that cardiovascular diseases (CVDs), primarily IHD, account for 17.9 million deaths annually.[13] Atherosclerotic lesions consist of cellular components (macrophages, smooth muscle cells), extracellular lipid and connective tissue matrix, and intracellular lipid (foam cells). Neovascularization and calcification are features of advanced lesions.[14] CAS can lead to angina (chest pain), myocardial infarction (heart attack), heart failure, and sudden cardiac death.

The prevalence and severity of CAS may vary across populations due to factors such as geography, ethnicity, socioeconomic status, and lifestyle. Studies indicate that coronary artery disease occurs earlier in the Indians, compared to Western populations.[15] India bears a substantial burden of IHD, with significantly higher age-standardized death rates compared to the global average.[16] This high prevalence is attributed to a combination of traditional risk factors and emerging factors like stress, poor diet, and physical inactivity, compounded by genetic predisposition.

Advancements in diagnostic imaging, such as coronary angiography, CT angiography, and MRI, along with the integration of artificial intelligence, have improved the assessment and understanding of CAS.[17] Stenosis is graded based on the degree of arterial narrowing, ranging from minimal to complete occlusion.[18] Treatment options include medical therapy, angioplasty, and coronary artery bypass graft (CABG) surgery.[19]

Understanding the etiology, clinical impact, and epidemiology of CAS is crucial for developing effective prevention and treatment strategies. This includes promoting healthy lifestyles, managing risk factors, and implementing targeted screening programs. Recognizing the variability in risk factors across different populations is essential for tailoring interventions and optimizing resource allocation.[20]

This study aims to investigate the prevalence and severity of CAS and its correlation with various risk factors in a specific population, contributing to a more comprehensive understanding of this critical health issue and informing strategies to reduce its global burden.

MATERIALS AND METHOD

The present study was undertaken after receiving approval for the same from the Institutional Research Committee & Ethics Committee vide letter no. _GMCH/IEC/759R/2022/154 dated 18.11.2022 .This prospective, cross-sectional postmortem study, was conducted from August 2022 to Jan 2024 (1.5 years) at the departments of Forensic Medicine & Toxicology and Pathology, Government Medical College &Hospital, Chandigarh, examined 100 bodies (20 years and above, both sexes) brought for medicolegal post-mortem examination to the mortuary of the department.

The sample size was calculated based on an anticipated 6.5% CAS prevalence, resulting in a minimum of 94 cases (rounded to 100) at a 95% confidence level and 5% precision.

Inclusion: All the cases with complete history and willing to participate in this study were included in my research. Exclusion criteria included unidentified/unclaimed bodies, decomposed bodies, cases where consent was denied by the relatives of the deceased, and individuals with prior bypass grafts.

After taking consent from the next of kin, history regarding Diet, Life style, Alcohol intake, Blood pressure, history of Diabetes, etc were taken. Postmortem examination in all cases was performed as per the department protocols.

The hearts were examined both grossly and microscopically. Coronary arteries were dissected with multiple longitudinal cuts, examining ostia, lumen, and measuring

stenosis. Heart chambers, valves, and myocardium were also inspected. Tissue samples were fixed in formalin, processed, embedded in paraffin, sectioned, and stained with hematoxylin and eosin for microscopic examination in the Pathology department.

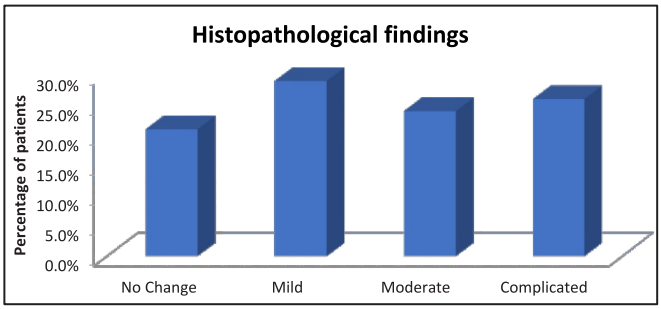
Data was analysed using SPSS version 26.0, employing descriptive statistics, correlation, and regression analysis. CAS prevalence was calculated, and its pattern tested for homogeneity using the Kolmogorov-Smirnov test.21Diagnostic accuracy (sensitivity, specificity, PPV, NPV, and overall accuracy) was also assessed using histopathology as the gold standard.

RESULTS

The study analysed the prevalence and grading of CAS and explored its correlation with various associated risk factors among a sample of 100 autopsy cases. CAS was prevalent in 79% of the cases. As regards severity, 21% showed no changes, 29% had mild atherosclerotic changes, 24% had moderate atherosclerotic changes, and 26% had complicated atherosclerotic changes as shown in table below. **(Figure 1)**

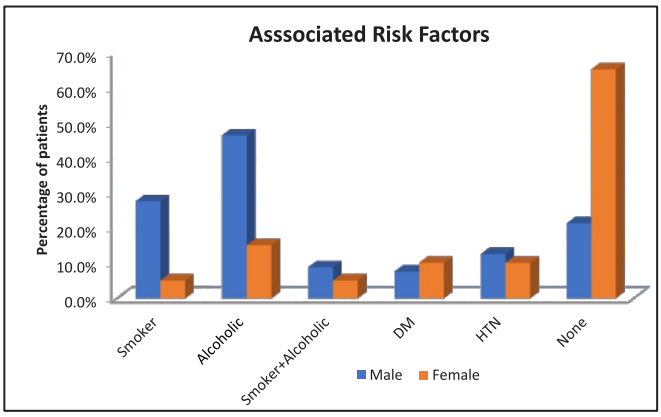
Percentage Narrowing of Lumen	Grade
0-25%	Mild
26 to 50%	Moderate
51- 75 %	Severe

Figure 1: Degree of Atherosclerosis, as per Histopathology



Males exhibited a higher prevalence of smoking and alcohol consumption compared to females. A significantly greater percentage of females had no specified risk factors contrary to males. **(Figure2)** Lifestyle analysis revealed that a sedentary lifestyle was more affiliated with moderate and complicated atherosclerosis, while individuals with a low active lifestyle were more likely to depict no change in histopathological findings. **(Figure 3)** Dietary habits indicated that non-vegetarians exhibited higher grades of atherosclerosis compared to vegetarians,

Figure 2: Associated Risk Factors, Gender-wise



although this difference was not statistically significant.

Regarding coronary vessel involvement, single and double vessel involvement was more common among smokers and alcoholics. Individuals with diabetes mellitus and hypertension also exhibited higher vessel involvement compared to those with no risk factors.**(Table 2)**

Statistical analysis showed significant associations. Gender and risk factors showed significant correlations with smoking (p = .032), alcohol consumption (p = .011), and the absence of specified risk factors (p = .0001). **(Figure 2)** Lifestyle and risk factors had a significant association with the absence of specified risk factors (p = .011). Histopathological findings correlated significantly with smoking (p = .001) and the absence of specified risk factors (p = .0001). **(Table 1)** Coronary vessel involvement was significantly associated with smoking (p=.0001), diabetes mellitus (p= .033), and the absence of specified risk factors (p=.002). **(Table 2)** Non-significant associations included dietary habits and gender (p = .682) and individual risk factors like smoking (p = .357), alcohol consumption (p = .252), diabetes mellitus (p = .374), and hypertension (p = .175) with lifestyle.

The histopathological photomicrographs from this study with findings of normal coronary artery and various stages

Figure 3: Distribution of Associated Risk Factors, Lifestyle-wise

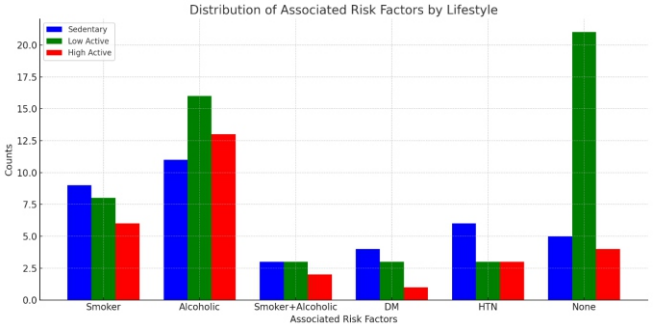


Table 1: Correlation between Associated Risk Factors and Histopathological Findings

		Histopathological Findings(n=100)										Chi-Square	p-value
		No Change		Mild		Moderate		Complicated		Total			
Associated Risk Factors		No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)		
	Smoker	2	9.5	1	3.4	10	41.7	10	38.5	23	23.0	16.645	.001**
	Alcoholic	4	19.0	16	55.2	9	37.5	11	42.3	40	40.0	6.743	.081
	Smoker + Alcoholic	1	4.8	0	0.0	2	8.3	5	19.2	8	8.0	7.280	0.063
	DM	1	4.8	2	6.9	0	0.0	5	19.2	8	8.0	6.890	0.075
	HTN	0	0.0	4	13.8	3	12.5	5	19.2	12	12.0	4.245	0.236
	None	16	76.2	7	24.1	4	16.7	3	11.5	30	30.0	28.062	.0001**
	Total	**21**	**100.0**	**29**	**100.0**	**24**	**100.0**	**26**	**100.0**	**100**	**100.0**		

Table 2: Correlation between Coronary Vessel Involvement and Risk Factors

		Involved Coronary Vessel								Chi-Square	p-value
		No Vessel Involved		Single Vessel		Double Vessel		Total			
Associated Risk Factors		No.	(%)	No.	(%)	No.	(%)	No.	(%)		
	Smoker	2	9.5	1	3.4	10	41.7	10	38.5	16.645	.001**
	Alcoholic	4	19.0	16	55.2	9	37.5	11	42.3	6.743	.081
	Smoker + Alcoholic	1	4.8	0	0.0	2	8.3	5	19.2	7.280	0.063
	DM	1	4.8	2	6.9	0	0.0	5	19.2	6.890	0.075
	HTN	0	0.0	4	13.8	3	12.5	5	19.2	4.245	0.236
	None	16	76.2	7	24.1	4	16.7	3	11.5	28.062	.0001**
	Total	**21**	**100.0**	**29**	**100.0**	**24**	**100.0**	**26**	**100.0**		

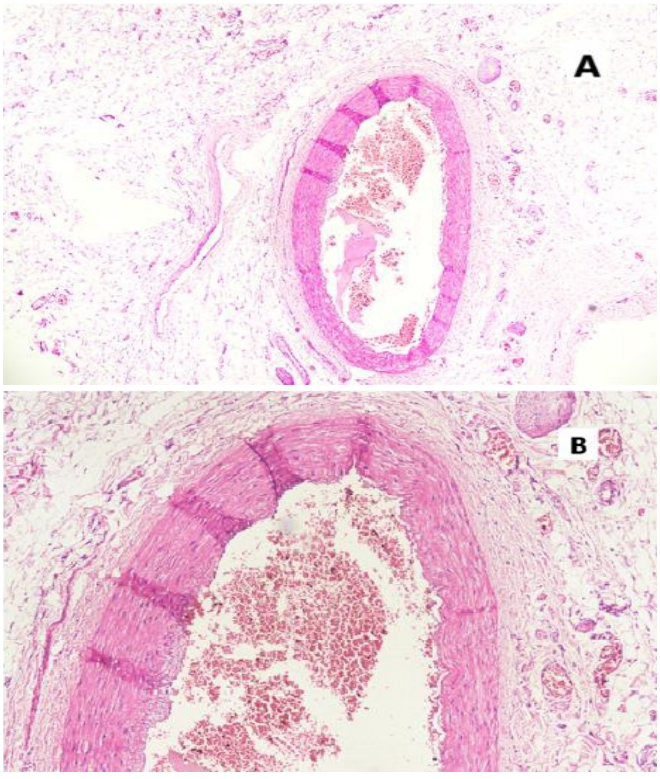
of atherosclerosis involving coronary artery including mild, moderate and complicated atherosclerosis and atheromatous plaque are shown here. **(Picture 1 to 6)**

DISCUSSION

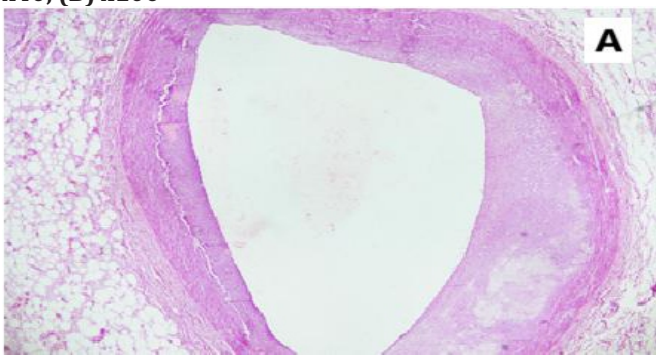
This study revealed a high prevalence of CAS, with 79% of cases exhibiting varying degrees of atherosclerotic changes, consistent with the studies of Yildiz, et al.[21] This high prevalence underscores the widespread nature of atherosclerosis, often present even in asymptomatic individuals. The distribution of atherosclerotic severity (21% no change, 29% mild, 24% moderate, and 26% complicated) highlights the spectrum of disease progression.

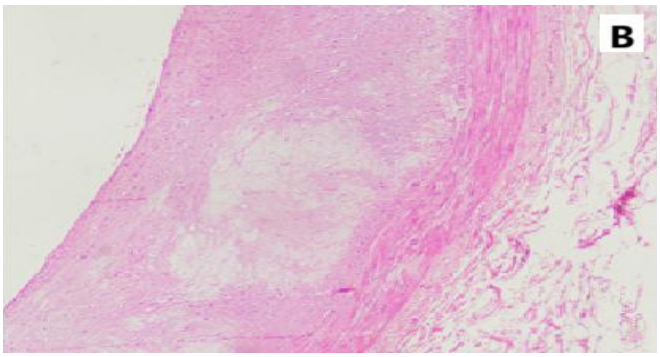
Gender played a role in risk factor profiles. Males exhibited higher rates of smoking and alcohol consumption, similar to the observations by Möller-Leimkühler,[22] while a larger proportion of females showed no specified risk factors. Statistically significant correlations between gender and their behaviour (smoking p = .032, alcohol p = .011) emphasize the need for targeted interventions, particularly for men, to mitigate CAS risk. This gender disparity suggests potentially influential factors in women

Picture 1: Showing coronary artery with no features of atherosclerosis and widely patent lumen (H&E) (A) x40, (B) x100

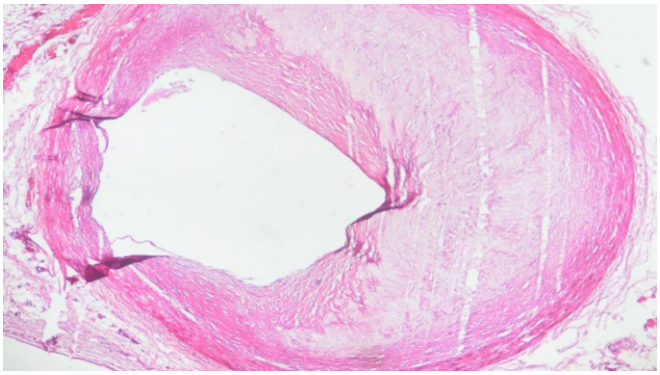


Picture 2: Coronary artery showing features of mild atherosclerosis with < 25% luminal occlusion, intimal thickening and focal lipid accumulation. (H&E)(A) x40, (B) x100

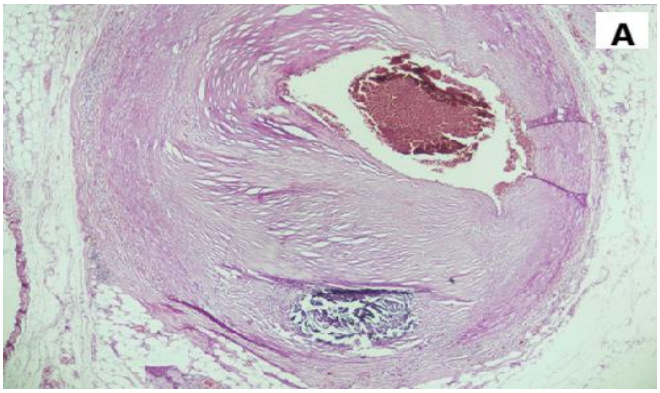


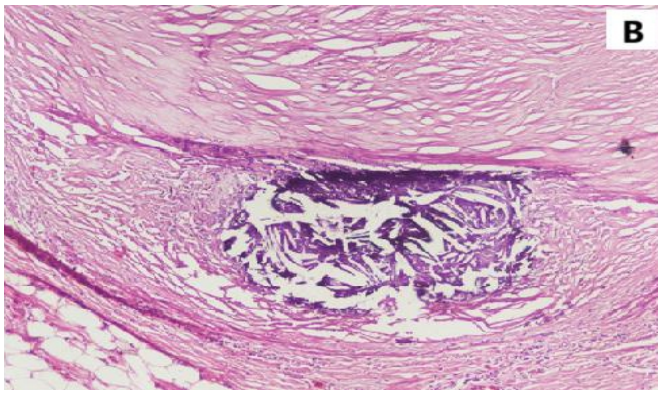


Picture 3: Coronary artery showing features of moderate atherosclerosis with atheromatous plaque showing abundant lipid and cholesterol rich core(H&E x40)

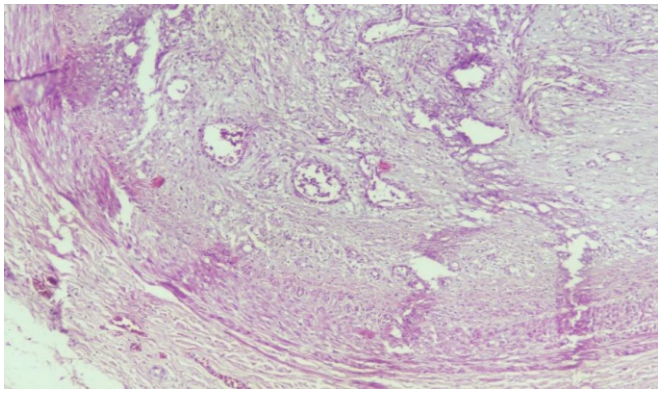


Picture 4: Coronary artery showing features of complicated atherosclerosis with atheromatous plaque having a focus of dystrophic calcification (H&E) (A) x40, (B) x100

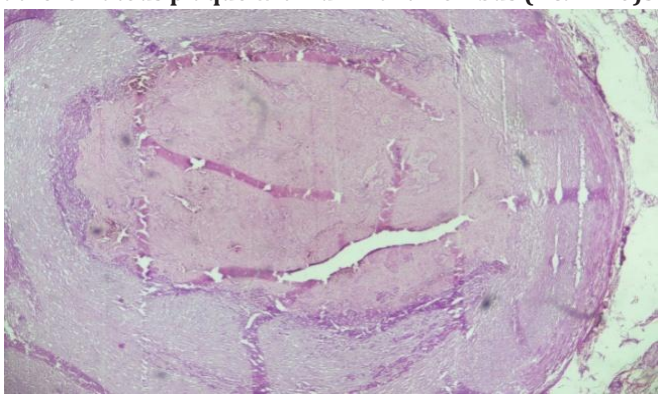




Picture 5: Coronary artery showing complicated atheromatous plaque with recanalization (H&Ex100)



Picture 6: Coronary artery showing complicated atheromatous plaque with luminal thrombus (H&E x40)S



beyond traditional risk factors, such as hormonal or genetic predispositions.

Lifestyle significantly impacted atherosclerosis. A sedentary lifestyle correlated with moderate and complicated atherosclerosis, whereas individuals with lifestyle such as stress management, good sleep, with physical activity and using less refined carbohydrates were more likely to show no histopathological changes, supporting Lechner, et al's[24] findings on the influence of physical activity on high-risk atherosclerosis. This highlights the crucial role of physical activity in preventing and delaying CAS progression.

Dietary habits also showed a trend, with non-vegetarians exhibiting higher grades of atherosclerosis compared to vegetarians, though the difference was not statistically significant, similar to the observations by Kaul, et al's[24] work on dietary habits and carotid artery stenosis, suggesting that diet interacts with other risk factors like lifestyle and genetics. The lack of statistical significance indicates the complex interplay of factors influencing CAS, requiring further research into the nuanced relationship between dietary patterns and other variables.

Coronary vessel involvement was also linked to specific risk factors. Single and double vessel involvement were more prevalent among smokers, alcoholics, and individuals with diabetes mellitus and hypertension. These findings are supported by the discussion by Ambrose and Barua[25] on smoking's pathophysiology and the established roles of diabetes and hypertension in exacerbating coronary artery disease. These associations underscore the importance of comprehensive risk factor management.

Statistical analysis revealed several significant associations: Smoking and histopathological findings (p = .001), absence of specified risk factors and histopathological findings (p = .0001), smoking and coronary vessel involvement (p = .0001), diabetes mellitus and coronary vessel involvement (p = .033), and absence of specified risk factors and coronary vessel involvement (p = .002). These strong associations emphasize the multifactorial nature of CAS and the significant impact of lifestyle, especially smoking. They also highlight the protective effect of a healthy lifestyle devoid of major risk factors. These findings reinforce the detrimental effects of smoking, the role of diabetes, and the importance of addressing modifiable risk factors.

Non-significant associations were found for dietary habits and gender (p = .682) and individual risk factors with lifestyle (smoking p = .357, alcohol p = .252, diabetes mellitus p = .374, hypertension p = .175). These findings suggest that the influence of these factors may be complex and modulated by other confounding variables, as noted in Yildiz et al.[21] This highlights the need for a more comprehensive understanding of the interplay between lifestyle, genetic, and environmental factors in CAS development. These non-significant findings do not negate the importance of these factors but suggest more nuanced relationships requiring further investigation.

CONCLUSION

This cross-sectional autopsy study of 100 cases revealed a high CAS prevalence (79%), with varying degrees of atherosclerotic changes. Males exhibited higher smoking and alcohol consumption rates, significantly correlating with these behaviours. Sedentary lifestyles were linked to more severe atherosclerosis, emphasizing the importance of physical activity. While non-vegetarians showed a trend towards higher atherosclerosis grades, it was not statistically significant. Smoking, diabetes, and hypertension significantly increased coronary vessel involvement. These findings highlight the interplay of lifestyle, demographics, and comorbidities in CAS, informing clinical practice, public health initiatives, and future research focusing on longitudinal studies and emerging risk factors.

Finally, the observationsof this study emphasize the multifactorial nature of the disease and the necessity of a holistic approach to risk factor management and prevention.

Acknowledgement: The authors are thankful to the deceased patient, relatives of the deceased patient for allowing this study voluntarily.

Conflict of Interest/Source of Funding: NIL

REFERENCES

1. Mohan H. The Blood Vessels and Lymphatics. From - Textbook of Pathology. JAYPEE-New Delhi 2017. 7th Ed.PP:373-80.
2. Reitsma S, Slaaf DW, Vink H, van Zandvoort MAMJ, Oude Egbrink M. The endothelial glycocalyx: composition, functions, and visualization. Pflugers Arch. Eur J Physiol. 2007;454:345-59.
3. Hermida N, Balligand JL. Low-density lipoprotein-cholesterol-induced endothelial dysfunction and oxidative stress: the role of statins. Antioxid Redox Signal. 2014;20:1216-37.
4. Allahverdian S, Chehroudi AC, McManus BM, Abraham T, Francis GA. Contribution of intimal smooth muscle cells to cholesterol accumulation and macrophage-like cells in human atherosclerosis. Circulation 2014;129:1551-9.
5. Stary HC, Chandler AB, Glagov S, Guyton JR, Insull W, Rosenfeld ME, et al. A definition of initial, fatty streak, and intermediate lesions of atherosclerosis. A report from the Committee on Vascular Lesions of the Council on Arteriosclerosis, American Heart Association. Circulation 1994;89:2462-78.

6. Rashid Nehal Khan, Ravi Rautji, K V Radhakrishna, Sandeep Bansal. Sudden death in a teenaged boy due to advanced coronary artery disease: A Case Report J Punjab Acad Forensic Med Toxicol 2020;20(1):155-8
7. Kumar V, Abbas AK, Aster JC, Robbins, Cotran. Pathological Basis of Disease. Elsevier-Health Science Division – Philadelphia. 20149th Ed. PP:491-96.
8. Zakkar M, O'Connell PR, McCaskie AW, Sayers RD. Cardiac Surgery. Bailey & Love's Short Practice of Surgery. CRC Press – Florida. 2023. 28th Ed. PP:947-9.
9. Vos T, Lim SS, Abbafati C, Abbas KM, Abbasi M, Abbasifard M, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet 2020;396(10258):1204-22.
10. Crowther MA. Pathogenesis of atherosclerosis. Hematology Am Soc HematolEduc Program. 2005;2005(1):436–41.
11. Watson KE, Bostrom K, Ravindranath R, Lam T, Norton B, Demer LL. TGF-β1 and 25-hydroxycholesterol stimulate osteoblast-like vascular cells to calcify. J Clin Invest 1994;93:2106-13.
12. Libby P, Ridker PM, Maseri A. Inflammation and atherosclerosis. Circulation 2002;105(9):1135-43.
13. Libby P, Theroux P. Pathophysiology of coronary artery disease. Circulation. 2005;111(25):3481-8.
14. Yusuf S, Reddy S, Ounpuu S, Anand S. Global burden of cardiovascular diseases: part I: general considerations, the epidemiologic transition, risk factors, and impact of urbanization. Circulation 2001;104(22):2746-53.
15. Mohammad AM, Jehangeer HI, Shaikhow SK. Prevalence and risk factors of premature coronary artery disease in patients undergoing coronary angiography in Kurdistan, Iraq. BMC Cardiovasc Disord 2015;15(1):1
16. Klein LW, Nathan S. Coronary artery disease in young adults. J Am Coll Cardiol2003;41(4):529-31.
17. Prabhakaran D, Jeemon P, Roy A. Cardiovascular diseases in India: current epidemiology and future directions. Circulation 2016;133(16):1605-20.
18. Gupta R, Mirza SS, Misra A, Agrawal A, Pandey RM, Rao S, et al. Increase in coronary risk factors in India: Indian national health survey, 1989-90 to 2015-16. Global Heart 2016;11(4):439-48.
19. Holmes Jr DR, Elveback LR, Frye RL, Kottke BA, Ellefson RD. Association of risk factor variables and coronary artery disease documented with angiography. Circulation 1981;63(2):293-99.
20. Doolub G, Mamalakis M, Alabed S, Van der Geest RJ, Swift AJ, Rodrigues JCL, et al. Artificial intelligence as a diagnostic tool in non-invasive imaging in the assessment of coronary artery disease. Med Sci. 2023;11(1):20.
21. Yusuf Can Sevil, Tugba Yildiz. Power comparison of the Kolmogorov-Smirnov Test under ranked set sampling and simple ramdm sampling. Journal of Statistical Computation and Simulation, 2017;87(11):1-11.
22. Yildiz A, Gurpinar S, Yagci F, Cayli E, Bayder C. Retrospective analysis of sudden cardiac deaths in a 10-year autopsy series in the city of Isparta in Turkey. Forensic Sci Med Pathol. 2020;41:263-8.
23. Möller-Leimkühler AM. Gender differences in cardiovascular disease and comorbid depression. Dialogues Clin Neurosci. 2007;9(1):71-83.
24. Lechner K, von Schacky C, McKenzie AL. Lifestyle factors and high-risk atherosclerosis: pathways and mechanisms beyond traditional risk factors. Eur J Prev Cardiol. 2020;27(4):394-406.
25. Kaul S, Alladi S, Mridula KR. Prevalence and risk factors of asymptomatic carotid artery stenosis in Indian population: An 8-year follow-up study. Neurol India. 2017;65(2):279-285.
26. Ambrose JA, Barua RS. The pathophysiology of cigarette smoking and cardiovascular disease. J Am Coll Cardiol. 2004;43(10):1731-7.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00039.0

Original Research Paper

Forensic Dating of Newspaper Inks : A Novel Approach Using ATR-FTIR Spectroscopy

1. **Ankita Pundir,** PhD Research Scholar, Forensic Science Department, Lovely Professional University, Phagwara, Punjab
2. **Meenakshi Mahajan,** Director, State Forensic Science Laboratory, Junga, HP, India
3. **Atheena Suresh,** M.Sc. Forensic Science Student, Forensic Science Department, Lovely Professional University, Phagwara, Punjab
4. **Jyoti Dalal,** Assistant Professor, Forensic Science Department, Amity University, Mohali, Punjab
5. **Neha Badhwar,** Assistant Professor, Forensic Science Department, Lovely Professional University, Phagwara, Punjab
6. **Kiran Kumari,** Assistant Professor, Forensic Science Department, Lovely Professional University, Phagwara, Punjab

ABSTRACT

Introduction: In forensic science, the accurate dating of documents, including newspapers, plays a crucial role in criminal investigations, particularly in cases involving the authenticity and timing of events. This study focuses on the aging processes of inks used in newspapers, a topic of significant interest due to its potential forensic applications. Despite the availability of simpler methods to determine publication dates, these methods often fall short when dealing with fragmentary evidence or when high precision is required. This research proposes a novel approach to dating newspaper fragments through the analysis of ink aging using Infrared Spectroscopy. The spectra were analyzed to identify changes in the chemical composition of the ink over time, with particular attention to the presence and intensity of functional group peaks. The findings indicate that the proposed method can provide a scientific basis for dating newspaper fragments with greater precision than traditional methods.

Corresponding Author :
Dr. Kiran Kumari, Assistant Professor,
Forensic Science Department,
Lovely Professional University, Phagwara, Punjab
E-mail: malikraw91@gmail.com
Contact : +918708358690

Article History:
Received: 08 August 2024
Received in revised form: 22 February 2025
Accepted on: 22 February 2025
Available online: 15 April 2025

Keywords: Fourier Transform Infrared Spectroscopy; Newspaper; Functional Group; Ink Analysis.

INTRODUCTION

Forensic document examiners (FDEs) analyze various questioned documents, including letters, cheques, identity papers, contracts, wills, insurance claims, petitions, and even threatening or suicide notes).[1-3] Their duties include searching for backdated inks, comparing different ink contributions, figuring out where the ink came from, examining the sequence in which intersecting ink entries occur, and identifying additions or changes to written information.[4]

Solid, writing, printing, inkjet, and inks for both conventional and digital printing are among the several types of inks.[5-7] Precise dating of records, such as newspapers, is essential to forensic science and is crucial to criminal investigations. Determining the timeliness and legitimacy of documents can be important in several legal situations, including alibis, forgeries, and chronological event sequence verification.[8] Newspapers are frequently the topic of forensic scrutiny because of their widespread availability and frequent usage in both public and private documentation. While contextual information and publication dates are important visual indications used in traditional methods of dating newspapers, these techniques may not be sufficient in cases where the data is incomplete or deteriorated. The exposure of ink to light, heat, and humidity among other environmental conditions causes changes in its chemical makeup over time.[9-10] These variations can be quantified and examined to determine the ink's age, offering a chronology of the document's printing.[11] When just small bits are accessible or the newspaper's physical appearance is compromised, this method is especially helpful. Because of the intricacy of the aging processes, the dating of inks problem is yet unsolved despite its potential.[12] Literature reports that Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (ATR-FTIR) is used to analyze the chemical composition of inks.[13-14] ATR-FTIR makes it possible to obtain infrared spectra from a sample's surface, giving comprehensive details about the molecular makeup of the

material, as this approach is non-destructive and can analyze even the smallest sample areas; it is very useful for ink analysis on paper .

MATERIALS AND METHOD

This study employed Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (ATR-FTIR) to analyze the aging of newspaper ink. Newspaper samples from a single edition (dated September 18, 2023) were categorized into three sections: blank areas (B1), bold-printed letters (B2), and normal-printed letters (B3), each analyzed in triplicate.

Samples (1cm × 1cm) were cleaned with a soft brush to remove surface contaminants before analysis. Baseline ATR-FTIR spectra were recorded on Day 1 (September 18, 2023) in the range of 4000–400 cm^{-1} at a resolution of 4 cm^{-1}, with 24 scans/ sample to enhance the signal-to-noise ratio. Follow-up analyses were conducted on Day 60 (November 23, 2023) and Day 120 (January 21, 2024) under identical conditions. Spectral variations in functional group peaks were analyzed to assess ink degradation over time.

RESULT AND DISCUSSION

The ATR-FTIR spectra of newspaper samples were collected on three different dates, revealing changes in key functional groups over time. The analysis revealed the presence of hydroxyl, carbonyl, and aromatic groups in the compounds, with noticeable changes in peak intensities and frequencies. These changes suggest possible chemical reactions or degradation processes occurring within the samples over time.

The blank area of the newspaper sample, designated as B1, underwent analysis for one day, sixty days, and one hundred twenty days. During these designated periods, the chemical composition of the area showed discernible variations. Common functional groups like alcohols, hydrocarbons, and ethers are stable, as they are consistently present in the blank area of the newspaper across all dates. The presence of chlorides or bromides may be indicated by peaks at 558.94 cm2 and 559.06 cm2, which are linked to halogen compounds.

The observations reveal dynamic chemical changes in the newspaper's blank section, revealing potential aging or changes over specified periods, as illustrated in **Table 1**. On the first day, the paper showed O-H stretch with hydroxyl groups, C-H stretch with aliphatic C-H stretching vibrations, and C-O stretch with C-O stretching vibrations, primarily from cellulose as shown in **Figure 1**.

On Day 60, the O-H Stretch exhibited minimal degradation, while the C-H Stretch showed negligible change, indicating the paper structures largely intact as shown in **Figure 2**. On Day 120, the O-H Stretch and C-H Stretch showed consistent stability, with no significant changes, and the C-O Stretch intensity remained stable, confirming minimal paper degradation **(Figure 3)**. The FTIR spectra of blank sections (B1) show minimal changes over 120 days, indicating the stability of cellulose in paper, which helps differentiate between ink degradation-induced changes as represent in **Table 1**.

Figure 1: FTIR Spectra Blank Area of Newspaper (B1) on Day 1

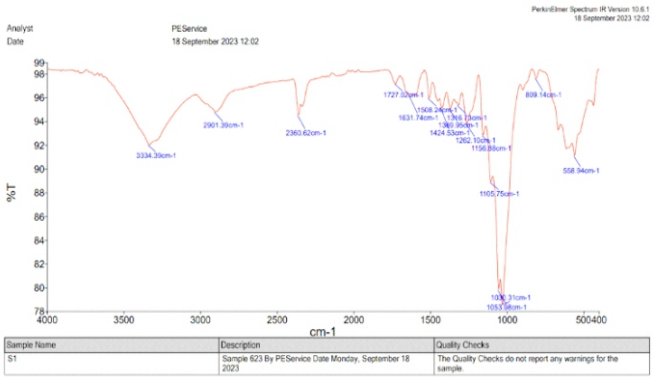


Figure 2: FTIR Spectra Blank area of newspaper (B1) on Day 60

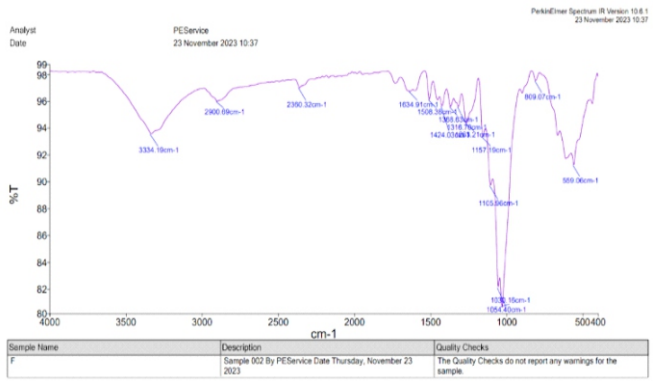


Figure 3: FTIR Spectra Blank area of newspaper (B1) on Day 120

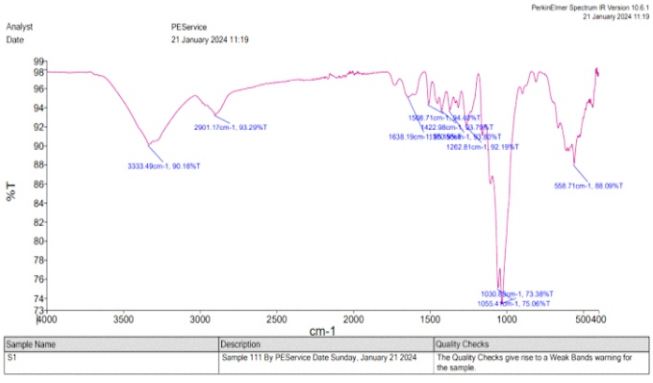


Table 1: FTIR Spectra of Blank Area of Newspaper (B1) on Day 1,60 and 120

Blank (1 day)		After 60 days		After 120 days	
Wavelength	**Functional Group**	**Wavelength**	**Functional Group**	**Wavelength**	**Functional Group**
3334.39 cm^-1	N-H stretch	3334.19cm-1	O-H stretch	3333.49cm-1, 90.16%T	O-H stretch
2901.39 cm^-1	C-H stretch	2900.69cm-1	C-H stretch	2901.17cm-1, 93.29%T	C-H stretch
2360.62 cm^-1	C=C stretch	2360.32cm-1	C≡C or C≡N	-	-
1727.02 cm^-1	C=O stretch	-	-	-	-
1631.74 cm^-1	C=N stretch	1634.91cm-1	C=C stretch	1638.19cm-1, 97.19%T	C=C stretch
1508.24 cm^-1	N-O stretch	1508.38cm-1	N-H bend	1508.71cm-1, 94.40%T	N-H bend
1424.53 cm^-1	C-C stretch	1424.03cm-1	C-H bend	1422.98cm-1, 93.79%T	C-H bending
1316.73 cm^-1	C-O stretch	1316.70cm-1	C-H stretch	1350.55cm-1, 93.80%T	C-N stretch
1262.10 cm^-1	C-N stretch	1263.21cm-1	C-N stretch	1262.81cm-1,	C-N stretch
1156.88 cm^-1	C-O stretch	1157.19cm-1	C-O stretch	-	-
1105.75 cm^-1	C-N stretch	1105.96cm-1	C-O stretch	-	-
1053.98cm-1	C-O stretch	1054.40cm-1	C-N stretch	1055.41cm-1, 75.06%T	C-N stretch
1030.31cm-1	C-O stretch	1030.16cm-1	C-H bending	1030.83cm-1, 73.38%T	C-H bending
809.14cm-1	C-Cl stretch	809.07cm-1	C-H bending	-	-
558.94cm-1	C-Br stretch	559.06cm-1	C-Br stretch	558.71cm-1, 88.09%T	C-Cl or C-Br stretch

Printed Bold Letters (B2)

The FTIR spectrum of newspaper sample B2 confirmed the presence of organic compounds in bold letter ink, including ethers, amines, alcohols, carbonyls, hydrocarbons, and aromatics. Functional groups such as O-H, C-H, and ether-related peaks were observed, along with halogen compounds (bromides, chlorides).

Wide peaks indicate evolving C-H bending/stretching patterns. The absence or reduction of specific functional groups suggests chemical composition shifts over time. These findings highlight the dynamic nature of ink in bold letter printing and provide insights into its changing composition **(Table 2)**.

On Day 1, the ink's aromatic C=C stretch, carbonyl groups' C=O stretch, and C-H bending vibrations were observed, with peak values around 1600 cm^{-1}, 1700 cm^{-1}, and 1450-1500 cm^{-1} respectively **(Figure 4)**. On Day 60, the ink's aromatic C=C stretch shows a slight decrease in intensity, indicating initial degradation of aromatic compounds, carbonyl-containing compounds, and minor changes in aliphatic components **(Figure 5)**. On Day 120, the ink's aliphatic components showed continued degradation, with a reduction in peak intensity indicating the ongoing degradation of aromatic compounds, carbonyl compounds, and C-H bend **(Figure 6)**.

The FTIR spectra of bold printed sections (B2) show significant changes over 120 days, indicating a faster degradation rate of ink components in bold printed areas

Figure 4: FTIR spectra Printed Bold Letters Area of Newspaper (B2) on Day 1

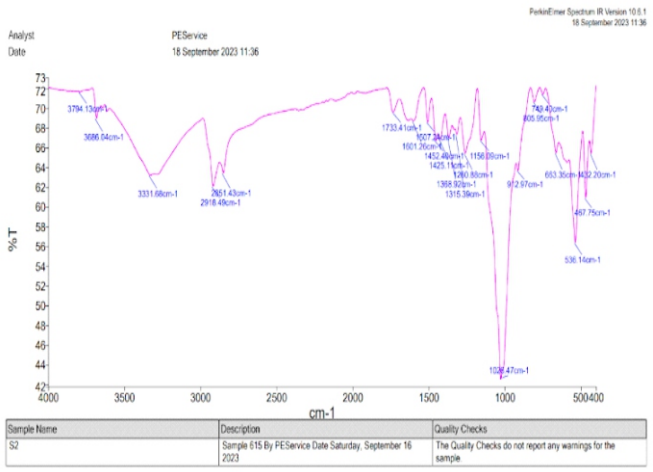


Figure 5: FTIR Spectra Printed Bold Letters Area of Newspaper (B2) on Day 60

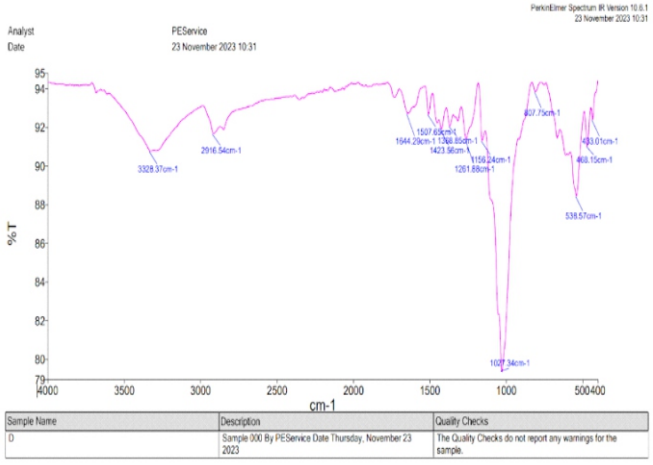
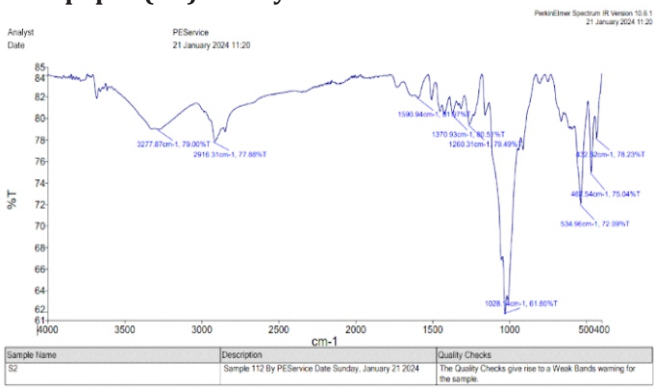


Figure 6: FTIR Spectra Printed Bold Letters Area of Newspaper (B2) on Day 120



compared to blank sections.

Printed Normal Letters (B3)

The FTIR spectrum of normal printed newspaper samples identifies chemical groups like N-H, O-H, C=O, C=C, C-N, Cl, and Br. Consistent O-H and C-H peaks indicate alcohols, hydrocarbons, and ethers, while variations in peak intensity suggest chemical changes over time. Broad peaks at 3687.47cm^{-1} and 2360.72cm^{-1} indicate possible molecular shifts. The reduction or absence of specific functional groups highlights composition changes due to aging or environmental factors. These findings provide insights into the evolving chemical makeup of normal letter printed areas **(Table 3)**.

On the first day, the ink exhibited aromatic C=C stretch, C=O stretch, and C-H bend vibrations, with peak intensity around 1600 cm^{-1}, 1700 cm^{-1}, and 1450-1500 cm^{-1}, respectively **(Figure 7)**. On Day 60, slight changes in intensity suggest initial degradation, with minor reductions indicating early stages, and small changes in intensity indicating some degradation **(Figure 8)**. On Day 120, the aromatic C=C stretch showed a reduction in peak intensity, indicating ongoing degradation, while the C=O stretch and C-H bend also showed a decrease in intensity **(Figure 9)**.

Table 2: FTIR Spectra of Printed Bold Letters Area of Newspaper (B2) on Day 1,60 and 120 Days

Bold letter (1 days)		Bold Letter (60 days)		Bold Letter (120 days)	
Wavelength	**Functional Group**	**Wavelength**	**Functional Group**	**Wavelength**	**Functional Group**
3794.13cm-1	N-H stretch (secondary amine)	-	-	-	-
3686.04cm-1	O-H stretch (carboxylic acid)	-	-	-	-
3331.68cm-1	O-H stretch (carboxylic acid, alcohol)	3330.13cm-1	O-H stretch	3277.87cm-1, 79.00%T	O-H stretch
2918.49cm-1	C-H stretch (alkane, alkene, alkyne)	2900.52cm-1	C-H stretch	2916.31cm-1, 77.88%T	C-H stretch.
2851.43cm-1	C-H stretch (alkane, alkene, alkyne)	-	-	-	-
1733.41cm-1	C=O stretch (carbonyl)	-	-	-	-
1601.26cm-1	C=C stretch (alkene, aromatic ring)	1644.34cm-1	C=C stretch	1590.94cm-1, 81.97%T	C=C stretch
1507.24cm-1	C-C stretch (aromatic ring)	-	-	-	-
1452.40cm-1	C-H bend (alkane)	-	-	-	-
1425.11cm-1	C-H bend (alkane)	1422.96cm-1	C-H bending	1370.93cm-1, 80.51%T	C-H bending.
1368.92cm-1	C-N stretch (amine)	-	-	-	-
1315.39cm-1	C-C stretch (alkane)	-	-	-	-
1260.88cm-1	C-N stretch (amine	1260.31cm-1, 79.49%T	C-N stretch	1260.31cm-1, 79.49%T	C-N stretch
1156.09cm-1	C-O stretch (ether	1159.49cm-1	C-O stretch	-	-
1026.47cm-1	C-O stretch (ether)	1028.64cm-1	C-N stretch	1028.14cm-1, 61.80%T	C-N stretch
912.97cm-1	C-H bend (alkane)	-	-	-	-
805.95cm-1	C-H out-of-plane bending (aromatic)	875.17cm-1	C-H bend.	-	-
749.40cm-1	C-H out-of-plane bending (aromatic)	-	-	-	-
663.35cm-1	C-H bend (alkane)	-	-	-	-
536.14cm-1	C=O stretch	555.35cm-1	C-Cl or C-Br stretch	534.96cm-1, 72.09%T	C-Cl or C-Br stretch

Figure 7: FTIR Spectra of Printed Normal Letters Area of Newspaper (B3) on day 1

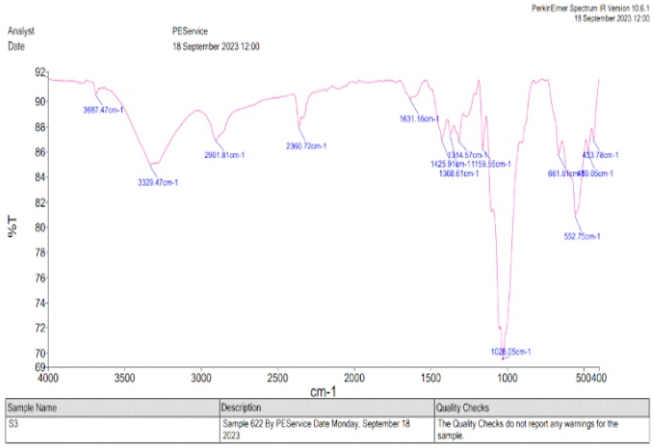


Figure 8: FTIR Spectra of Printed Normal Letters Area of Newspaper (B3) on Day 60

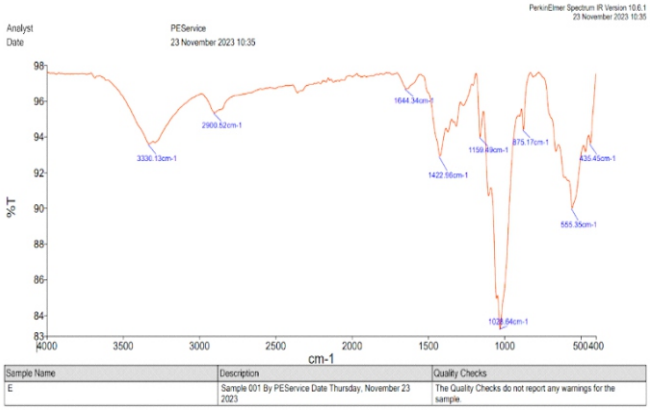
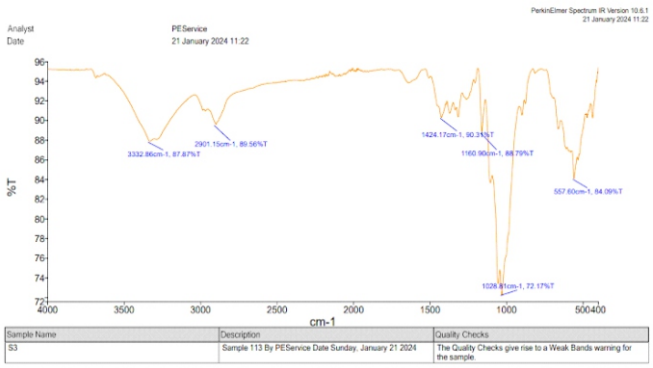


Figure 9: FTIR Spectra of Printed Normal Letters Area of Newspaper (B3) on Day 120



The decrease in peak intensities associated with functional groups such as C=C (aromatic ring), C=O (carbonyl), and C-H bending vibrations indicates the continuous degradation of the ink components this observation is consistent with prior research on the photodegradation and oxidation of ink compounds,[8-9] and this degradation in bold letters is likely due to the higher concentration of ink present which is more like getting oxidized and undergoing environmental influences which aligns with the findings of previous researches.[15]

CONCLUSION

This study explores the use of Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (ATR-FTIR) for

Table 3: FTIR Spectra of Printed Normal Letters Area of Newspaper (B3) on Day 1, 60 and 120 Days.

Normal Letter (1 Day)		Normal Letter (60 Days)		Normal Letter (120 Days)	
Wavelength	**Functional Group**	**Wavelength**	**Functional Group**	**Wavelength**	**Functional Group**
3687.47cm-1	N-H stretch	3328.37cm-1	O-H stretch	3332.86cm-1, 87.87%T	O-H stretch
3329.47cm-1	O-H stretch	2916.54cm-1	C-H stretch	-	-
2901.81cm-1	C=O stretch	2901.15cm-1, 89.56%T	C-H stretch.	2901.15cm-1, 89.56%T	C-H stretch.
2360.72cm-1	C=C stretch	-	-	-	-
1631.16cm-1	C-N stretch	1644.29cm-1	C=C stretch	-	-
1425.91cm-1	C=C stretch	1423.56cm-1	C-H bending.	1424.17cm-1, 90.31%T	C-H bend
1368.61cm-1	C-O stretch	1368.85cm-1	C-N stretch	-	-
1314.57cm-1	C-N stretch	-	-	-	-
1159.55cm-1	C-C stretch	1156.24cm-1	C-O stretch	1160.90cm-1, 88.79%T	C-O stretch
1028.05cm-1	C-O stretch	1027.34cm-1	C-H bend	1028.81cm-1, 72.17%T	C-N stretch
661.81cm-1	C-Br stretch	-	-	-	-
552.75cm-1	C-Cl stretch	557.60cm-1, 84.09%T	C-Br or C-I stretching	557.60cm-1, 84.09%T	C-Br or C-I stretching
538.57cm-1	C-Cl or C-Br stretching	538.57cm-1	C-Cl or C-Br stretching	-	-
468.15cm-1	C-Cl stretch	468.15cm-1	C-Cl stretch	-	-
433.01cm-1	C-Br stretch	433.01cm-1	C-Br stretch	-	-

dating newspaper fragments by analyzing the aging of inks. The research demonstrates that ATR-FTIR effectively detects chemical changes in newspaper ink over 120 days, providing a more precise dating method than traditional techniques. Key contributions include a methodological framework for forensic ink dating and insights into its forensic applicability.

Although results of this study were promising, certain limitations could be there as this study was conducted under controlled conditions, but in the real-world various environmental factors such as humidity, temperature changes, and exposure to different light sources may further influence ink aging. Future research could be concentrated on extended aging periods and examine the impact of diverse environmental conditions on ink degradation. Additionally, studying different newspaper brands and ink formulations will help in generalization of the findings.

Conflicts of Interest\Funding: Nil

Acknowledgments: Authors pay hearty gratitude to the faculty of Central Instrument Laboratory, Lovely Professional University, Phagwara (Punjab) for providing instrument facility.

REFERENCES

1. Sharma DB. Forensic science in criminal investigation & trials. Universal Law Publishing Company; 2005.
2. Purba, Mandeep Kaur, Shruti Gupta, Reeta Rani Gupta, and S. K. Shukla. A survey of techniques used for Ink examination. Journal of Punjab Academy of Forensic Medicine and Toxicology.2019; 19 (1): 155-161.
3. Ellen D, Day S, Davies C. Scientific examination of documents: methods and techniques. CRC Press; 2018.
4. Calcerrada M, García-Ruiz C. Analysis of questioned documents: A review. Analytica Chimica Acta. 2015;853:143–66.
5. Yuen CWM, Ku SKA, Choi PSR, Kan CW, Tsang SY. Determining Functional Groups of Commercially Available Ink-Jet Printing Reactive Dyes Using Infrared Spectroscopy. Research Journal of Textile and Apparel 2005;9:26–38.
6. Sharma N, Agarwal A, Negi Y, Bhardwaj H, Jaiswal J. History and Chemistry of Ink—A Review. World Journal of Pharmaceutical Research. 2014;3:2096-105.
7. Pathak DR. Determination of the Sequence of Strokes Made from the Same Color and Type of the Ink. Punjab Academy of Forensic Medicine & Toxicology.2018: 50-53.
8. Kapoor N, Sulke P, Shukla RK, Kakad R, Pardeshi P, Badiye A. Forensic analytical approaches to the dating of documents: An overview. Microchemical Journal 2021;170.
9. Islek DS, Cengiz S. Ink Dating On Documents Aging Due To Environmental Factors Using Tdgc/Ms and HPLC –UV. Feb Fresenius Environmental Bulletin. 2020: 8689.
10. Brunelle RL, Crawford KR. Advances in the forensic analysis and dating of writing ink. Charles C Thomas Publisher; 2003.
11. Bhattacharya, Nikita, Amrita Dey, and Spriha Sharma. Forensic Discrimination of Blue Gel Pen Inks by UV-Visible Spectroscopy and Chemometrics. Journal of Punjab Academy of Forensic Medicine and Toxicology. 2024: 98-103.
12. Said HM, Ismail D. Study on the effect of ageing to gel pen ink on papers using attenuated reflectant mode fourier transform infrared (ATR-FTIR) spectroscopy. The international Journal of Medicine and Sciences 2018;3:38–43.
13. Reed G, Daeid NN, Savage K. The discrimination of black gel inks by FTIR--ATR and the application of a statistical methodology to achieve objective classification. Group. 2012;900:1.
14. Gawad AA, Salama TM, Meshref M, Mohamed GG, Zedan AF. Coupling ATR-FTIR Spectroscopy and Chemometric Analysis for Rapid and Non-Destructive Ink Discrimination of Forensic Documents. Egyptian Journal of Chemistry. 2022;65:471–81.
15. Weyermann C, Almog J, Bügler J, Cantu AA. Minimum requirements for application of ink dating methods based on solvent analysis in casework. Forensic Science International. 2011;210:52–62.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00040.1

Original Research Paper

Anthropometric Correlation of Odontometric Parameters with The Stature of a Person – A Forensic Evaluation

1. **Sonali Khatri,** Post Graduate Student*
2. **Shally Gupta,** Professor & Head*
3. **Anubha Gulati,** Associate Professor*
4. **Simranjit Singh,** Senior Assistant Professor*

*Department of Oral and Maxillofacial Pathology and Microbiology, Dr Harvansh Singh Judge Institute of Dental Sciences, Panjab University, Chandigarh, India

ABSTRACT

Introduction: Stature, defined as height in an upright position, has established correlations with various bones and bone fragments. This study aimed to explore the anthropometric correlation between odontometric parameters and stature. Given the common origin of teeth and bones as hard tissues, this research sought to establish a correlation between odontometric parameters and stature. The study aimed to devise regression formulas for stature estimation using selected odontometric parameters.

Materials and Method: The study involved 162 subjects (82 males and 82 females) aged 18–45 years. A digital Vernier callipers was used on the study models recorded from the subjects' mouths to record the odontometric parameters, while stature was measured using an anthropometer. Regression equations derived from the first 82 individuals were applied to the remaining 82 to validate the derived equations.

Results: Regression analysis revealed a significant correlation of body height with maxillary intercanine width, mesiodistal width, and cervicoincisal length of maxillary and mandibular canines for the combined group (males and females). Additionally, the labiolingual width of mandibular canines in females significantly correlated with stature.

Conclusion: The derived equations present a promising avenue for stature estimation and warrant further exploration in the interdisciplinary realm of dental and forensic sciences. Encouraging additional research in this field can advance our understanding and application of odontometric parameters in stature calculations of unidentified persons.

Corresponding Author :
Dr. Sonali Khatri, Post Graduate Student
Department of Oral and Maxillofacial Pathology and Microbiology, Dr Harvansh Singh Judge Institute of Dental Sciences, Panjab University, Chandigarh, India
E-mail: sonaliviolet@yahoo.com
Contact : +919530570720

Article History:
Received: 11 October 2024
Received in revised form: 05 January 2025
Accepted on: 05 January 2025
Available online: 15 April 2025

Keywords: Forensic; Anthropometric; Regression; Stature.

INTRODUCTION

"The unspoken and unseen are unfolded by forensics."

Forensic odontology, derived from the Latin forensis (forum or court of law) and odontology (study of teeth), serves as a cornerstone of criminal investigations by leveraging dental evidence in legal contexts.[1,2] Central to forensic analysis is person identification, a multifaceted process essential for recognizing victims, suspects, or individuals lost in natural disasters.

This becomes particularly vital when dealing with unidentified bodies or fragmented remains, necessitating connections to missing persons or crime victims.[3]

The identification process begins with constructing a physical profile based on age, sex, race, and stature-the "Big Four" of forensic anthropology. In cases where antemortem records are unavailable, methods such as visual examination, fingerprint analysis, DNA profiling, and anthropometry—the scientific measurement of body dimensions-play pivotal roles.[2,3]

When skeletal remains are absent, odontometric parameters serve as an alternative to traditional stature estimation methods, which typically depend on long bones. Teeth dimensions provide an alternative due to their genetic and environmental dependence, influenced

by factors like race and ethnicity.[4,5]

Teeth are uniquely resilient to extreme conditions such as decomposition or mutilation, making them indispensable in reconstructive identification when conventional methods fail.[3] Canines, often the least extracted and most durable teeth, are frequently encountered in forensic and archaeological contexts.

Studies have explored correlations between tooth dimensions and stature, revealing statistically significant relationships that enhance forensic methodologies. For instance, research has identified intercanine width and crown length as reliable parameters for stature estimation in diverse populations.[5-7]

This study aimed to refine stature estimation methods by analysing correlations between maxillary and mandibular canine dimensions and body height. Through the development of precise regression formulas based on these relationships, it sought to contribute practical applications for forensic medicine and disaster management. These findings underscore the anthropometric significance of odontometric parameters in advancing identification techniques and improving disaster response strategies.[4,5]

MATERIALS AND METHOD

The study was designed as a cross-sectional exploration conducted at the Department of Oral and Maxillofacial Pathology & Microbiology in the Dr. Harvansh Singh Judge Institute of Dental Sciences and Hospital at Panjab University, Chandigarh, India with a primary objective to discern correlations within specific parameters.

It was approved by Institutional Ethics Committee, Panjab University (PUIEC) on 06.04.2021 (Ref No: EC-D-2103-40). The duration of study was 1.5 years with 01.06.2021 and 30.12.2022 as commencement and completion dates respectively.

The determination of the sample size was influenced by a correlation coefficient of 0.35 with a confidence level of 90%. To ensure statistical reliability, standard normal distribution values ($Z\alpha = 1.9600$ and $Z\beta = 1.2816$) were used to calculate the correlation transformation factor ($C = 0.3654$), determining a sample size of 164.

The study recruited 164 participants (82 males, 82 females) from the outpatient department and dental institute students. The sample was divided into two equal groups of 82 individuals each. The first group's data was used to derive regression equations, which were then validated using the second group, ensuring the accuracy and reliability of the findings.

Subject Selection: The study protocol was explained to each subject, and signed informed consent was obtained. Subjects were selected based on the following:

Inclusion Criteria:

- Fully erupted maxillary and mandibular anterior teeth that were periodontally healthy, intact, not carious, and aligned normally.
- No history or clinical indications of cleft lip and palate, orthodontic treatment, or trauma.
- No history or clinical indications of endocrine, metabolic, or protracted disease.
- Minimal to no wear on the incisal aspect of teeth.

Exclusion Criteria:

- Grossly decayed teeth
- Teeth with severe attrition and abrasion
- Fractured teeth
- Non-vital teeth
- Restored or root canal-treated teeth
- Teeth with root caries
- Patients with Interdental spacing

PROCEDURE

1. Measurement of Stature:

Stature was measured using an anthropometer, with subjects standing barefoot against a straight wall, ensuring alignment of heels, shoulders, and head curvature. The anthropometer's movable rod was positioned at the vertex of the head, and height readings were taken three times. The mean of these measurements was used as the final stature value.

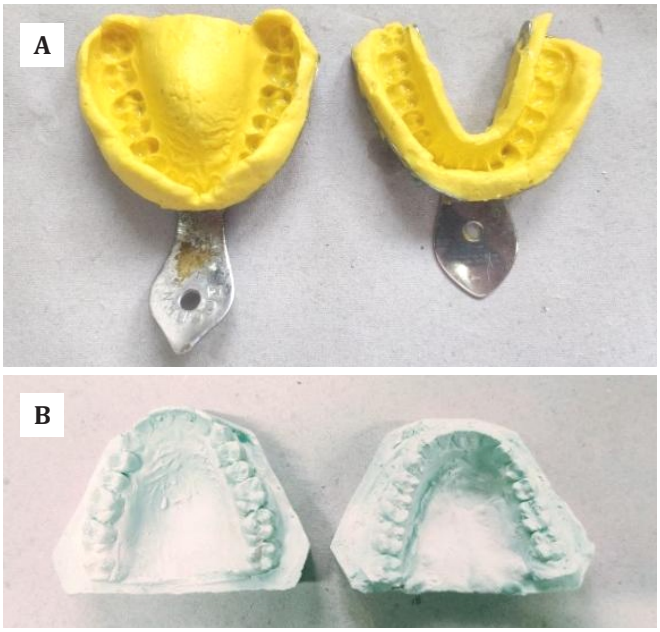
2. Recording Impressions

The patient was seated on the dental chair, and impressions were recorded for both maxillary and mandibular arches using irreversible hydrocolloid impression material. The casts were poured using dental stones. **(Figure 1A** and **Figure 1B)**

3. Measurements of Required Tooth Parameters:

A Digital Vernier callipers (accurate up to 0.01mm), disinfected with isopropyl alcohol was used for measuring odontometric parameters on the casts. The following parameters were recorded:

Figure 1: A) Impressions using Alginate B) Study Models Made in Dental Stone.



a) Intercanine Width (Maxillary and Mandibular):

Measured at the cusp tips of permanent canines from the left to the right quadrants.

b) Canine Dimensions (Maxillary and Mandibular):

i. Mesiodistal (MD): Measured at contact points on a line parallel to the occlusal plane.

ii. Labiolingual (LL): Measured at the crest of curvatures perpendicular to and bisecting the line defining the mesiodistal dimension.

iii. Cervicoincisal (CI): Clinical crown length measured from the cusp tip of the canines to the crest of the gingival margin.

All measurements were recorded by a single examiner and were taken thrice for each parameter. The mean value was recorded to minimise error. All measurements were calibrated in millilitres. **(Figure 2** and **Figure 3)**

4. Correlation of Obtained Results:

The estimated height obtained by odontometric methods from the first half of the subjects was correlated with the actual height of these subjects. The regression formulas obtained were then applied to calculate the height of the remaining half of the blinded samples.

OBSERVATIONS AND RESULTS

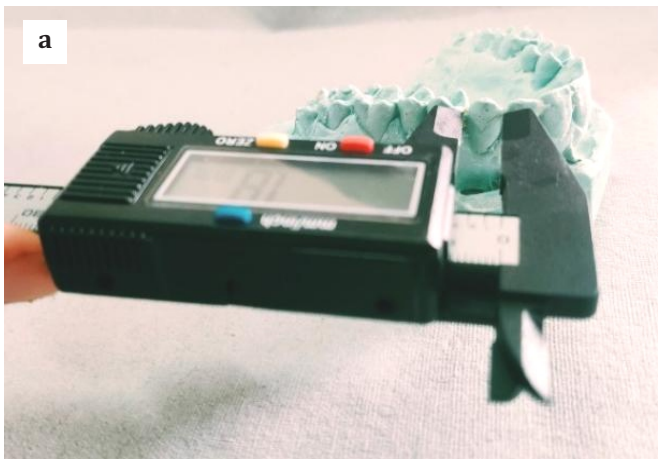
In the initial phase of the study, data encompassing body height and eight odontometric parameters were recorded, organized in Microsoft Excel, and subjected to statistical

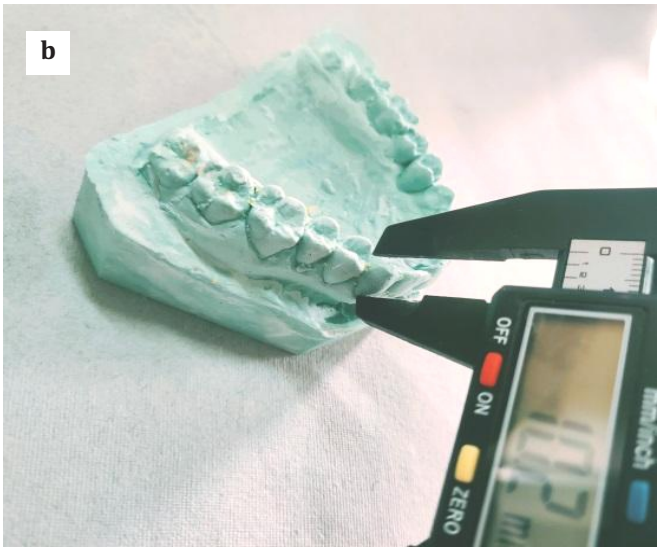
Figure 2: Measurement of Inter-canine using Digital Vernier Callipers.

analysis to evaluate correlations with individual height and derive regression formulas for significant parameters. Statistical computations were performed using SPSS version 20 (IBM SPSS Statistics Inc., Chicago, USA), employing descriptive statistics such as mean and standard deviation, alongside chi-square tests for sensitivity and accuracy assessments.

The dataset was verified for normality and found to be normally distributed. Key descriptive metrics, including mean, median, standard deviation, and the range of maximum and minimum values for each parameter, were calculated to facilitate further analysis **(Table 1)**. In this study, body height served as the dependent variable, while eight odontometric parameters were independent variables. A significance threshold of $p \leq 0.05$ was established.

Figure 3: Measurements of canine dimensions using digital Vernier calipers (a) Mesiodistal width (b) Labiolingual width (c) Cervicoincisal length.





To quantify correlations between odontometric parameters and stature, multiple linear stepwise regression analysis was employed, complemented by Pearson's correlation coefficient (r) to measure the strength and direction of relationships. Correlation values ranged from -1 (perfect negative correlation) to +1 (perfect positive correlation), with a value of 1 indicating self-correlation. **(Table 2)**

The analysis identified parameters exhibiting significant positive and negative correlations across combined data and separate groups. **Table 3** summarizes these findings, including r-values, r2, and adjusted r2, which explained variations of 7.5–7.9% in combined groups and 4.7% in females for the dependent variable (body height). The F-ratio further confirmed that the regression model provided a robust fit for evaluating the data.

The regression formulas that were derived by applying simple linear regression to correlate each parameter separately are as follows:

FOR COMBINED DATA (GROUPS)

1. Body Height (Cm) = 114.277+ 1.487 * Maxillary Intercanine Width
2. Body Height (Cm) = 131.774+ 4.503/Maxillary Canine Dimensions (MD)
3. Body Height (Cm) = 146.454+ 2.148 * Maxillary Canine Dimensions (CI)
4. Body Height (Cm) = 150.446+ 2.256 * Mandibular Canine Dimensions (MD)
5. Body Height (Cm) = 145.338+ 2.267 * Mandibular Canine Dimensions (CI)

FOR FEMALES

1. Body Height (Cm) = 183.513-3.410*Mandibular Canine Dimensions-LL

   This simulates the basic derivation:

   Y = C + MX

   Y = dependent variable (estimated height)

   C= Constant

   M = regression coefficient

   X = independent variable (odontometric parameters)[8]

Table 1: Descriptive Statistics of the First Set of Data Consisting of Nine Recorded Parameters

Wavelength	N	Mean	Std. Deviation	Median	Minimum	Maximum
Maxillary Intercanine Width (mm)	82	34.33	±2.11	34.40	29.70	39.80
Mandibular Intercanine Width (mm)	82	26.05	±1.69	26.20	21.20	29.00
Maxillary Canine Dimension-MD (mm)	82	7.45	±.57	7.50	6.10	8.80
Maxillary Canine Dimensions-LL (mm)	82	8.02	±.71	8.00	6.10	10.00
Maxillary Canine Dimensions-CI (mm)	82	8.80	±1.07	8.60	7.10	12.00
Mandibular Canine Dimension-MD (mm)	82	6.61	±.80	6.50	4.80	9.00
Mandibular Canine Dimensions-LL (mm)	82	7.34	±.76	7.30	5.30	9.20
Mandibular Canine Dimensions-CI (mm)	82	8.82	±1.00	8.85	7.30	12.50
Body Height (cm)	82	165.35	±8.12	166.20	149.10	190.00

Table 2: Correlation Analysis for Various Odontometric Parameters with Body Height.

Correlations				
		Body Height (Cm)		
		Combined	Male	Female
Maxillary Intercanine Width(mm)	Pearson Correlation	.386**	.164	.192
	p-value	.000	.305	.230
Mandibular Intercanine Width(mm)	Pearson Correlation	.166	.109	-.205
	p-value	.136	.497	.198
Maxillary Canine Dimensions-MD(mm)	Pearson Correlation	.313**	.217	.258
	p-value	.004	.173	.104
Maxillary canine dimensions-LL(mm)	Pearson Correlation	.161	-.149	.112
	p-value	.148	.353	.486
Maxillary canine dimensions-CI(mm)	Pearson Correlation	.282*	-.104	-.023
	p-value	.010	.517	.887
Mandibular Canine Dimensions-MD(mm)	Pearson Correlation	.221*	.050	-.013
	p-value	.046	.757	.934
Mandibular canine dimensions-LL(mm)	Pearson Correlation	.213	.049	-.409**
	p-value	.054	.763	.008
Mandibular canine dimensions-CI(mm)	Pearson Correlation	.280*	.205	-.053
	p-value	.011	.200	.744

The derived equations were applied to the second set of subjects using a single-blinded method, where actual heights were recorded but kept hidden from the examiner. Estimated heights were calculated by inputting data into the formulas **(Table 4)**. The correlation test revealed a significant association between actual and estimated body heights.

Notably, certain tooth dimensions deviated from expected norms. For instance, the mesiodistal width of mandibular canines in females reached up to 9mm, surpassing both male values and the typical range of 7mm. Conversely, the minimum cervicoincisal lengths for maxillary and mandibular canines were 7.1mm and 7.3mm, respectively, falling below the standard values of 10mm and 11mm.

DISCUSSION

Reconstructing a physical profile through factors like age, sex, race, and stature is critical in forensic identification, enabling the narrowing of victim pools through elimination processes. Stature estimation, a key component of this process, often relies on odontometric

Table 3: Linear Regression Model Summary and Overall Fit Statistics for the Dependent Variable Actual Body Height with Independent Variables for (a) Combined- Males and Females, (b) Females.

(a) Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Std. Error of the Estimate	Change Statistics			
						F Change	df 1	df 2	Sig. F Change
Combined	0.386	.149	.138	7.54201	.149	13.980	1	80	.000
Combined	0.313	.098	.087	7.76246	.098	8.718	1	80	.004
Combined	0.282	.079	.068	7.84299	.079	6.906	1	80	.010
Combined	0.221	.049	.037	7.97195	.049	4.117	1	80	.046
Combined	0.28	.079	.067	7.84707	.079	6.815	1	80	.011

(b) Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df 1	df 2	Sig. F Change
Females	0.409	.168	.146	4.70954	.168	7.857	1	39	.008

Table 4: Correlation Analysis for Actual and Estimated Body Height.

Correlations		
		Actual Height (cm)
Estimated height (cm) (Maxillary Intercanine width)	Pearson Correlation	.223*
	p-value	.044
	N	82
Estimated height (cm) (Maxillary Canine-MD)	Pearson Correlation	.540**
	p-value	.000
	N	82
Estimated height (cm) (Maxillary Canine-CI)	Pearson Correlation	.203
	p-value	.068
	N	82
Estimated height(cm) (Mandibular Canine-CI)	Pearson Correlation	.017
	p-value	.877
	N	82
Estimated height (cm) (Mandibular Canine-MD)	Pearson Correlation	.269*
	p-value	.015
	N	82
Estimated height (cm) (Mandibular Canine-LL)-Female	Pearson Correlation	.323*
	p-value	.039
	N	41
**. Correlation is significant at the 0.01 level (2-tailed).		
*. Correlation is significant at the 0.05 level (2-tailed).		

(b) Coefficients								
		Unstandardized Coefficients		**Standardized Coefficients**	**t-value**	**p-value**	**95.0% Confidence Interval for B**	
		B	**Std. Error**	**Beta**			**Lower Bound**	**Upper Bound**
Females	(Constant)	183.513	8.585	-	21.375	.0001**	166.147	200.878
	Mandibular Canine Dimensions-LL	-3.410	1.216	-.409	-2.803	.008**	-5.870	-.949

parameters when teeth are among the primary evidence. Regression equations derived from dental measurements have gained prominence due to the shared developmental origins of bones and teeth. Unlike bones, tooth enamel remains largely unchanged after formation, making teeth reliable for stature estimation. However, wear from attrition was excluded in this study to ensure accurate results.[8-11]

Studies have been conducted to develop regression equations that connect foot measurements to height, as well as hand width and circumference, in the populations of Karnataka and Iran, respectively.[12,13] Additionally, in the Mazhabi Sikh population of Punjab, male hand length and extremity length in females have shown a significant relationship with height. Craniometric measurements, such as head circumference, have demonstrated strong correlations in various studies involving Indian participants.[14-15]

Despite existing research, a gap persists in linking anthropometric and odontometric parameters. This study addresses that gap by correlating body height with tooth dimensions in individuals aged 23–45 years-a period marked by minimal dental attrition and stable skeletal maturity.

Odontometric parameters analyzed included intercanine widths and mesiodistal, labiolingual, and cervicoincisal dimensions of maxillary and mandibular canines. Regression analysis identified six significant parameters: five for combined data (males and females) and one exclusively for females. Separate regression equations were formulated for these variables.

To validate results, a single-blinded approach was employed with a second sample set. Actual heights were concealed from investigators, ensuring unbiased calculations. Among the parameters, maxillary intercanine width showed a significant correlation with stature (r = 0.386; p = 0.0001) for combined data but was insignificant when analyzed separately for males and females. The predicted heights using regression formulas deviated within ±1 to ±24 mm from actual values, aligning with findings by Khangura et al. (2015) and Yesha Jani et al.[8,9]

Other significant correlations included mesiodistal widths (maxillary: r = 0.313; p = 0.004; mandibular: r = 0.221; p = 0.046) and cervicoincisal lengths (maxillary: r = 0.282; p = 0.010; mandibular: r = 0.280; p = 0.011). Conversely, mandibular intercanine width (r = 0.166; p = 0.136) and maxillary canine labiolingual width (r = 0.161; p = 0.148) showed no significant correlation with stature.

Interestingly, mandibular canine labiolingual width in females exhibited a strong negative correlation (r = -0.409; p = 0.008), suggesting an inverse relationship between this parameter and height-a finding not widely reported in earlier studies.

The highest correlations were observed for maxillary mesiodistal canine dimensions (r = 0.540), followed by mandibular labiolingual dimensions in females (r = 0.323), mandibular mesiodistal dimensions (r = 0.269), maxillary intercanine width (r = 0.223), and maxillary cervicoincisal dimensions (r = 0.203). Mandibular cervicoincisal dimensions showed no significant correlation (r = 0.017; p = 0.877).

In conclusion, this study highlights the potential of dental measurements in stature estimation for forensic applications, particularly when conventional methods are unavailable or impractical.[9] Maxillary mesiodistal canine dimensions emerged as the most reliable parameter for combined data analysis, underscoring the importance of odontometry in victim identification and criminal investigations. These findings contribute to advancing forensic methodologies while addressing gaps in existing research.

CONCLUSION

This study underscores the pivotal role of teeth in forensic science as a crucial identification tool, bridging the disciplines of forensic science, dentistry, and anthropology. When teeth are the sole evidence available from mutilated remains, they can provide vital clues for reconstructing a person's basic profile. While teeth serve as a valuable adjunct in identification, their application has limitations. The correlation between tooth dimensions and stature is debated, partly due to differences in bone and tooth development timelines and potential alterations from physiological wear. Our research addressed these challenges by focusing on subjects with minimal dental wear and an age group less prone to such changes.

Significantly, this study developed regression equations for six key odontometric parameters, offering a new framework for stature estimation. However, further interdisciplinary research is essential to fully leverage the potential of dentistry in forensic science, fostering a holistic advancement in these fields.

REFERENCES

1. Emam NM. Role of Forensic Odontology in Identification of Persons: A Review Article. Cureus. 2024 Mar 20;16(3):e56570.
2. Jeddy N, Ravi S, Radhika T. Current trends in forensic odontology. J Forensic Dent Sci. 2017 Sep-Dec;9(3):115-119.
3. Pramod JB, Marya A, Sharma V. Role of forensic odontologist in post mortem person identification. Dent Res J (Isfahan). 2012 Sep;9(5):522-30.
4. Menon, P.Aishwarya, Kumar, N. Anoop. Recent Advances in Forensic Odontology: An Overview. Journal of Forensic Science and Medicine 7(3):p 105-108, Jul–Sep 2021.
5. Saxena S, Sharma P, Gupta N. Experimental studies of forensic odontology to aid in the identification process. J Forensic Dent Sci. 2010 Jul;2(2):69-76.
6. Krishan K, Kanchan T, Garg AK. Dental Evidence in Forensic Identification - An Overview, Methodology and Present Status. Open Dent J. 2015 Jul 31;9:250-6.
7. Divakar KP. Forensic Odontology: The New Dimension in Dental Analysis. Int J Biomed Sci. 2017 Mar;13(1):1-5. PMID: 28533730; PMCID: PMC5422639.
8. Jani Y, Parikh S, Dudhia B, Bhatia P, Patel P, Patel R. Body height from tooth size: A novel study on stature estimation by odontometric parameters. Journal of Indian Academy of Oral Medicine and Radiology. 2018 Jul 1;30(3):275-80.
9. Khangura RK, Sircar K, Grewal DS. Four odontometric parameters as a forensic tool in stature estimation. J Forensic Dent Sci. 2015 May-Aug;7(2):132-6.

10. Kalia S, Shetty SK, Patil K, Mahima VG. Stature estimation using odontometry and skull anthropometry. Indian Journal of dental research. 2008 Apr 1;19(2):150-4.
11. Prabhu S, Acharya AB, Muddapur MV. Are teeth useful in estimating stature?. Journal of forensic and legal medicine. 2013 Jul 1;20(5):460-4.
12. Nirmal MK, Nayak VC, Kumar A, Palimar V, Bakkannavar SM, Anitha S, Gupta C. Estimation of the most significant foot measurement in determining the stature of an individual in karnataka population.
13. Soltani S, Memarian A, Aghakhani K, Nasab NP. Evaluation of height based on measurement of width, circumference, thickness of palm and width, circumference of the wrist in Iranian adults by gender.
14. Pundir S, Nandita KP, Natarajan S, Yellapurkar S, Kaul A. Role of Craniometric Measurements In Stature Identification In Indian Population.
15. Sharma S, Kaurb M, Yadav PK, Bangwald B. Anthropometric Stature Estimation in Mazhabi Sikh Population of North India.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00041.8

Original Research Paper

Fire Accelerant Detection in Fabric Residues : A GC-MS Approach for Fire Forensics

1. **Sourabh Kumar Singh,** Assistant Professor, Department of Forensic Science, K.R. Mangalam University, Sohna Road, Haryana, India
2. **Manoj Kumar,** Associate Professor, Department of Forensic Medicine, National Capital Region Institute of Medical Sciences, Meerut, Uttar Pradesh, India
3. **Amarnath Mishra,** Associate Professor, Amity Institute of Forensic Sciences, Amity University, Noida, UP, India

ABSTRACT

Arson investigations provide a great difficulty for forensic scientists since the type and cause of the fire depends on the identification of ignitable liquid remains. Usually applying analytical methods, these residues are discovered; their consistent burning characteristics lead to the use of fire accelerators. The aim of this work is to investigate the efficiency of several fire accelerants (camphor, diesel, ethanol, and gasoline) applied on cotton as a matrix for residue detection. Built using cotton, simulated micro arson models, fire accelerant residues were extracted from the charred remains once the fire was out. Two solvues, hexane and p-xylene, and ultrasonic waves were used in extraction. Gas chromatography coupled with mass spectrometry (GC-MS) revealed the main constituents in both standard and charred fire accelerators.

The results showed that, when removing fire accelerant residues from charred matrices, p-xylene and hexane combined was more effective than hexane by itself. These results could help researchers choose appropriate solvents for the extraction of fire accelerant residue, so supporting forensic arson investigations.

Corresponding Author :
Dr. Amarnath Mishra, Associate Professor,
Amity Institute of Forensic Sciences,
Amity University, Noida, UP, India
E-mail: amishra5@amity.edu
Contact : +919818978527

Article History:
Received: 11 October 2024
Received in revised form: 05 January 2025
Accepted on: 05 January 2025
Available online: 15 April 2025

Keywords: Forensic Chemistry; Arson; Fire Accelerants; Matrix; GC-MS; Functional Groups.

INTRODUCTION

Arson is a major criminal act with the possibility of great property damage and death toll. Arson investigations depend on the detection and evaluation of fire accelerant residues in fire debris, so providing important proof. But because fire can destroy important evidence and the possible damage caused by weathering and fire extinguishers to trash samples, forensic investigators face major challenges.

Usually, arsonists use petroleum compounds including diesel, petrol and kerosene as accelerators. In the forensic environment, selecting the suitable analytical method and extraction technique for fire accelerant residue (FAR) detection is absolutely vital. FAR detection uses diverse extraction techniques (solvent extraction, headspace with solid-phase micro-extraction (SPME), and activated carbon strips (ACS), analytical methods (gas chromatography (GC), isotope ratio mass spectrometry (IR), capillary electrophoresis (CE), laser-induced breakdown spectroscopy (LIBS), derivative ultraviolet (UV) spectroscopy, vibrational spectroscopy (infrared (IR) spectroscopy and Raman spectroscopy). This field has seen significant scholarly activity and analytical development.[1-2]

Forensic experts are often involved in cases of arson to find fire accelerants, so guiding the origin of the fire. Examining charred samples of several accelerants can provide important information on the source of the fire and whether it was started intentionally. In this work, we provide a method based on cotton as a matrix to assess charred samples of several fire accelerants. Among the accelerants are camphor, ethanol, diesel, petrol and their combinations.[3]

MATERIALS AND METHOD

The Following Materials were used for the Analysis: 1. Cotton fabric (matrix) 2. Fire Accelerants: camphor, ethanol, diesel, petrol, p-xylene, and hexane. ***3. Methanol (HPLC grade) 4. Water (HPLC grade) 5. Sodium chloride***

(analytical grade) 6. Hexane (HPLC grade) 7. P-xylene (HPLC grade) 8. GC-MS instrument 9. Glass vials (2 mL) 10. Syringe (1 mL)

Preparation of Burnt Samples: The study used 1 cm x 1 cm tiny cotton cloth pieces. Ten minutes in a 1 mL fire accelerant solution, they let them naturally dry at room temperature for two hours. The ashes were collected and kept in a sterile glass vial ready for further investigation once the dried cloth was suitably burned on a Bunsen burner.[4-8]

Extraction of Fire Accelerants: A modified form of the Solid-Phase Microextraction (SPME) process was used to remove burned textile samples. To the vial holding the ashes was added a 1ml mixture of p-xylene and hexane (1:1 v/v). The vial was then continuously shaken and left in an 80°C water bath for half an hour. Following extraction, the extract was piped to a fresh glass vial and let to cool to room temperature.[9-11]

GC-MS Analysis: Agilent GC-7890 with MS-5977A from Agilent was used for this query. Agilent J & W DB-Wax UI column with the GC column utilized had a length of 30m, an internal diameter of 0.25mm, and a film thickness of 0.25m. This column can endure temperatures as high as 350°C and as low as -60°C. The instrument was controlled using a Dell® computer running the Xcalibur TM program that Agilent supplied along with the instrument.

The recovered fire accelerants were evaluated using a GC-MS apparatus equipped with a DB-5MS capillary column (30 m x 0.25 mm x 0.25 µm). The GC-MS was operated in splitless mode with the following temperature program: an initial temperature of 50°C was retained for 2 minutes, followed by a ramp at 10°C/min to 150°C which was held for 5 minutes, then ramped at 20°C/min to 300°C which was held for 5 minutes. The injector temperature and detector temperature were set at 250°C and 300°C respectively. Helium was the carrier gas used; it was flowing 1 mL/min.[12-16]

The following instrumental parameters were applied in this experiment: For two minutes, the oven was maintained at its initial temperature of 52°C. At a rate of 4.0 °C per minute, the temperature was then raised until it reached 80 °C. It was kept at this temperature for a minute before being gradually raised to 250 °C at a rate of 30.0 °C/min using a column flow of three millilitres per minute (mL/min). For the length of the GC run, the MS ran in positive ion modes and full scan (m/z 40–400). On the transfer line, the temperature was 250°C; the MS scan rate was 10 scans every second. The scan event ran 0.58 seconds total. Three micro-scans helped to choose a maximum ion time of 25 m/s. The ion source was tuned to 280°C while the quad was set at 180°C.

RESULTS

Method Development

Optimization of the SPME Extraction: To maximise the SPME process's efficiency, varying extraction times (10–60 minutes) and temperatures (50–100°C) were investigated. The ideal extraction conditions were found by looking at charred samples of camphor, ethanol, diesel, petrol and their mixtures laced with p-xylene and hexane. Following an assessment of the extraction efficiency, the extraction time and temperature were deduced to be 30 minutes and 80°C, respectively, based on the highest recovery of p-xylene and hexane.

Optimization of the GC-MS Method: The GC-MS approach was tuned by means of analysis of several temperature programs and column flow rates. The best conditions were found by mixing p-xylene and hexane laced with fire accelerants and then analysing. The temperature program and column flow rate were deduced from the specified conditions of the experimental section.

Validation of the Method: To validate the technique, samples of burned fabric loaded with known concentrations of fire accelerants were investigated. Testing the samples at six different concentrations (10, 25, 50, 100, 200, and 500 ng/mL) and calculating the correlation coefficients for each fire accelerant allowed for the determination of the technique's linearity. Every value was greater than 0.99, indicating that the method was linear.[16] For all fire accelerants, the limit of detection (LOD) and limit of quantitation (LOQ), which were established using signal-to-noise ratios of 3 and 10, respectively, were found to be between 1 and 5 ng/mL and 5 and 10 ng/mL.

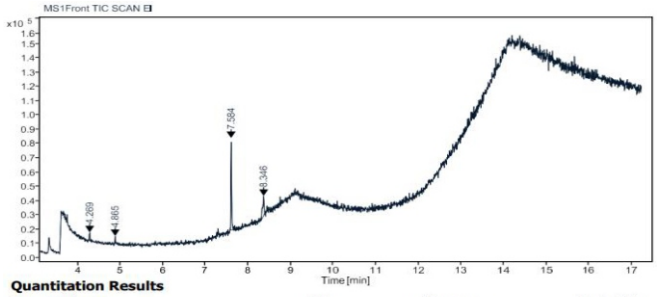
Samples of burned fabric containing camphor, ethanol, diesel, petrol and their mixtures were tested using the developed analytical technique. The GC-MS chromatograms of burned materials loaded with fire accelerants are displayed in **Figure 1**. Retention times and mass spectra were used to identify fire accelerants. The findings confirmed the effectiveness of p-xylene and hexane as extractants for the fire accelerants by showing that they were present in all charred samples. **Table 1** lists the various compounds found in the fire accelerants, which

ranged from C20 to C70. While p-xylene and hexane primarily contained aromatic hydrocarbons, camphor, ethanol, diesel, and petrol were primarily composed of aliphatic hydrocarbons. Both aliphatic and aromatic hydrocarbons were present in the fire accelerant mixtures.[17]

This study's methodology effectively distinguished between the fire accelerants and their mixtures. These findings suggest that the method is capable of differentiating between the components that make up certain fire accelerants and is selective for identifying them.

Samples of burned fabric containing camphor, ethanol, diesel, petrol and their mixtures were tested using the analytical technique that was created. The GC-MS chromatograms of burned materials loaded with fire accelerants are displayed in **Figure 1**. Retention times and mass spectra were used to identify fire accelerants. All charred samples contained p-xylene and hexane, according to the results, indicating their effectiveness as extractants for the fire accelerants.[17]

Figure 1: Chromatogram of Camphor



Quantitation Results

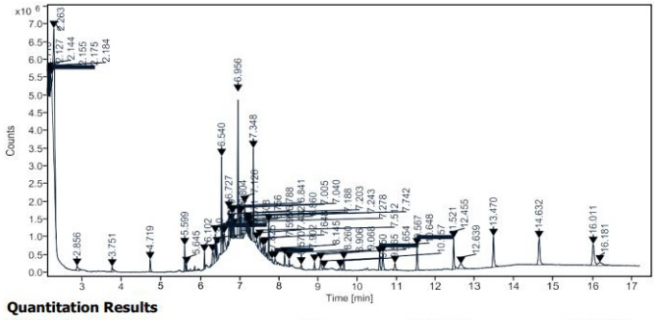
Compound	RT	Response	Probability
Camphor	7.584	375171	87.41
Permethrin	8.346	74322	12.59

Table 1 lists the various compounds found in the fire accelerants, which ranged from C20 to C70. While p-xylene and hexane primarily contained aromatic hydrocarbons, camphor, ethanol, diesel, and petrol were primarily composed of aliphatic hydrocarbons. Both aliphatic and aromatic hydrocarbons were present in the fire accelerant mixtures.

Table 1: Range of Compounds Identified in Burnt Samples of Fire Accelerants.

S. No.	Fire Accelerant	Compound Range (C)
1.	Camphor	C20-C50
2.	Ethanol	C20-C40
3.	Diesel	C20-C70
4.	Petrol	C20-C50
5.	P-xylene	C8-C16
6.	Hexane	C6-C12

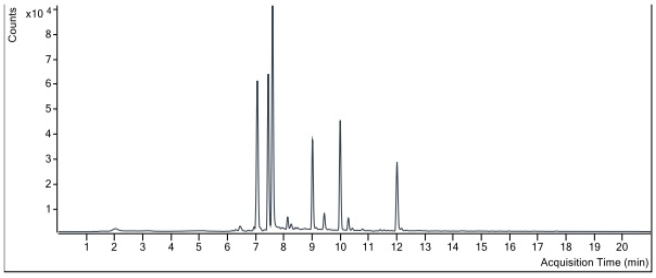
Figure 2: Chromatogram of Camphor & Diesel



Quantitation Results

Compound	RT	Response	Probability
Camphor	6.540	45868	31.2300
Diesel	6.956	78045	37.0000
Permethrin	7.348	53727	32.6700

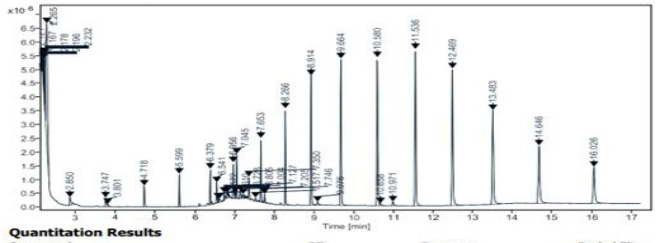
Figure 3: Chromatogram of Camphor & Ethanol



Quantitation Results

Compound	RT	Response	Probability
Ethanol	7.600	170383	34.2300
Camphor	9.010	68302	32.2500
Permethrin	10.010	79984	33.5200

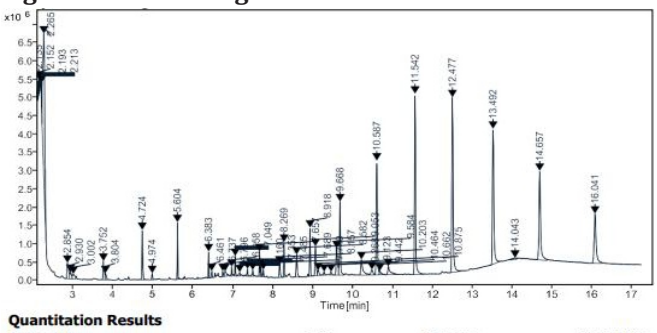
Figure 4: Chromatogram of Camphor & Petrol



Quantitation Results

Compound	RT	Response	Probability
Camphor	7.653	157839	17.2300
Permethrin	10.971	5782	1.7700
C10	2.850	5905	2.9370
C12	3.747	6793	3.0810
C14	4.718	7395	3.5815
C16	5.599	7940	3.9470
C18	6.379	8204	4.1340
C20	6.956	9945	4.2100
C22	7.045	110484	5.4300
C24	8.266	120849	6.4840
C26	8.914	160043	7.4893
C28	9.664	170404	8.3000
C30	10.580	175400	9.7300
C32	11.536	179876	10.7902
C34	12.469	129492	6.4100
C36	13.483	97482	2.0383
C38	14.646	94928	1.3894
C40	16.026	90483	1.0483

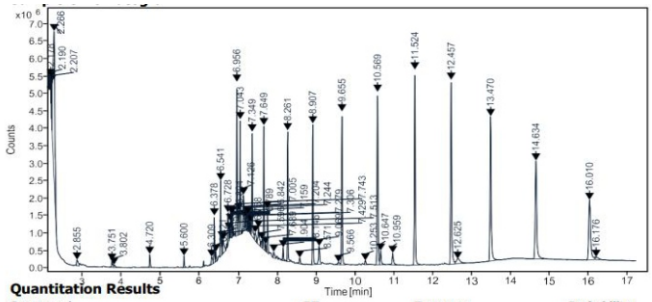
Figure 5: Chromatogram of Diesel



Quantitation Results

Compound	RT	Response	Probability
Diesel	11.542	81854	79.42
Permethrin	14.657	7089	21.58

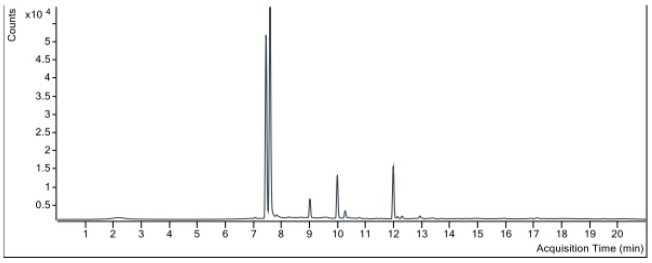
Figure 6: Chromatogram of Diesel & Ethanol



Quantitation Results

Compound	RT	Response	Probability
Diesel	11.524	148392	53.1410
Ethanol	6.956	167371	45.0890
Permethrin	8.261	94879	1.7700

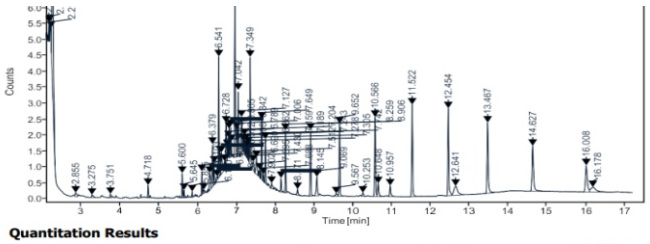
Figure 7: Chromatogram of Ethanol



Quantitation Results

Compound	RT	Response	Probability
Ethanol	7.600	161376	89.2300
Permethrin	10.010	62638	10.7700

Figure 8: Chromatogram of Ethanol & Petrol



Quantitation Results

Compound	RT	Response	Probability
Ethanol	6.957	92531	22.13
C10	2.855	6149	2.29
C12	3.275	6348	2.49
C14	3.751	6597	3.52
C16	4.718	6629	3.62
C18	5.600	7049	4.14
C20	6.541	7059	4.24
C22	7.042	7499	4.44
C24	7.349	7568	4.40
C26	10.648	7829	4.66
C28	10.957	8142	4.67
C30	11.522	8474	4.89
C32	12.454	8089	5.09
Permethrin	10.566	7628	8.43
C34	13.467	7448	5.13
C36	14.627	7214	5.50
C38	16.008	7049	5.34
C40	16.178	6548	5.02

Figure 9: Chromatogram of Petrol

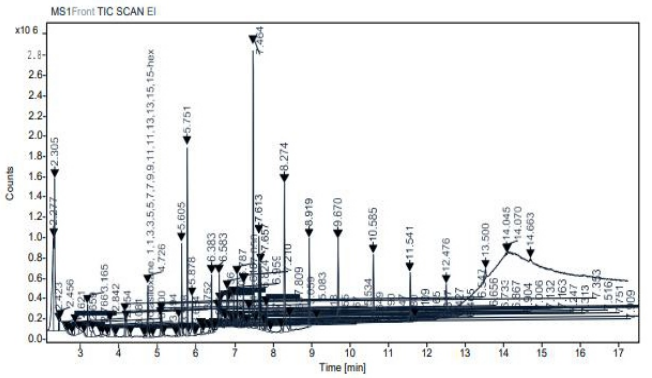
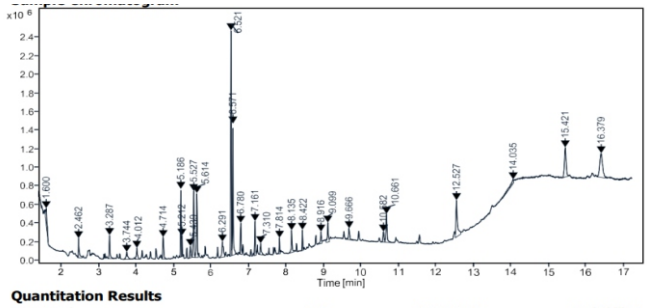


Table 2: Compounds RT Value of Petrol

Compound	RT	Probability (%)
C10	4.726	95.32
C12	5.605	94.21
C14	5.751	95.78
C16	5.878	88.88
C18	6.383	66.12
C20	6.583	78.86
C22	6.787	91.08
C24	7.464	97.81
Permethrin	7.613	76.23
C26	7.657	5.37
C28	8.274	31.94
C30	8.919	76.88
C32	9.670	70.02
C34	10.585	84.98
C36	11.541	49.42
C38	12.476	9.04
C40	13.500	40.14

Figure 10: Chromatogram of Petrol & Diesel



Quantitation Results

Compound	RT	Response	Probability
Diesel	6.521	92531	21.42
C10	2.462	7089	2.29
C12	3.287	7248	2.49
C14	5.186	7497	3.52
C16	5.527	7529	3.92
C18	6.780	7949	4.04
C20	7.161	8047	4.24
C22	7.814	8399	4.34
C24	8.135	8568	4.40

Figure 11: Linearity Graph of Camphor Sample

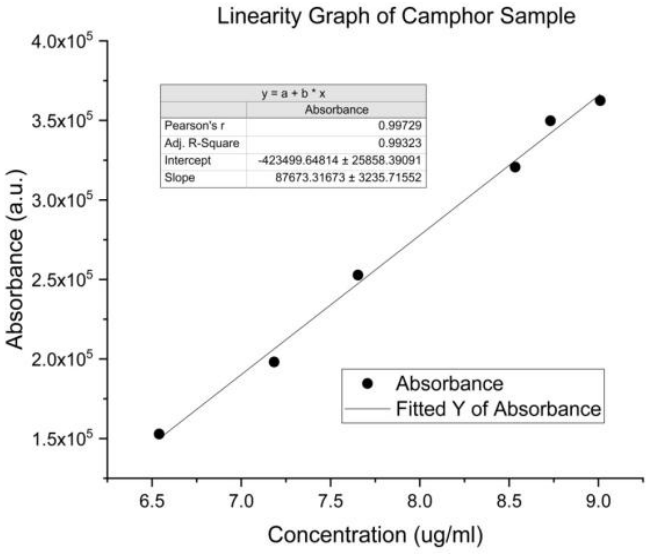


Figure 12: Linearity Graph of Diesel Sample

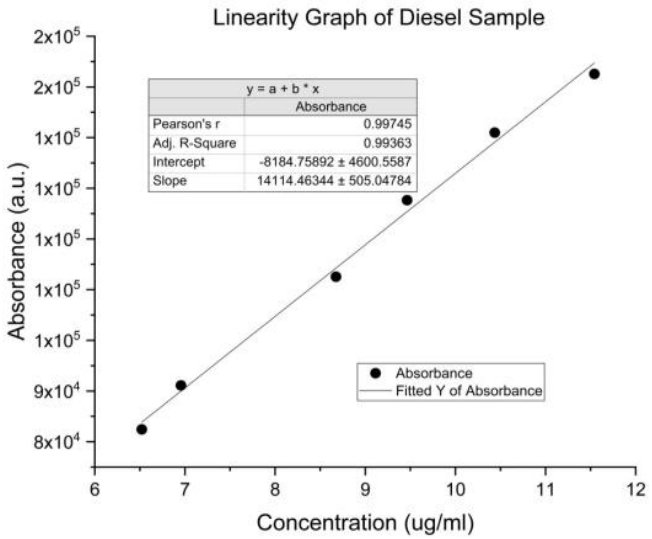


Figure 13: Linearity Graph of Ethanol Sample

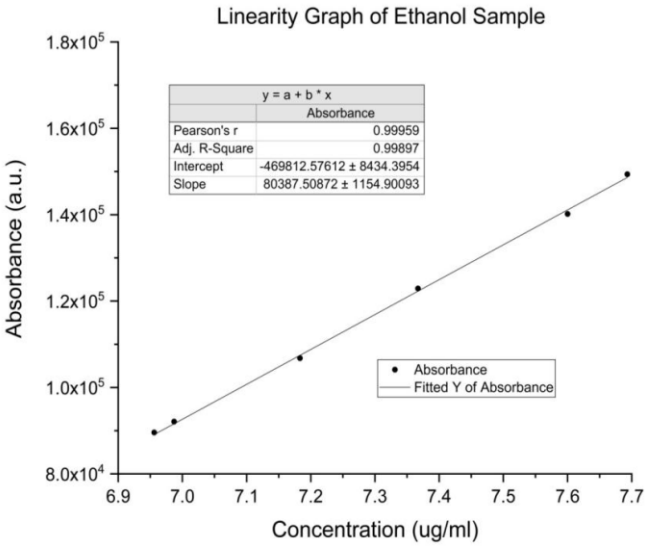
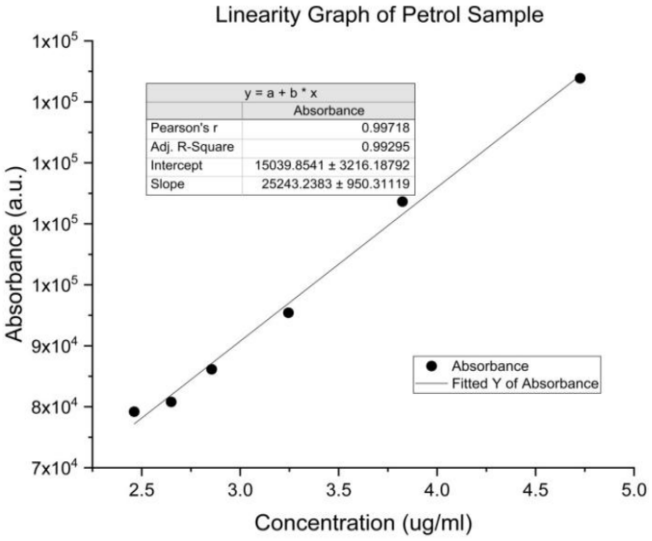


Figure 14: Linearity Graph of Petrol Sample



Linearity Graph of Samples/Accelerants:

The ability of the method to produce test results that are exactly proportionate to the analyte concentration in the sample is known as linearity. This graph will confirm that the analyte signal in calibration solutions is linear if it is linear in samples.There are three factors which affects the linearity: -a) Ion source: b) Ion transport: c) Transmission efficiency

This study's methodology effectively differentiated between the fire accelerants and their mixtures. These findings suggest that the method can distinguish between the components that make up certain fire accelerants and is selective for identifying them.[18]

DISCUSSION

The developed technique offered a quick and reliable means of determining the fire accelerants present in samples of burned fabric. The SPME extraction process was changed in order to raise the fire accelerant extraction efficiency. Thanks to the mix of p-xylene and hexane as extractants, a broad spectrum of compounds from C6 to C70 could be extracted including several often used fire accelerators in arson cases.

Developed was a consistent and effective method for identifying fire accelerants in samples of charred fabric. The SPME extraction technique was changed to improve the extractability of the fire accelerators. By means of the extractants p-xylene and hexane, a wide spectrum of compounds-from C6 to C70-including several often used fire accelerators in arson cases could be extracted.

Good separation and identification of the fire accelerators were obtained by optimising the GC-MS technology applied in the investigation. Column flow rate and temperature program were changed to guarantee suitable peak separation and detection of every compound. The approach was found to be selective, sensitive, and linear for the combinations of the fire accelerators. A fingerprint was created for each accelerant using this GC technique, which analysed individual ions from each class of target components and used mass spectral analysis to examine the accelerant components.

The findings of the study revealed that fire accelerants revealed a wide spectrum of compounds, ranging from C6 to C70, implying that different accelerant chemical compositions are present in arson events. Determining the source of the fire could depend critically on the combination of aliphatic and aromatic hydrocarbons

present in the fire accelerant compositions.

The GC-MS technology of the study was developed to efficiently separate and identify the fire accelerators. Column flow rate and temperature program were changed to guarantee appropriate peak separation and detection of every chemical. The approach proved to be linear, sensitive, and selective for the fire accelerators and their mixtures.

The results of the study revealed that fire accelerants contained a wide spectrum of molecules ranging from C6 to C70, implying that different chemical compositions of accelerators were present in arson events. Combining aliphatic and aromatic hydrocarbons revealed in the fire accelerant mixes could help determine the source of the fire.

CONCLUSION

Finally, a consistent and efficient approach was developed to evaluate burned fabric samples including fire accelerators. The improved SPME extraction method and GC-MS analysis help one to extract and identify many different compounds ranging from C6 to C70. The created approach was able to discriminate between the fire accelerants and their mixtures and was found to be linear, sensitive, and selective for the fire accelerators. This developed approach allows forensic investigators to identify fire accelerants in burned fabric samples, so helping to ascertain the cause of the fire and point the arsonist. Different compounds present in the fire accelerants can give vital information regarding the origin of the fire.

Future research with varying matrices and a greater sample size will allow one to validate the suggested approach. One can look at how environmental elements such as temperature and humidity affect the extraction efficiency of the fire accelerants. Moreover, combining the newly found approach with other forensic methods, such DNA analysis, helps to offer a more comprehensive study of arson events.

All things considered, the fresh analytical method is a valuable instrument for arson forensic investigations. It is sensitive and selective and can separate between mixtures of fire accelerants and their individual components. The ability of the method to extract and identify a wide range of compounds from fire accelerators helps one to find crucial information about the sources of the fire.

REFERENCES

1. Siegel JA, Saukko PJ. Encyclopedia of forensic sciences. Academic Press; 2012 Dec 28.
2. Yadav VK, Das T, Harshey A, Yadav MM, Nigam K, Srivastava A. A forensic approach to evaluate the effect of different matrices and extraction solvents for the identification of diesel residue in simulated arson by GC–MS. Chromatographia. 2021 May;84:413-23.
3. Corry RA. Fundamentals of fire investigation. InHandbook on firesetting in children and youth 2002 Jan 1 (pp. 75-98). Academic Press.
4. Nelson Jr RM. Power of the fire-a thermodynamic analysis. International journal of wildland fire. 2003;12(1):51-65.
5. Lentini JJ. Scientific protocols for fire investigation. CRC press; 2018 Sep 28.
6. Nowicki J. Analysis of fire debris samples by gas chromatography/mass spectrometry (GC-MS): Case studies. Journal of Forensic Sciences. 1991 Sep 1;36(5):1536-50.
7. Bertsh W, Ren QL. Gas chromatography/mass spectrometry (GC/MS). Is it really needed in accelerant analysis?. Fire and Arson Investigator. 1999;25:17-21.
8. Lennard C, Tristan Rochaix V. GC-MS Target Compound Chromatography for the Detection and Identification of Arson Accelerants. Advances in Forensic Sciences. 1996:182-6.
9. de Vos BJ, Froneman M, Rohwer E, Sutherland DA. Detection of petrol (gasoline) in fire debris by gas chromatography/mass spectrometry/mass spectrometry (GC/MS/MS). Journal of forensic sciences. 2002 Jul 1;47(4):736-56.
10. Newman R, Gilbert MW, Lothridge K. GC-MS guide to ignitable liquids. CRC Press; 2020 Aug 26.
11. Fabritius MM, Broillet A, König S, Weinmann W. Analysis of volatiles in fire debris by combination of activated charcoal strips (ACS) and automated thermal desorption–gas chromatography–mass spectrometry (ATD/GC–MS). Forensic science international. 2018 Aug 1;289:232-7.
12. Dhabbah AM. Detection of petrol residues in natural and synthetic textiles before and after burning using SPME and GC-MS. Australian Journal of Forensic Sciences. 2020 Mar 3;52(2):194-207.

13. Zhang J, Yang Q. GC/MS analysis on combustion smoke of different flammable liquids. Procedia Engineering. 2014 Jan 1;71:139-44.
14. Wu CH, Chen CL, Huang CT, Lee MR, Huang CM. Identification of Gasoline Soot in Suspect Arson Cases by Using Headspace Solid Phase Microextraction –GC/MS. Analytical letters. 2004 Dec 28; 37(7):1373-84.
15. Dhabbah AM, Al-Jaber SS, Al-Ghamdi AH, Aqel A. Determination of gasoline residues on carpets by SPME–GC-MS technique. Arabian Journal for Science and Engineering. 2014 Sep;39:6749-56.
16. Aqel A, Dhabbah AM, Yusuf K, AL-Harbi NM, Al Othman ZA, Yacine Badjah-Hadj-Ahmed A. Determination of gasoline and diesel residues on wool, silk, polyester and cotton materials by SPME–GC–MS. Journal of Analytical Chemistry. 2016 Jul;71:730-6.
17. Singh SK, Mishra A, Sharma RK. Identification of selected fire accelerants from different matrices in forensic samples by using ATR-FTIR. International Journal of Medical Toxicology & Legal Medicine. 2022;25(1and2):127-34.
18. Singh SK, Mishra A, Sharma RK. Development of atr-ftir technique and pattern recognition of fire accelerants and fabrics in forensic samples. International Journal of Medical Toxicology & Legal Medicine. 2021 Jan;24(1-2).

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00042.4

Original Research Paper

Pattern of Internal Neck Injuries in Suicidal Hanging : A Histopathological and Gross Examination - Based Study

1. **Asharam Gorchiya,** Assistant Professor, Department of Forensic Medicine and Toxicology, Ananta Institute of Medical Sciences and Research Centre, Rajsamand, India
2. **Vikarn Vishwajeet,** Associate Professor, Department of Pathology and Lab Medicine, All India Institute of Medical Sciences, Jodhpur, India.
3. **Puneet Setia,** Professor, Department of Forensic Medicine and Toxicology, All India Institute of Medical Sciences, Jodhpur, India

ABSTRACT

Introduction: Hanging is a common method of suicidal asphyxiation, often leaving distinct external and internal neck injuries. This study aims to analyse the pattern of internal neck injuries in suicidal hanging cases through both gross and microscopic examination.

Materials and Method: A total of 34 cases of suicidal hanging, autopsied over one year, were analysed for gross and histopathological findings in the internal neck structures. Histopathological examination of the sternocleidomastoid muscle and thyroid gland was conducted to assess internal injuries.

Results: Most cases (n=24; 70.6%) were males, with the highest incidence in the 21–30-year age group (44.1%). Atypical hanging was more common (n=26; 76.5%), with the knot positioned laterally in most cases. The predominant ligature materials were soft and broad fabrics (n=20; 58.8%). Gross internal examination showed visible soft tissue injuries in only 17.6% of cases, while histopathological analysis revealed microscopic damage in 91.2% of cases ($p<0.05$). The most frequent histopathological findings included congestion (67.6%) and follicular destruction (32.4%) in the thyroid gland, and hemorrhages (47.1%) and muscle fibre degeneration (55.9%) in the sternocleidomastoid muscle. Hyoid bone fracture was rare (2.9%), and no fractures of the thyroid cartilage or cervical vertebrae were observed. Intimal tears in the carotid arteries were detected in 5.9% of cases.

Conclusion: The study highlights the significance of histopathological examination in detecting internal neck injuries in suicidal hanging. While external findings provide crucial preliminary evidence, microscopic analysis reveals subtle antemortem tissue changes that may be undetectable on gross examination.

Corresponding Author :
Dr. Asharam Gorchiya, Assistant Professor, Department of Forensic Medicine and Toxicology, Ananta Institute of Medical Sciences and Research Centre, Rajsamand, India
E-mail: asharamgorchiya56@gmail.com
Contact : +917424906464

Article History:
Received: 11 October 2024
Received in revised form: 05 January 2025
Accepted on: 05 January 2025
Available online: 15 April 2025

Keywords: Suicidal Hanging; Forensic Pathology; Histopathology; Neck Injuries; Sternocleidomastoid Muscle; Thyroid Gland.

INTRODUCTION

Hanging is one of the most common methods of suicide worldwide and a significant medico-legal concern, especially in forensic pathology. It is characterized by neck compression due to a ligature, leading to asphyxia, vascular obstruction, or neurological impairment, ultimately resulting in death.[1] The patterns of injuries in hanging cases can vary based on factors such as the type of ligature material used, the position of knot, kind of suspension, duration of hanging, and individual anatomical differences.[2] Hanging is classified as typical or atypical based on the position of the knot, and as complete or partial based on the type of body suspension. Both the position of the knot and the type of body suspension influence the ligature mark and the mechanical effect on the neck.[3]

Autopsy studies play a critical role in understanding the pathological changes associated with hanging. Macroscopic (gross) findings, such as ligature marks, soft tissue haemorrhages, fractures of the hyoid bone or thyroid cartilage, and signs of asphyxia, are commonly documented in forensic practice.[1] However, a histopath-

ological examination of neck structures can provide additional insights into the mechanism and timing of injury.[4] Histopathological evaluation can reveal minute hemorrhages, muscle fiber degeneration, cellular infiltrations, and vascular alterations that may not be evident on gross examination. Studies suggest that microscopic examination can help differentiate ante-mortem from post-mortem injuries, contributing to the accuracy of medico-legal conclusions.[4-5]

This study aims to analyze pattern of internal neck injuries in suicidal hanging cases through gross and histopathological findings. By correlating external ligature marks, deep tissue damage, vascular injuries, and histological changes, the study seeks to enhance forensic understanding and assist in the accurate interpretation of hanging-related deaths.

MATERIALS AND METHOD

This observational study was conducted in the Department of Forensic Medicine and Toxicology, in collaboration with the Department of Pathology and Lab Medicine, at All India Institute of Medical Sciences (AIIMS), Jodhpur, India, over a period of one year, from January 2020 to December 2020. Ethical clearance was obtained from the Institutional Ethics Committee vide letter No. IEC-2110, Date- 20/01/2020, prior to the commencement of the study. A total of 34 cases of suicidal hanging were included in this study based on the history provided by the police and relatives of the deceased.

Inclusion Criteria:

- Autopsy cases of suicidal hanging reported to the mortuary during the study period.
- Availability of informed consent from the next of kin.

Exclusion Criteria:

- Cases of homicidal strangulation or other forms of neck compression.
- Cases presenting with advanced decomposition.

Socio-demographic details of the victims, along with information related to hanging-such as the type of hanging, type of ligature used, and position of the knot, were obtained from the investigating officer and relatives.

During the external examination, the position and dimensions of the ligature mark, along with other grossly visible findings, were recorded. A bloodless dissection of the neck was carried out after evisceration of the thoracoabdominal and cranial organs. To minimize artifacts during the internal examination, a layer-by-layer dissection of the neck muscles was carried out and examined for the presence of hemorrhages and injuries. Further dissection was conducted to detect fractures in the thyroid cartilage and hyoid bone, bruises in the thyroid gland, and intimal tears in the carotid arteries.

For histopathological examination, two tissue specimens (1–2 cm sections) were collected:

1. One specimen was taken from the sternocleido-omastoid muscle underlying the ligature mark.
2. Another specimen was taken from the thyroid gland.

The collected tissues were fixed in 10% neutral buffered formalin, embedded in paraffin, and sectioned for Hematoxylin and Eosin (H&E) staining. The histopathological slides were examined under a light microscope for tissue changes. Muscle tissue were analysed for the presence of focal or diffuse hemorrhages, congestion, muscle fibre breakdown, and cellular infiltration. The thyroid gland specimens were analysed for hemorrhages, congestion, and other cellular changes.

Data were recorded in a structured proforma, categorizing findings as grossly visible vs. microscopically evident. The data were tabulated in an Excel spreadsheet, and descriptive statistics such as the mean and percentage distribution were used to analyse trends and pattern of injuries.

RESULTS

A total of 34 cases of suicidal hanging were studied over a period of one year. Of these, 24 subjects (70.6%) were male, and 10 subjects (29.4%) were female. The mean age at death for males and females was 31.54 years (range: 17–65) and 21.30 years (range: 12–37), respectively. The highest number of cases belonged to the 21–30-year age group in both sexes **(Table 1)**.

Atypical hanging was more common, with the position of the knot or suspension point located on the right side of the neck in 14 cases (41.1%), on the left side of the neck in 11

Table 1: Age & Sex-Wise Distribution of Cases.

Age Group (Age in years)	Male	Female	Total
11-20	6	3	9 (26.5%)
21-30	9	6	15 (44.1%)
31-40	4	1	5 (14.7%)
41-50	2	0	2 (5.9%)
51-60	1	0	1 (2.9%)
Above 60	2	0	2 (5.9%)
Total	24	10	34 (100%)

cases (32.4%), and below the chin in 1 case (2.9%). In 8 cases (23.5%) of typical hanging, the position of the knot was at the back of the neck or over the occipital area. Complete body suspension was observed in 23 cases (67.6%), whereas 11 cases (32.4%) involved partial hanging.

Easily available soft and broad ligature materials were used in most cases. Bedsheets, sarees, and dupattas were used in 20 cases (58.8%), ropes in 9 cases (26.5%), and curtains in 2 cases (5.9%). Thin and narrow materials, such as metal wires, rubber pipes, and shoelaces, were used in 3 cases (8.8%).

The ligature mark was dry, hard, parchmentized, oblique, and incomplete over the upper part of the neck in 26 cases (76.5%). It was oblique, deeply grooved, and completely encircled the upper neck in 3 cases (8.8%). Internal examination of the neck in these cases showed a pale and glistening appearance of the underlying soft tissues on gross examination with the naked eye. Submucosal hemorrhages were observed in the laryngeal mucosa in 3 cases (8.8%). Out of the total cases, the ligature mark was very faint and intermittent over the upper part of the neck in 5 cases (14.7%), and internal neck examination was normal in these cases.

The position of the ligature mark was above the level of the thyroid cartilage in most cases (50%, n=17). In 9 cases (26.5%), the ligature mark was broad and present over and above the thyroid cartilage. In the remaining 8 cases (23.5%), it was over the thyroid cartilage only. A fracture of the hyoid bone was found in only one case, and intimal tears in the carotid arteries were found in two cases. Fractures of the thyroid cartilage and cervical vertebrae were not found in any case.

The histopathological findings of the sternocleidomastoid muscle and thyroid gland are shown in **Table 2**. Microscopic examination of the sternocleidomastoid muscle showed the presence of congestion in 44.1% of cases (n=15), hemorrhages in 47.1% of cases (n=16), and muscle fibre degeneration in 55.9% of cases (n=19) **(Figure 1)**. Leukocyte infiltration was not found in any muscle slides. The most common findings in the thyroid tissues were congestion and follicular destruction, observed in 67.6% (n=23) and 32.4% (n=11) of cases, respectively. Interstitial hemorrhages were detected in

Table 2: Incidence and Distribution of Histopathological Changes in the Sternocleidomastoid Muscle and Thyroid Gland.

Tissue	Microscopic Changes	No. of Cases	(%)
Sternocleidomastoid muscle	Congestion	15	44.1
	Hemorrhages	16	47.1
	Myofibrillar damage	19	55.9
	Leukocyte infiltration	0	0
Thyroid gland	Congestion	23	67.6
	Hemorrhages	3	8.8
	Follicular destruction	11	32.4
	Leukocyte infiltration	5	14.7

Table 3: Comparison of Gross and Histopathological Findings in the Internal Neck Structures.

Findings Seen	Grossly	Histopathological
Positive in	06 cases (17.6%)	31 cases (91.2%) ($p<0.05$)
Negative/Nil	28 cases (82.4%)	03 cases (8.8%)
Total	34 (100%)	34 (100%)

Figure 1(a-b): Longitudinal Section of Sternocleidomastoid Muscle, (a) Showing Hemorrhages (Black arrow); (b) Showing Myofibrillar Damage (Black Arrowhead) (H&E, 40x).

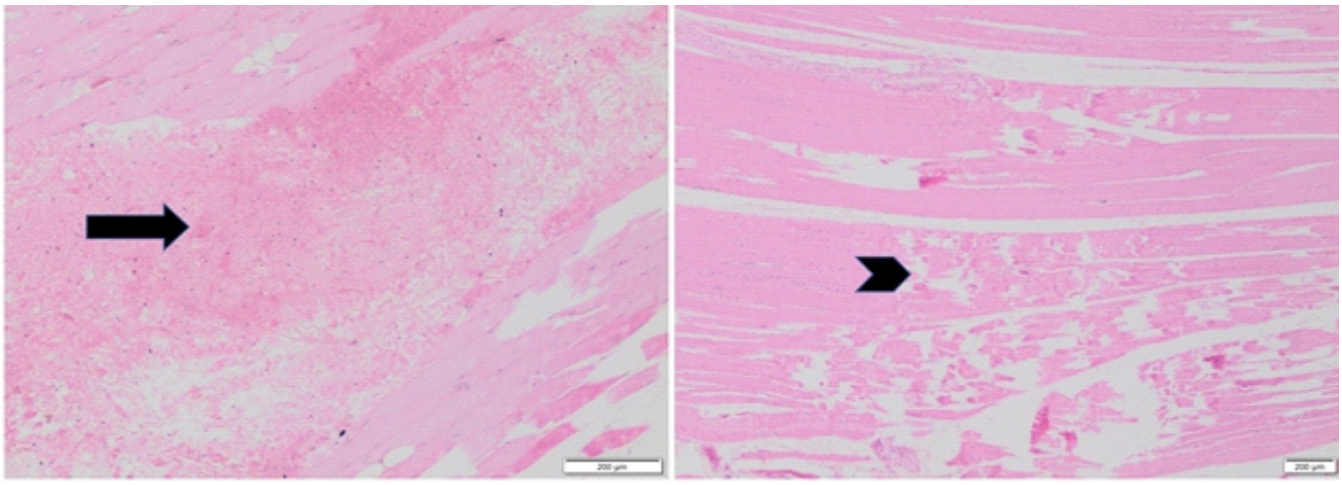
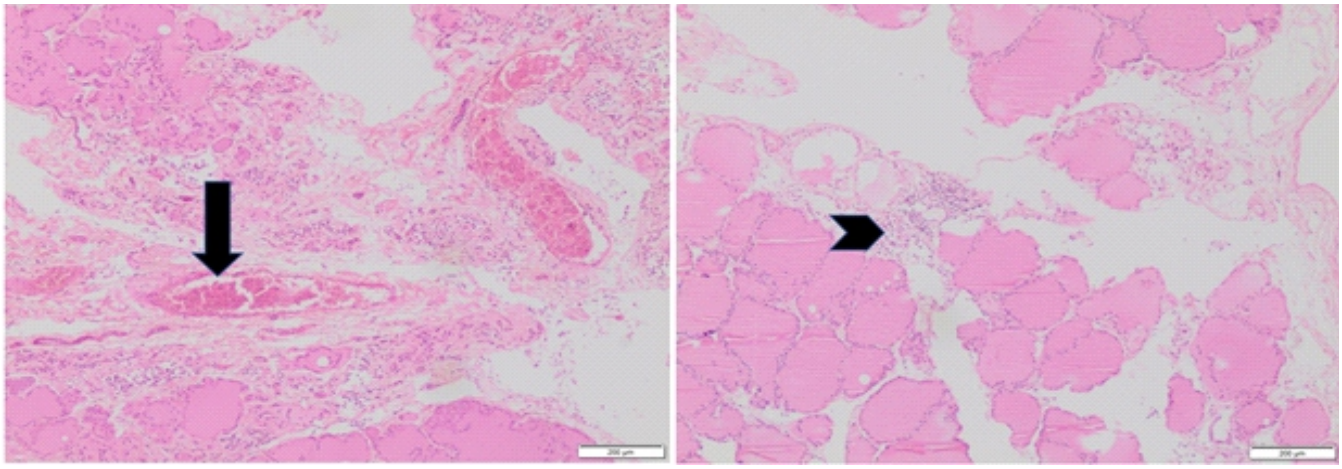


Figure 2(a-b): Cross-Section of Thyroid Gland, (a) Showing Congestion and Surrounding Hemorrhages (Black arrow); (b) Showing Leukocyte Infiltration (Black Arrowhead) (H&E, 40x).



8.8% of cases (n=3), and leukocyte aggregates between follicles were found in 14.7% of cases (n=5) **(Figure 2)**.

Histopathological examination of the sternocleidomastoid muscles and thyroid gland showed the presence of at least one microscopic finding in 31 out of the total 34 cases. The distribution of gross and microscopic findings in the internal neck structures is shown in **Table 3**.

DISCUSSION

This study examined the patterns of internal neck injuries in cases of suicidal hanging through gross and histopathological examination. The findings were compared with previous studies on hanging-related injuries, with a focus on demographic patterns, external and internal neck findings, and histopathological alterations.

In our study, males constituted the majority of cases (n=24; 70.6%), with a mean age of 31.54 years, whereas females had a lower mean age of 21.30 years. The highest number of cases (n=15; 44.1%) occurred in the 21–30-year age group, which is consistent with the 2022 National Crime Records Bureau (NCRB) statistics, indicating that the most vulnerable age group is between 18 and 30 years.[6] Previous studies, such as those by Sharma et al.[2] and Ambade et al.[7] have similarly reported a male predominance in hanging cases, attributing it to higher suicide rates in men due to socio-economic stress, psychiatric disorders, and substance abuse. Furthermore, the predominance of younger age groups aligns with the study of Das et al.,[8] who highlighted that younger individual, particularly those under 30 years, are at increased risk due to impulsivity, economic instability, and societal pressures.

Atypical hanging was the most common form (n=26; 76.5%), with the knot positioned laterally in most cases. This pattern aligns with the findings of Vinita et al.,[9] and Sharma and Kumar,[10] who observed that atypical hangings are more frequent in suicidal cases due to variability in ligature placement. Our study finds a higher incidence of complete body suspension (n=23; 67.6%) compared to partial suspension (n=11, 32.4%). However, studies conducted by Ambade et al.[7] and Rao D[11] reported higher incidence of partial hanging. This variation may be due to differences in study populations, preferred suspension methods, or the availability of suspension points in the studied region.

The ligature materials used in our cases predominantly consisted of soft and broad fabrics (n=20, 58.8%), such as sarees and bedsheets, which were found to cause incomplete ligature marks in most cases. Similar to this study, Jayaprakash and Sreekumari[12] and Naik and Patil[13] reported the use of soft material in 47% and 54.7% of cases, respectively. In contrast, the findings of Jiwane et al.[5] and Ambade et al.[7] differed, as they observed the use of nylon rope in majority of cases.

Our study found hyoid bone fracture in only one case (2.9%), with no fractures of the thyroid cartilage or cervical vertebrae. In this case the ligature material was bedsheet. This aligns with research by Bhausaheb et al.,[14] which reported that fractures of the hyoid and thyroid cartilage are uncommon in suicidal hanging, particularly in younger individuals due to the flexibility of cartilaginous structures. However, studies such as Di Maio & Di Maio[3] have noted that hyoid fractures are more prevalent in older individuals due to ossification, which may explain the low incidence in our younger cohort.

Intimal tears in the carotid arteries were detected in only two cases (5.9%), an infrequent finding consistent with the study by Sharma et al.,[2] who reported that vascular injuries are rare in suicidal hanging due to gradual compression rather than traumatic rupture. In our case, one ligature material was a nylon rope and the second ligature material was a electrical wire, responsible for the intimal tears of the carotid arteries.

Histopathological analysis of the sternocleidomastoid muscle revealed that interstitial hemorrhages (n= 16; 47.1%) and muscle fiber degeneration (n= 19; 55.9%) were common, supporting previous observations by Yadav and Gupta[4] and Jiwane et al.,[5] who suggested that these changes indicate antemortem trauma due to pressure from the ligature. The absence of leukocyte infiltration in the muscles in our cases is noteworthy, as Maxeiner[15] pointed out that the presence of leukocyte infiltration suggests a longer survival period post-hanging, whereas its absence confirms rapid fatality. Histopathological analysis of thyroid gland revealed congestion (n=23; 67.6%) and follicular destruction (n=11; 32.4%) in thyroid tissues. Similarly, Bamousa et al.[16] reported congestion in 91% cases and Ikeda et al.[17] found follicular destruction in 62.5% cases of hanging.

Gross examination of internal neck structures revealed visible soft tissue injuries in only 17.6% of cases (n=6), whereas histopathological analysis identified microscopic damage in 91.2% of cases (n=31), underscoring the limitations of gross examination in detecting subtle injuries.

This study had certain limitations. Firstly, the sample size was relatively small, which may affect the generalizability of the findings. Additionally, control samples were not collected for comparison of microscopic changes in neck structures in deaths unrelated to asphyxia.

CONCLUSION

The study highlights the predominance of young males in suicidal hanging cases, with atypical hanging being the most common type. The external ligature mark was typically oblique, incomplete, and parchmentized, whereas internal injuries were often microscopic and undetectable on gross examination. Histopathology proved to be a crucial diagnostic tool, revealing muscle and vascular changes indicative of antemortem trauma. The findings contribute valuable forensic insights into the interpretation of neck injuries in hanging deaths, reinforcing the importance of detailed histopathological analysis in medico-legal investigations.

Financial/Material Support: None.

Disclosures: None to declare.

REFERENCES

1. Knight B, Saukko P. Fatal pressure on neck. Knight's forensic pathology. 4th ed. Boca Raton, FL: CRC press; 2016:369-97.
2. Sharma BR, Harish D, Sharma A, Sharma S, Singh H. Injuries to neck structures in deaths due to constriction of neck, with a special reference to hanging. J Forensic Legal Med. 2008;15(5):298-305.
3. Dimaio VJ, Dimaio D. Forensic pathology. 2nd ed. London: CRC press, 2001: 260-75.
4. Yadav A, Gupta BM. Histopathological changes in skin and subcutaneous tissues at ligature site in cases of hanging and strangulation. J Indian Acad Forensic Med. 2009;31(3):200-05.
5. Jiwane AS, Zine KU, Bardale RV. Microscopic analysis of compression injury over neck: One-year prospective study. Indian J Forensic Community Med. 2021; 8(2):125-131.
6. National Crime Records Bureau. Accidental deaths & suicides in India. New Delhi: Ministry of Home Affairs; 2022.
7. Ambade VN, Kolpe D, Tumram N, Meshram S, Pawar M and Kukde H. Characteristic Features of Hanging: A Study in Rural District of Central India. J Forensic Sci. 2015; 60: 1216-1223.
8. Das P, Singh A, Dasari H. Multifactorial analysis of deaths due to hanging. J Punjab Acad Forensic Med Toxicol. 2021; 21(1): 29-33.
9. Vinita VE, Paul PM, Janani, Pradhan P, Kumar PS. Pattern of neck tissue injuries in hanging- A prospective study. J Punjab Acad Forensic Med Toxicol. 2014; 14(2): 101-104.
10. Sharma N, Kumar S. Morphology of ligature marks in hanging and ligature strangulation in Jodhpur region, Rajasthan. J Punjab Acad Forensic Med Toxicol. 2018; 18(2): 48-51.
11. Rao D. An Autopsy Study of Death Due to Suicidal Hanging–264 Cases. Egypt J Forensic Sci. 2016;6(3): 248-54.
12. Jayaprakash S, Sreekumari K. Pattern of injuries to neck structures in hanging-an autopsy study. Am J

Forensic Med Pathol. 2012;33(4):395-9.

13. Naik SK, Patil DY. Fracture of Hyoid Bone in cases of Asphyxial deaths resulting from constricting force round the neck. J Indian Acad Forensic Med. 2005;27(3):149-153.
14. Bhausaheb NA, Baburao CS, Banerjee KK, Kohli A. Pattern of external and internal findings in deaths owing to hanging- a study in northeast Delhi. Int J Med Sci Public Health. 2015; 4(11): 1536-39.
15. Maxeiner H. Zur lokalen Vital reaktion nach Angriff gegen den Hals. Z Rechtsmed 1987; 99:35-54.
16. Bamousa MS, AL-Madani OM, Alsoway KS et al. Importance of tissue biopsy in suicidal hanging deaths. Egypt J Forensic Sci. 2015; 5(4): 140-143.
17. Ikeda T, Tani N, Michiue T, Oritani S, Morioka F, Potente S, et al. Postmortem histopathological examination of changes due to systemic ischemia/hypoxia in the thyroid gland. Forensic Sci Criminol. 2017;2 (3). 10.15761/fsc.1000118.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00043.0

Original Research Paper

Y-27 STR mediated genetic diversity analysis of Tibetans of the Northern Range of Himachal Pradesh, India

1. **Shivam Saini***
2. **Meenakshi Mahajan,** Directorate of Forensic Services Himachal Pradesh, Shimla, India
3. **Bhuvnesh Yadav***

*Department of Chemistry, Biochemistry & Forensic Science, Amity School of Applied Sciences, Amity University Haryana, Gurugram, India

ABSTRACT

Introduction: Forensic DNA profiling has revolutionized criminal investigations and has been instrumental in solving cold cases, confirming or excluding suspects, and providing crucial evidence in legal proceedings. Additionally, it has been used in humanitarian efforts to identify victims of mass disasters or conflicts, as well as in paternity testing to establish familial relationships. The reliability and discriminatory power of Y STR markers make them essential tools in the field of forensic genetics. Blood samples were collected from 50 healthy male individuals with their written consent. Studying the genetic characteristics of a specific population, such as Tibetans in Himachal Pradesh, helps in understanding the unique genetic traits and variations within that population. The amplification of samples using a Y-chromosomal Short Tandem Repeat (Y-STR) marker kit, specifically the one targeting 27 Y-STR markers (Y-Filer Plus™ amplification kit), provides valuable genetic and forensic information. The range of Gene Diversity (GD) values across all 27 loci (from 0.449 to 0.851) suggests a variable level of polymorphism across the Y-STR markers examined. A high gene diversity value suggests a higher level of polymorphism at that particular locus within the studied population. DYS385B marker has turned to be more prominent and polymorphic marker in the analysis of studied population as it showed highest power of discrimination among all markers that is 0.834, highest genetic diversity i.e.0.851, lowest matching probability i.e.0.165 and highest value of effective alleles i.e. 6.03 among all other markers.

Corresponding Author :
Dr. Bhuvnesh Yadav, Department of Chemistry, Biochemistry & Forensic Science, Amity School of Applied Sciences, Amity University Haryana, Gurugram, India
E-mail: bhuvneshyadav@gmail.com
Contact : +919899402613

Article History:
Received: 11 October 2024
Received in revised form: 05 January 2025
Accepted on: 05 January 2025
Available online: 15 April 2025

Keywords: DNA; Genetic diversity; Haplotype; Himachal Pradesh; Tibetan population; Y-STR.

INTRODUCTION

Buddhism is prevalent in the Trans-Himalayan region or Western Himalayas, encompassing the Indian states of Jammu and Kashmir and Himachal Pradesh, bounded on the extreme west by the Indus River and on the extreme east by the Tons-Yamuna River valley.[1] Since 1959, the inflow of Tibetan refugees into India has significantly increased the popularity and practice of Tibetan Buddhism. Today, Tibetans practicing Tibetan Buddhism resettled in Himachal Pradesh, Dehradun (Uttarakhand), Kushalnagar (Karnataka), Darjeeling (West Bengal), Arunachal Pradesh, Sikkim, and Ladakh, in addition to the original practitioners of Tibetan Buddhism in ancient and medieval India. Despite reform movements and migrations, Buddhism has remained anchored in the region, mainly in the Kangra (Dharamshala), Lahaul, Spiti, and Kinnaur valleys.

As a result of the influx of Tibetans in Dharamshala, the number of criminal cases within their community has also increased. Recent political upheaval has attracted waves of Tibetan exiles to different areas of Himachal Pradesh, mainly Dharamshala, where their social and religious leader has claimed asylum. Greater allele frequency disparities across populations in India than in Europe are a result of powerful founder effects, preserved through endogamy for thousands of years.[2-5] The high variability of STRs among individuals makes them powerful tools for forensic DNA profiling.[6]

In forensic investigations, amplifying 27 Y-STR markers allows for a detailed analysis of genetic diversity on the Y

chromosome. This diversity reflects the unique genetic characteristics within the male population, helping to identify specific Y-chromosomal haplotypes and variations.[7-8] The Y-STR markers can reveal population structure by identifying patterns of genetic variation.[9-10]

This study provides information on the genetic diversity of the Tibetan population in the Dharamshala region of Himachal Pradesh as determined by 27 Y-STR markers. It also investigates the genetic link between Tibetans and other populations by calculating genetic distance between the populations. Well-documented human migrations and gene flow between the Himachal and Tibetan people can provide an intriguing context for studying their genetic variations. The genetic data obtained can be used to link individuals to crime scenes, establish paternity, and identify potential relatives through the paternal lineage.

MATERIALS AND METHOD:

Before conducting the study, written consent was obtained from all participants, ensuring they were informed about the study and agreed to participate voluntarily. The study also received ethical approval from the Institutional Human Ethical Committee (IHEC) of Amity University in Haryana, India (Ref No. IEC-AIB/AUH/2021-9).

Sample Collection and DNA Isolation:

Inclusion Criteria: Healthy males with no major disease diagnosed.

Exclusion Criteria: Participants those were paternally related up to three generation were excluded from the study.

50 healthy adult male participants from the diverse Tibetan community residing at Dharamshala, Himachal Pradesh for at least three generations were selected for the study. Blood samples were collected randomly aiming to be unbiased using FTA cards for storing and preserving DNA under sterile conditions, emphasizing the importance of maintaining aseptic conditions to prevent contamination. In the lab, the FTA protocol was implemented using a purification buffer.[11] The analysis was carried out as follows:

- **Lysis of Samples:** Lysis of FTA punches containing blood was done to break down the cell membrane, releasing the DNA. This process occurred for 4-5 hours at 56°C, a temperature optimized to enhance DNA extraction efficiency.
- **Addition of Purification Buffer and Proteinase K:** FTA purification buffer and Proteinase K were added to each sample during lysis. This step helps digest proteins and release DNA from cells.
- **Incubation:** The sample tubes were incubated at 56°C. After this step, sufficient DNA was obtained.
- **Washing of Samples:** After incubation, the samples were washed gently and slowly with Milli-Q water to remove impurities like cellular debris or any other residual chemicals.

This process is crucial for preparing DNA samples for downstream analysis, such as PCR or other molecular techniques. Positive control DNA templates and negative controls were utilized throughout the investigation to maintain quality control. The experimental work was conducted at the Regional Forensic Science Laboratory in Dharamshala, Himachal Pradesh, India, which is an ISO/IEC 17025:2017-accredited laboratory.

Amplification of DNA and Genotyping

The DNA samples were amplified using the Y Filer™ Plus PCR amplification kit from Applied Biosystems, which is designed for specific genetic analyses, particularly targeting Y-chromosomal markers. The samples underwent 25 amplification cycles, which involved a series of temperature changes to denature, anneal, and extend DNA fragments. The amplification was performed on an ABI Veriti Thermal Cycler, a device used for conducting polymerase chain reactions (PCR) and designed to precisely control temperature conditions during each amplification cycle.

The amplified products were mapped using an automated Genetic Analyzer ABI 3500. Data analysis and DNA profile generation were performed with the software GeneMapper™ ID-X 1.6.

Statistical Analysis:

The genetic data were evaluated using descriptive statistics, including Hardy-Weinberg Equilibrium (HWE), Gene Diversity, Haplotype Diversity, and Allele Frequencies of the studied population. Hardy-Weinberg Equilibrium helped describe the relationship between the frequencies of alleles and genotypes in a population over generations. Deviations from HWE indicated factors such as genetic drift or selection operating in the population. Gene Diversity measured the genetic variation within the population, taking into account the number of alleles at each locus and their frequencies.

Haplotype diversity assessed the variety of combinations of alleles on a single chromosome or genetic locus.

Analyzing allele frequencies was essential for understanding the genetic makeup of a population and is informative in fields such as population genetics and forensic studies.

Statistical methods were employed to assess the significance of matches and determine the probability of a given haplotype occurring in the population. Utilizing the GenAlEx 6.2 program[12], allele and haplotype frequencies were determined to evaluate the genetic relatedness of the Tibetan population. STRAF software was used for Principal Component Analysis (PCA), as shown in **Figure 1**, and for assessing other forensic parameters.[13] Genetic distance with other Indian and world populations was calculated to find out the genetic relatedness of this population with others.[14-19] To infer evolutionary history UPGMA method[20] and for evolutionary analyses MEGA6 was used.[21]

RESULTS

Based on all 27 STR markers from the 50 blood samples on FTA cards, complete Y-STR DNA profiles were detected. **Table 1** displays the values for polymorphism information content, power of discrimination, matching probability, and genetic diversity observed in Tibetan haplotypes in the Dharamshala region. In **Table 2**, values for the number of effective alleles, the number of different alleles, Shannon's information index, and unbiased diversity are presented for the Tibetan population at various loci.

The genetic diversity (GD) values for all analyzed loci were greater than 0.44. The loci with the highest GD were DYS385B and DYS518, with values of 0.851 and 0.850, respectively, while the lowest was observed in DYS391, with a GD value of 0.449, as shown in **Table 1**. **Figure 1** depicts the observed haplotype allelic patterns of the investigated Tibetan population in the Dharamshala region. The data demonstrate its utility in forensic genetic applications, with a high power of discrimination (PD) in DYS385B (0.834) and DYS533 (0.833). The matching probability (PM) value was also found to be lowest in DYS385B (0.165) and DYS533 (0.166), respectively, as shown in **Table 1**.

The tested population exhibited an intriguingly high level of haploid genetic diversity, according to Nei's formula. The effective alleles value of 6.03 at the DYS385B locus indicates the diversity of alleles observed at this specific Y-chromosomal Short Tandem Repeat (Y-STR) marker within the analyzed population **(Table 2)**. In forensic applications, a locus with higher effective alleles can be more informative for individual identification as it enhances the power of discrimination.

Figure 1: Principal Component Analysis within the Tibetan Population.

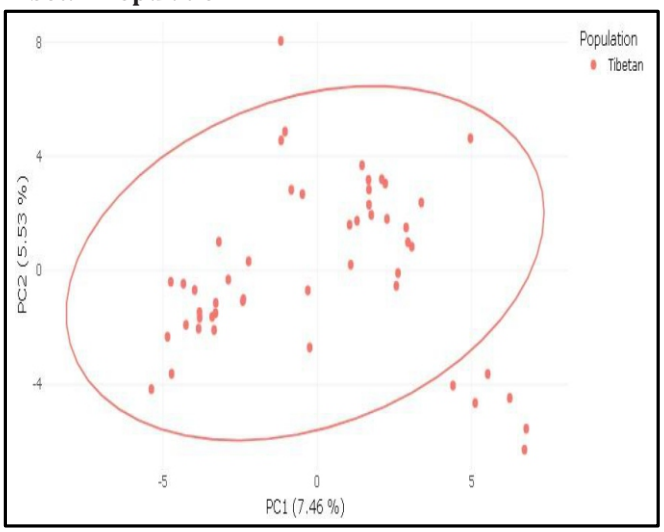
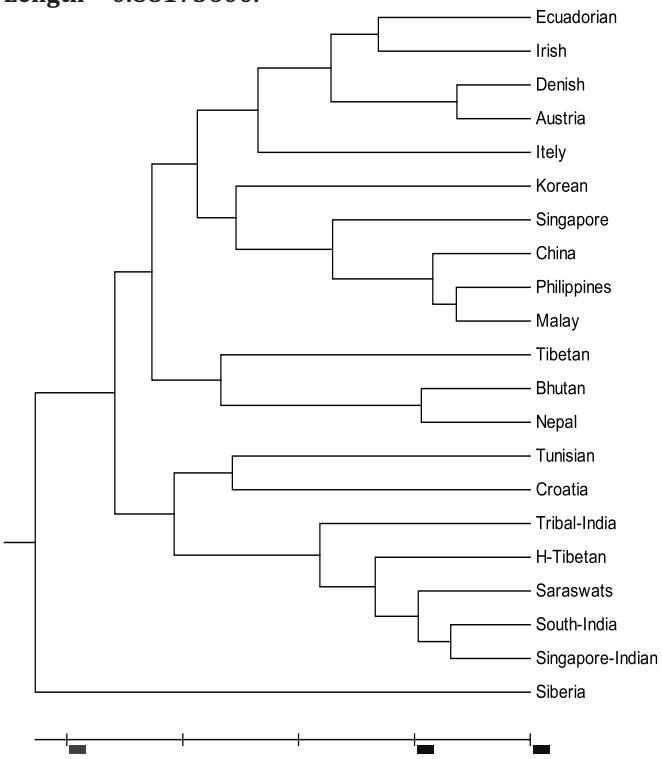


Figure 2: Evolutionary Relationships of Himachal Tribal Population with other Indian and World Populations. The Pptimal tree with the Sum of Branch Length = 0.88173600.



The Shannon's Index value observed at the DYS385B locus was 1.95, which is relatively high, suggesting a diverse set of alleles within the analyzed population. In forensic applications, a high Shannon's Index indicates a high level of informativeness for individual identification. The unbiased diversity values were the same at both DYS385B

Table 1: Values for Polymorphism Information Content, Power of Discrimination, Matching Probability and Genetic Diversity Observed Among Tibetan Population of NR, Himachal Pradesh using STRAF Software.

Locus	N	GD	PIC	PM	PD
DYF387S1A	50	0.72897959	0.67506784	0.2856	0.7144
DYF387S1B	50	0.73061224	0.66870624	0.284	0.716
DYS19	50	0.63183673	0.5631648	0.3808	0.6192
DYS385A	50	0.80653061	0.76044864	0.2096	0.7904
DYS385B	50	0.85142857	0.81449632	0.1656	0.8344
DYS389I	50	0.68163265	0.61579104	0.332	0.668
DYS389II	50	0.79673469	0.74713152	0.2192	0.7808
DYS390	50	0.76816327	0.7110256	0.2472	0.7528
DYS391	50	0.44979592	0.37276768	0.5592	0.4408
DYS392	50	0.48408163	0.43883872	0.5256	0.4744
DYS393	50	0.58367347	0.47939424	0.428	0.572
DYS437	50	0.52734694	0.47432256	0.4832	0.5168
DYS438	50	0.69795918	0.62005344	0.316	0.684
DYS439	50	0.77061224	0.71252032	0.2448	0.7552
DYS448	50	0.77795918	0.72276064	0.2376	0.7624
DYS449	50	0.82612245	0.78440256	0.1904	0.8096
DYS456	50	0.73142857	0.68302912	0.2832	0.7168
DYS458	50	0.79836735	0.75398976	0.2176	0.7824
DYS460	50	0.64081633	0.55671904	0.372	0.628
DYS481	50	0.73061224	0.67212192	0.284	0.716
DYS518	50	0.85061224	0.81269568	0.1664	0.8336
DYS533	50	0.65877551	0.60688224	0.3544	0.6456
DYS570	50	0.84979592	0.811752	0.1672	0.8328
DYS576	50	0.8	0.7489024	0.216	0.784
DYS627	50	0.84979592	0.81224352	0.1672	0.8328
DYS635	50	0.79183673	0.7524	0.224	0.776
YGATAH4	50	0.64	0.55339008	0.3728	0.6272

**– number of samples, GD- Gene diversity, PIC- Polymorphism Information Content, PM- Matching Probability, PD- Power of differentiation*

and DYS518, each with a value of 0.851. This indicates that within the given population, these two loci exhibit similar patterns of allelic diversity. The similar unbiased diversity values at DYS385B and DYS518 suggest that both loci may be equally suitable for forensic and genetic studies within the analyzed population.

Although all the statistical analyses provide a more comprehensive understanding of allelic diversity compared to simply counting the number of observed alleles, the findings of high haploid and genetic diversity in the Tibetan community of Dharamshala, as indicated by the wide distribution of 27 Y-STRs, offer valuable insights into the unique genetic makeup of this population.

Principal Component Analysis (PCA) was also conducted, helping to identify patterns of genetic variation and revealed clusters or groups of individuals with similar genetic profiles. The phylogenetic analysis revealed that the Himachal Tibetan population is genetically closer to the India populations (tribal, Saraswat populations) than the Tibetan and Bhutani populations **(Figure 2)**. It indicates the local admixture in the population.

DISCUSSION

This study analyzed the Tibetan population in the Dharamshala region of Himachal Pradesh using 27 Y-STRs and served as a resource for the development of a Y-STR database for Tibetan migrants. The genetic makeup of the population suggests that Tibetans in the Dharamshala district are not closely related. Our findings align with previous investigations, which have not revealed significant differences in allelic patterns between groups. It's important to note that the use of forensic DNA databases raises ethical questions related to privacy, consent, and potential misuse.

Table 2: Values of No. of Effective Alleles, No. of Different Alleles, Shannon's Information Index Value and Unbiased Diversity Observed Among Tibetan Population of NR, Himachal Pradesh using GenAlex Software.

Locus	N	Na	Ne	I	uh
DYS576	50	6	4.630	1.607	0.800
DYS3891	50	5	3.012	1.264	0.682
DYS635	50	8	4.464	1.764	0.792
DYS38911	50	7	4.562	1.649	0.797
DYS627	50	8	5.981	1.920	0.850
DYS460	50	4	2.688	1.091	0.641
DYS458	50	7	4.596	1.694	0.798
DYS19	50	5	2.626	1.144	0.632
YGATAH4	50	3	2.682	1.039	0.640
DYS448	50	5	4.209	1.502	0.778
DYS391	50	3	1.788	0.729	0.450
DYS456	50	6	3.531	1.493	0.731
DYS390	50	5	4.045	1.469	0.768
DYS438	50	4	3.165	1.211	0.698
DYS392	50	4	1.903	0.908	0.484
DYS518	50	9	6.010	1.933	0.851
DYS570	50	9	5.981	1.919	0.850
DYS437	50	5	2.070	0.994	0.527
DYS385a	50	6	4.771	1.665	0.807
DYS385b	50	9	6.039	1.952	0.851
DYS449	50	9	5.252	1.835	0.826
DYS393	50	4	2.336	0.961	0.584
DYS439	50	6	4.085	1.495	0.771
DYS481	50	7	3.521	1.460	0.731
DYF387S1a	50	6	3.501	1.475	0.729
DYF387S1b	50	6	3.521	1.421	0.731
DYS533	50	6	2.822	1.318	0.659

**– Population size, Na- observed number of alleles, Ne- effective number of alleles, I- Shannon Index, and UH- unbiased gene diversity.*

Therefore, the establishment and maintenance of these databases are subject to legal frameworks and oversight to ensure the responsible and lawful use of genetic information in criminal investigations.[22] This comparative STR profile matching for human identification is limited for completely unidentified criminals whose STR profiles are not yet accessible. However, Y-STR haplotyping is incredibly useful for identifying groups of male relatives who share the same paternal ancestry and for eliminating criminal suspects by establishing non-matching haplotypes.

The genetic information derived from the study has diverse applications, benefiting both forensic investigations and genealogical research. The insights gained contribute not only to solving crimes and identifying individuals but also to understanding the genetic history, diversity, and cultural context of the studied population. However, the study can be extended to larger population group and comparison with other studied populations form Northern region and world population can be performed.

Acknowledgements We thank the donors who provided samples for this study. The authors acknowledge My Gene Life Solutions LLP(India) for giving a Y FilerTM Plus PCR amplification kit for this study.

Conflict of interest: Nil

Ethical approval: The Institutional Human Ethical Committee (IHEC) of Amity University, Haryana, India. approved the study with Ref. No., IHEC/IEC-AIB/AUH/2021-9 dt. 29/06/2021).

REFERENCES

1. Sharma A, Sharma A. Exploring Heritage of a Hill State - Himachal Pradesh, in India. Almatourism - Journal of

Tourism, Culture and Territorial Development. 2015;6(12).

2. Bhattacharya, A. (2019). India–China Relations: Putting the Record Straight. India Quarterly, 75(2), 262-268.
3. Reich, D., Thangaraj, K., Patterson, N. et al. Reconstructing Indian population history. Nature 2009. 461, 489–94.
4. Basu A, Sarkar-Roy N, Majumder PP. Genomic reconstruction of the history of extant populations of India reveals five distinct ancestral components and a complex structure. Proc Natl Acad Sci U S A. 2016;113(6):1594-9
5. Zerjal T, Wells RS, Yuldasheva N, Ruzibakiev R, Tyler-Smith C. A genetic landscape reshaped by recent events: Y-chromosomal insights into Central Asia. Am J Hum Genet. 2002;71(3): 466-82
6. Yadav B, Balayan A, Raina A, Dogra TD. Paternity suspicion: Current scenario in India. J Punjab Acad Forensic Med Toxicol. 2017;17(2): 55-59.
7. Yadav B, Raina A, Dogra TD. Haplotype diversity of 17 Y-chromosomal STRs in Saraswat Brahmin Community of North India. Forensic Sci Int Genet. 2011;5(3): e63-e70.
8. Balayan AP, Kumar V, Pandya P, Kanga U, Seth T, Raina A. Y STR profiling in blood, buccal swab & hair follicles in sex mismatch HSCT: A case of chimerism. J Punjab Acad Forensic Med Toxicol. 2020;20(1): 139-141.
9. Bamshad M, Kivisild T, Watkins WS, Dixon ME, Ricker CE, Rao BB, et al. Genetic evidence on the origins of Indian caste populations. Genome Res. 2001;11(6): 994–1004.
10. Thanseem I, Thangaraj K, Chaubey G, Kumar Singh V, Bhaskar LVKS, Reddy BM, et al. Genetic affinities among the lower castes and tribal groups of India: Inference from Y chromosome and mitochondrial DNA. BMC Genet. 2006;7.
11. Sahajpal V, Rajput S, Sharma T, Sharma A, Thakar MK. Development and evaluation of a novel DNA purification buffer and protocol for blood samples on FTA cards. Forensic Science International: Reports. 2019;1: 100014
12. Peakall R, Smouse P. Appendix 1 – Methods and Statistics in GenAlEx 6 By Rod Peakall and Peter Smouse. Statistics (Ber). 2005;502.
13. Gouy A, Zieger M. STRAF—A convenient online tool for STR data evaluation in forensic genetics. Forensic Sci Int Genet. 2017;30: 148-151.
14. Zhu B, Wu Y, Shen C, Yang T, Deng Y, Xun X, et al. Genetic analysis of 17 Y chromosomal STRs haplotypes of Chinese Tibetan ethnic group residing in Qinghai province of China. Forensic Sci Int 2008;175(2–3): 238–43.
15. Parkin EJ, Kraayenbrink T, Opgenort JRML, Driem JLV, Tuladhar NM, Knijff P, et al. Diversity of 26-locus Y-STR haplotypes in a Nepalese population sample: isolation and drift in the Himalayas. Forensic Sci Int 2007;166(2–3):176–81.
16. Emma J, Parkin EJ, Kraayenbrink T, Driem GLV, Gaselô KT, Knijff P, et al. 26 locus Y-STR typing in a Bhutanese population sample. Forensic Sci Int 2006;161:1–7.
17. Ljubkovic J, Stipisic A, Sutlovic D, Gojanovic MD, Bucan C, Andelinovic S. Y chromosomal short tandem repeat haplotypes in Southern Croatian male population defined by 17 loci. Croat Med J 2008;49:201–206.
18. Woz ´niak M, Derenko M, Malyarchuk B, Dambueva I, Grzybowski T, S ´liwka DM. Allelic and haplotypic frequencies at 11 Y-STR loci in Burtyats from South East Siberia. Forensic Sci Int 2006;164(2):271–275.
19. Singh M, Sarkar A, Kumar D, Nandineni MR. The genetic affinities of Gujjar and Ladakhi populations of India. Sci Rep. 2020 Feb 6;10(1):2055.
20. Sneath PHA, Sokal RR. Numerical Taxonomy. Freeman, San Francisco. 1973.
21. Tamura K, Stecher G, Peterson D, Filipski A, Kumar S. MEGA6: Molecular Evolutionary Genetics Analysis version 6.0. Molecular Biology and Evolution 2013; 30: 2725-2729.
22. Williams R, Johnson P. Inclusiveness, effectiveness and intrusiveness: Issues in the developing uses of DNA profiling in support of criminal investigations. Journal of Law, Medicine and Ethics 2005; 33.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00044.7

Original Research Paper

An Observational One Year study On Socio - Demographic Profile of Suicidal Deaths in Bikaner Region of Rajasthan

1. **Anchal,** Postgraduate Student*
2. **O.P. Saini,** Senior Professor and Head*
3. **Shalender Kumar,** Associate Professor*
4. **Rajendra Singh,** Assistant Professor
5. **Chandra Pal,** Assistant Professor*

*Department of Forensic Medicine and Toxicology, Sardar Patel Medical College, Bikaner, Rajasthan

ABSTRACT

Introduction: Self-injurious behaviors are amongst the most alarming of all human behaviours and leading cause of death worldwide. The word suicide originated from a latin word Suicidium (to kill oneself). The essential ingredients of suicide include, unnatural death with desire from within and reason for ending life. In 2017, Indian Parliament decriminalised suicide. A one-year cross sectional study was conducted from February 2023 to January 2024 in the Department of Forensic Medicine, SPMC, Bikaner. 150 cases with history of suicide subjected to medicolegal autopsy were included in study on a purposive sampling basis. Information was gathered from autopsy related documents, proforma, history of relatives of the deceased, suicide notes, hospital records, concerned investigating agencies and laboratory reports. Number of suicides committed by males were more as compared to females with a ratio of 2:1, maximum in the age group of 21-30 year. Hanging was the most common pattern followed by poisoning. Some cases have previous history of suicide attempt and only few left suicide note explaining the reason behind their action. Extreme of summer season i.e. months of May, June and July showed more cases and evening time was preferred by most cases. Marital issues was the most common motive behind committing suicide.

Corresponding Author :
Dr. Anchal, Postgraduate Student,
Department of Forensic Medicine and Toxicology, Sardar Patel Medical College, Bikaner, Rajasthan
E-mail: dranchaljalwa17@gmail.com
Contact : +919517833678

Article History:
Received: 11 October 2024
Received in revised form: 05 January 2025
Accepted on: 05 January 2025
Available online: 15 April 2025

Keywords: Suicide; Cross Sectional Study; Suicidal Methods; Hanging; Self Harm.

INTRODUCTION

Self-injurious behaviours are the most perplexing of all human behaviours. Most of what we do as humans is aimed at keeping ourselves alive and passing on our genetics. In some instances, some people act in complete opposition to this innate drive of self-preservation and intentionally end their own lives. Deliberate termination of own life is called suicide. Suicide has been in attention of society since ages.

The word suicide originated from a Latin word Suicidium and Sui caedere, Sui (of oneself) and, cidium from caedere (to kill).[1] Despite having one of the highest suicide burdens in the world, India has yet to develop a systematic response to suicide. The major national source of surveillance for suicides in India is the National Crime Records Bureau (NCRB). Suicide in any age is a painful and devastating event that has a widespread effect on families, friends, and the community. To many, the very idea of people dying by their own hands is incomprehensible.

The pattern of suicidal deaths in a particular area point not only to the quality of living, but also the social and mental makeup of the population. In India, suicide was illegal and survivor would face jail up to one year and fine under section 309 of Indian Penal Code.[2] However, the Indian Government decided to annul this law in 2014. In April 2017, Indian Parliament decriminalised suicide by passing the "Mental Healthcare Act 2017" and the act came into force in July 2018.

The objective of this study is to examine the patterns of suicidal deaths, analyze socio-demographic characteristics, and assess the methods used in suicide completion

within the areas surrounding Sardar Patel Medical College, Bikaner, over the course of one year.

MATERIALS AND METHOD

The study was conducted in the Department of Forensic Medicine and Toxicology, S.P. Medical College, Bikaner (Rajasthan) after taking Institutional ethics committee approval to conduct the study vide Letter No. 2479 dated 22.02.2023 SPMC, Bikaner. A one-year cross-sectional study was conducted from February 2023 to January 2024 for observational purposes. Data were collected from 150 selectively chosen suicide cases reported at a medical college during this period.

The study was based on routine post-mortem examinations performed in the mortuary of SPMC, Bikaner, with no experimental procedures involved. The study material comprised autopsy-related documents, structured proformas, information from the deceased's relatives, hospital records, reports from investigating agencies, and laboratory analyses of viscera, bodily fluids, deceased tissues, organs, and other relevant suspicious samples available in the department. Information on age, marital status, educational background, and socio-economic status was gathered from reliable attendants of the deceased, while details regarding the manner of death were obtained from investigating police officers.

Inclusion & Exclusion Criteria

All death cases with history of suicide brought to mortuary for postmortem examination were included. Cases which not have confirmation of suicide and unidentified bodies were excluded. Cases in which the relatives of the deceased refused consent were not included in the study.

RESULTS

Out of the total 150 cases studied, it was observed that male outnumbered females in committing suicide by ratio 2:1 i.e. 100 males and 50 females. Maximum cases were seen in the age group 21-30 years (N=63, 42%) followed by the age group of 31 to 40 years (N=31, 20.67%) and minimum persons were from the age group more than 80 years (N=1, 0.67%). We observed that the mean age of suicide was 30.85 years. Most of the suicides involved Hindus (N=137, 91.33%), followed by Muslims (N=7, 4.67%) and Sikhs (N=6, 4%).

According to our analysis 54 cases (36%) of suicidal autopsies were from urban areas and 96 cases (64%) were from rural areas. Hanging was the most common method in urban areas (N=43, 79.6%) whereas poisoning (N=45, 46.8%) was more common in rural areas.

Most cases (N=90, 60%) were married. 57 males and 33 females were married. Most of suicides were reported from housewives (N=29, 19.33%). However, if considering both genders, unemployment comprised a maximum 28 cases (18.67%) out of which 19 were males and 9 females. In this study it was observed that suicides were more common amongst the hot and humid months of May, June and July (N=79, 52.67%).

DISCUSSION

Bikaner is a district of the state of Rajasthan in Western India comprising eight Tehsils. There are 1498 villages and 290 Gram Panchayats. As of the 2011 Census of India the population of Bikaner city was 644,406. Most of the population of the city follows Hinduism, with followers of Islam as minority. According to statistical data from the Rajasthan Police, Bikaner district ranks fourth in suicide prevalence among all districts of Rajasthan.

It was observed that male outnumbered females in committing suicide **(Table 1)**. Distribution of study population according to age in cases of alleged suicide and their distribution according to sex shows maximum number of suicides were in the age group of 21 to 30 years. **(Table 1)** Though women suffer from depression more than males, females commit more 'attempted suicide' whereas males committed more 'completed suicide'. Similar results were seen in a study conducted by Kinyand E[3], Lahti A et al[4], Sukhadeve R et al.[5] In this study it was

Table 1: Distribution of Study Cases According to Sex & Age.

Age Groups (in years)	Male N (%)	Female N (%)	Total N (%)
0-10	0	0	0
11-20	15 (15%)	14 (28%)	29 (19.33%)
21-30	42 (42%)	21 (42%)	63 (42%)
31-40	18 (18%)	13 (8.67%)	31 (20.67%)
41-50	12 (12%)	01 (2%)	13 (8.67%)
51-60	11 (11%)	0	11 (7.33%)
61-70	01 (1%)	01 (2%)	02 (1.33%)
71-80	0	0	0
>80	01 (1%)	0	01 (0.67%)

Table 2: Distribution of Study Cases According to Religion.

Religion	Male	Female	Total
Hindu	94 (94%)	43 (86%)	137 (91.33%)
Muslim	03 (3%)	04 (8%)	07 (4.67%)
Sikh	03 (3%)	03 (6%)	06 (4%)

Table 3: Distribution of Study Cases according to Methods of Suicide and Area of Residence.

Method of Suicide	Urban	Rural	Total
Burns	02 (3.70%)	04 (4.16%)	06 (4%)
Drowning	0	09 (9.35%)	09 (6%)
Firearm	0	01 (1.04%)	01 (0.67%)
Hanging	43 (79.62%)	34 (35.42%)	77 (51.33%)
Poisoning	08 (14.81%)	45 (46.87%)	52 (34.67%)
Run over Railway Track	01 (1.85%)	03 (3.12%)	04 (2%)
Jump from Height	0	01 (1.04%)	01 (0.67%)
Total	54 (36%)	96 (64%)	150 (100%)

Table 4: Distribution of Study Cases according to Marital Status.

Marital Status	Male	Female	Total
Married	57 (57%)	33 (66%)	90 (60%)
Unmarried	38 (38%)	17 (34%)	55 (36.67%)
Divorced	05 (5%)	0	05 (3.33%)

Figure 1: Distribution of Study Cases According to Occupation and Sex.

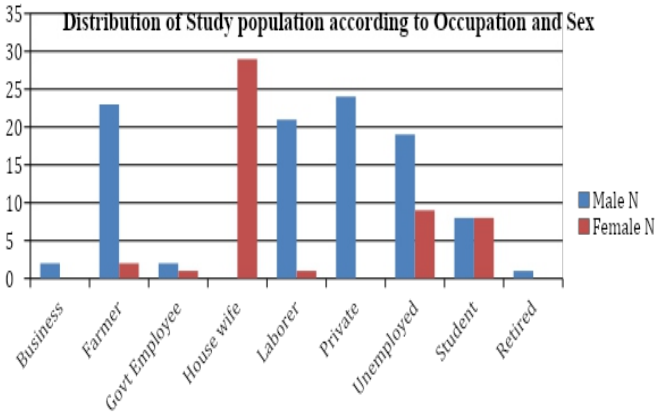


Figure 2: Distribution of Study Cases according to Education and Gender.

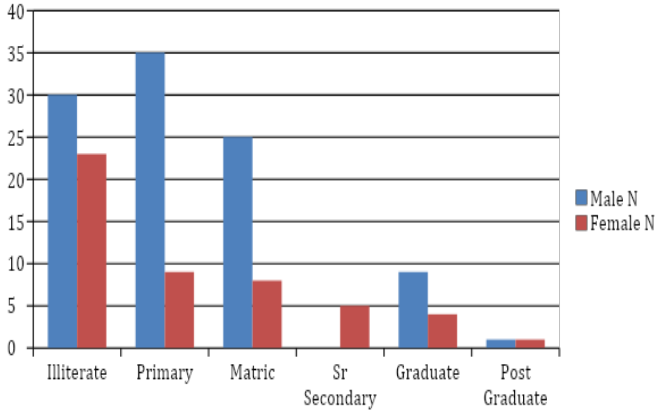
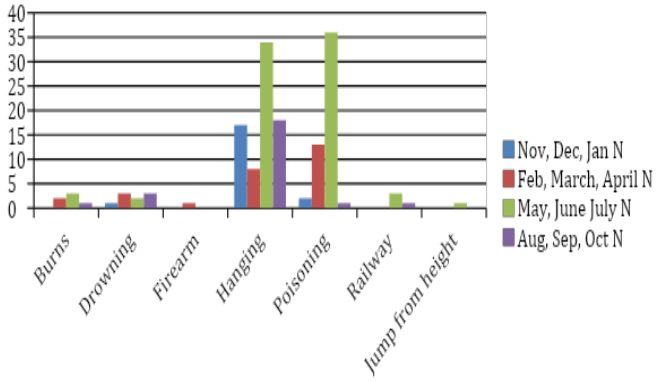


Figure 3: Distribution of Study Cases according to Methods of suicide and Seasonal Variations.



observed that most of the suicides involved Hindus followed by Muslims and Sikhs **(Table 2)**. These values in themselves may show highly skewed statistics; however, when compared with the total population of the area under study this is highly representative of the population involved. According to our analysis, cases were more from rural populations than urban areas. Hanging is the most common method in urban areas whereas poisoning is more common in rural areas **(Table 3)**.

Most of the cases were married **(Table 3)**. These findings were found almost similar to studies done by Sukhadeve R et al,[5] Maharani B et al[6] and Baruah AM et al,[7] Bhagwath et al,[8] Pawle DA et al.[9] It was observed that most of suicides were reported from housewives. However, if considering both genders, unemployment comprised maximum cases. Amongst males, the most deaths were from private employees followed by labourers and the minimum being from the retired persons. From the females, most deaths were from housewives and unemployed, with the minimum being from the government employees and labourers **(Figure 1)**.

The most common method opted for suicide was Hanging, followed by poisoning and drowning from amongst the total sample. In respect to gender of victims, it is observed that most common method opted for suicide by males as well as females was hanging, which shows almost similar percentage of victims in total. The least common method used was firearms and jump from height which was seen only in case of males. The next being burns and railways.

The railways as a method of suicide is much commoner in males as compared to females. Similar results were observed in a study by Pawale DA et al[9] whereas our results vary with study done by Rajendra S et al[10] where females opted for poison intake and burns as method of suicide. The relationship of education with the method of

suicide used, where the education status was available, hanging was common in illiterate, matric, graduates as well as post graduates, whereas poison was common in persons with primary and senior secondary education **(Figure 2)**.

This observation aligns with results of study done by Parkar SR et al[11] and Naveen N et al.[12] Burns are commoner amongst warmer months from February to July. Hanging is common in the extreme climates of summers i.e. May, June, July and winters i.e. November, December. Poisoning is common in months of May, June and July **(Figure 3)**. Similar results were seen in a study conducted by Gopal BK et al.[13]

CONCLUSION

Number of suicides committed by males were more than females with maximum number in age group of 21-30 years. Most cases were Hindus and from rural areas. Maximum cases were illiterate, housewives and unemployed as per education and occupation. Most cases were married and living in a joint family. Hanging was the most common method opted.

Limitations and Recommendations

Study was confined to a population of a particular area. Risk factors differ between populations according to the prevalence of underlying conditions in that population. Future research should necessarily focus on understanding differences in risk factors among populations. Future studies should be with a large sample size and there is a need to address and account for known risk factors. The information about the deceased is based only on the history provided by police and relatives rather than assessment of suicide attempts should be relied on accurate assessment and documentation by the provider. Suicide must be addressed as the significant health problem and make national strategies to prevent loss of life and suffering suicide causes.

REFERENCE

1. Saxena S, Krug EG, Chestnov O, World Health Organization, editors. Preventing suicide: a global imperative. Geneva: World Health Organization; 2014.
2. Lakshmanan AR. Humanization and Decriminalization of Attempt to Suicide. New Delhi: Law Commission of India, Government of India; 2008.
3. Kinyanda E, Wamala D, Musisi S, Hjelmeland H. Suicide in urban Kampala, Uganda: a preliminary exploration. Afr Health Sci 2011;11(2):219-27.
4. Lahti A, Räsänen P, Riala K, Keränen S, Hakko H. Youth suicide trends in Finland, 1969-2008. J Child Psychol Psychiatry. 2011 Sep;52(9):984-91.
5. Sukhadeve R, Parchake MB, Hosmani A, Pathak H, Kamble R, Tyagi S. Study of Trends of Suicidal Deaths in Central Mumbai Region of India. Sch J Appl Med Sci 2015;3(3B): 1178-83.
6. Maharani B, Vijayakumari N. Profile of poisoning cases in a Tertiary care Hospital, Tamil Nadu, India. J Appl Pharm Sci 2013;3(1):91-4.
7. Baruah AM, Chaliha R. Pattern of suicidal deaths brought for medicolegal autopsy at Gauhati Medical College: A Retrospective study. J Punjab Acad Forensic Med Toxicol 2014;14(2):86-90.
8. Bhagavath P, Bhandary S, Soans S, et al. Victim profile of suicidal deaths: a perspective from tertiary health care centre, Mangalore, southern India. J Evol Med Dent Sci 2014;3(39):9876-80.
9. Pawale DA, Jagtap NS. Trends in suicidal deaths brought for medico legal autopsy at RCSM medical college Kolhapur: retrospective study. J Forensic Med Sci Law 2015;24(2):1-7.
10. Kulhari Rajendra, Soni Keshav, Saini OP, Saini P ,Buri Sanjeev, Kumar Shalender. Pattern of suicidal deaths among females in the reproductive age group of western rajasthan-An autopsy study. J of Punjab Acad of Forensic Med & Toxicol 2018;18(2):45-47.
11. Parkar SR, Dawani V, Weiss MG. Gender, Suicide, and the Sociocultural Context of Deliberate Self-Harm in an Urban General Hospital in Mumbai, India. Cult Med Psychiatry 2008;32(4):492-515.
12. Naveen N, Madhuvardhana T, Arun M, Balakrishna Rao AJ, Kagne RN. Profile of suicidal poisoning in Puducherry area. Int J Recent Trends Sci Technol 2015;14(1):76-9.
13. Gopal BK, Viswakanth B, Shruthi P, Varma RK. A Retrospective Analysis of Suicidal Poisoning Deaths in a Metropolitan City of South India. J Indian Acad Forensic Med 2015;37(2):140-3.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00045.3

Original Research Paper

Pattern and Severity of Injuries in Assault Victims in Bikaner Region of Rajasthan – A Prospective Study

1. **Vandana Gahlot,** Postgraduate Resident*
2. **O.P. Saini,** Senior Professor and Head*
3. **Rajendra Singh,** Assistant Professor*
4. **Shalender Kumar,** Associate Professor*
5. **Neha Tanwar,** Senior Demonstrator*

*Department of Forensic Medicine and Toxicology, Sardar Patel Medical College, Bikaner, Rajasthan.

ABSTRACT

Introduction: Injury is any harm, whatever illegally caused to any person in body, mind, reputation or property. Injuries of a widely differing nature may be inflicted with widely different instruments in many ways.

Materials and Method: This study comprised of 262 assault cases presented to OPD of FMT department, admitted and brought dead cases in our institution from February 2023 to January 2024.

Results: Total n=266 weapons were used of which Blunt weapons (n=251, 94.36%) were most prevalent in this study followed by sharp weapon (n=10, 3.75%), amongst them use of body part was widespread in urban region and lathi/danda/wooden stick were used frequently in rural region. Out of total n=938 injuries, Abrasion (n=348, 37.1%) was most common. Greater number of the assaulted victims sustained injuries on head and neck (n=301, 32.08%). Most of the injuries were simple in nature (n=825, 85.76%).

Conclusion: There was preponderance of use of blunt weapon. In urban region use of body parts were most commonly reported then lathi/danda/wooden stick. Desi katta was used in only 1 case. In rural areas most prevalent weapon was lathi/danda/wooden stick. Use of kulhadi, barchi and chosagi was reported from rural areas only. Injuries to case ratio turned up 3.58:1 indicating multiple injuries seen in single victim. Abrasions were most common type of injury. Head and neck region was the preferred site for attack by assailant.

Corresponding Author :
Dr. Vandana Gahlot, Postgraduate student, Department of Forensic Medicine and Toxicology, Sardar Patel Medical College, Bikaner, Rajasthan.
E-mail: gahlot.vandana12@gmail.com
Contact : +919116815134

Article History:
Received: 11 October 2024
Received in revised form: 05 January 2025
Accepted on: 05 January 2025
Available online: 15 April 2025

Keywords: Injury; Weapons; Abrasion; Fractures; Simple.

INTRODUCTION

Injury is defined as any harm, whatever illegally caused to any person in body, mind, reputation or property. Medically a wound or injury is a break of the natural continuity of any of the tissues of the living body. Mechanical injuries are produced by physical violence.[1]

According to WHO data of 2021, injuries- both unintentional and violence related- take the lives of 4.4 million people around the world each year and constitute nearly 8% of all deaths. Of the 4.4 million injury-related deaths, unintentional injuries take the lives of 3.16 million people every year and violence-related injuries kill 1.25 million people every year.

Roughly 1 in 3 of these deaths result from road traffic crashes, 1 in 6 from suicide, 1 in 10 from homicide and 1 in 61 from war and conflict.[2]

Worldwide over 1,76,000 homicides occur among youth 15-29 years of age each year, which is 37% of the total number of homicides globally each year, making it the third leading cause of death for people in this age group.[3] According to the latest WHO data published in 2020 Violence Deaths in India reached 51,767 or 0.61% of total deaths. The age adjusted Death Rate is 3.84 per 100,000 of population ranks India at104th position in the world.[4]

Violence plays a part in day to day lives, affecting almost everybody, directly or indirectly. The experience of assault or violence-related injuries has a negative psychological impact on any individual. Studies done in the West and in

India have shown that assault-related injuries as a leading cause of preventable injuries. These studies also demonstrated that injury rates secondary to assault or violence are 3.6 times higher in low-to-middle-income countries than high-income countries, whereas mortality rates are 13.8 times higher in low-to-middle-income countries.[5]

Injuries of a widely differing nature may be inflicted with widely different instruments in many ways. The character of an injury caused by any mechanical force are dependent on the nature and shape of the weapon, the amount of energy in the weapon or instrument when it strikes the body, whether it is inflicted upon a moving or a fixed body and the nature of the tissue involved. The aim of this study was to study the pattern of injuries and commonly used weapon in inter personal violence and their outcome in victims presented to the Medical Jurist (Forensic Medicine) OPD, Prince Bijay Singh Memorial (PBM) and Attached Groups of Hospitals, Bikaner and subjects got admitted with history of assault.

MATERIALS AND METHOD

The present cross-sectional study was conducted in Department of Forensic Medicine and Toxicology, S.P. Medical College, Bikaner (Rajasthan) after taking Institutional ethics committee approval (vide letter no. 614 dated 14.02.2023) for period of One year from Feb 2023 to Jan 2024. The study was conducted on OPD cases brought by police in the Department of Forensic Medicine and Toxicology, Cases admitted to the Prince Bijay Singh Memorial (PBM) Hospital and Brought dead cases shifted in Prince Bijay Singh Memorial (PBM) mortuary.

All patients with history of assault during the study period and meeting the inclusion criteria were included in study after taking written informed consent. This study consists of total 262 cases. Data collection was done and entered in predesigned proforma from taking history given by the victim, relatives, and police person.

Inclusion Criteria:

1. Those subjects in whom there is history of assault and got admitted and assault victims presented to OPD of the Department of Forensic Medicine and Toxicology Department, S.P. Medical College, Bikaner (Rajasthan) are included in the study after taking informed consent.

Exclusion Criteria:

1. Those absconded or referred to higher centre before MLC examination are excluded from the study.
2. Victims who do not have obvious visible injury and just have complaint of pain.
3. Cases of self-inflicted injuries.
4. Victims who refused to give consent for physical examination.

Observations and Results

Maximum number (n=251, 94.36%) of cases reported use of blunt weapon followed by sharp weapon in (n=10,3.75%) cases. One case of firearm recorded in male and no case in female. Teeth bite was recorded in one female case and no male case.

Most commonly used weapon in both urban and rural region was Wooden stick/ Lathi/ Danda (n=97, 29.39%) followed by body part (punch, kick etc.) (n=84, 25.45%) and iron rod (n=29, 8.79%). Body part was used more commonly in urban area (n=72, 32.58%), while in rural area Wooden stick/ Lathi/ Danda (n=37, 16.74%) was more common. Barchhi, Kulhadi and Chosangi only used by residents of rural area.

Maximum injuries (n=348, 37.1%) were of abrasion type followed by bruise (n=248 , 26.43%). In Males, majority (n=300, 37.78%) of injuries were abrasion type followed by bruise (n=200, 25.19%), laceration (n=138, 17.38%) and ill-defined swelling (n=130, 16.37%). In Females, abrasion and bruise were (n=48, 33.33%) each but they had more (n=31, 21.53%) of ill- defined swelling type injury than laceration (n=10, 6.94%).

n=301 (32.08%) injuries were observed on head and neck of which (n=107, 35.54%) were abrasions, (n=92, 30.56%) lacerations, (n=62, 20.59%) bruises, (n=36, 11.96%)

ill-defined swelling and incised and burn wounds (n=2, 0.66%) each. On upper limb (n=117, 42.55%) were abrasions.

In males (n=685, 83.84%) injuries were simple and (n=100, 12.24%) were grievous in nature while (n=32, 3.92%) were dangerous to life. In females (n=140, 96.55%) injuries were simple and (n=4, 2.75%) were grievous in nature.

Maximum number of cases were of OPD (n=105, 40.08%) followed by discharged from casualty (n=81, 30.91%). (n=13, 4.96%) cases were expired and (n=7, 2.67%) cases were absconded.

n=(192, 73.28%) of victims not required admission to the hospital.

DISCUSSION

A sum of 266 weapons, shows that more than one weapons were used in some cases (as stated by the victims also). Blunt weapons (n=251, 94.36%) were most prevalent in this study followed by sharp weapon (n=10, 3.75%), amongst them use of body part was widespread in urban region and lathi/danda/wooden stick were used frequently in rural region. These findings align with the literatures- Swarnkar M et al,[5] Shepherd et al,[6] Ole brink et al,[7] Praveen et al.[8] While results are not similar to study done by Kumar R[9] where firearms were the most common weapon used, in studies done by Dr Basappa S. Hugar et al,[10] Neha Gupta et al,[11] sharp weapons were more common. The kind of weapon used depends on its availability, aggressiveness and intention of assailant. Use of blunt weapons could be explained by its easy availability in vicinity and, as most of the fights were not pre-planned. Differences in the use of weapons might be due to the use of different weapons in different areas.

Out of total 938 injuries, Abrasion (n=348, 37.1%) was most commonly seen in assault cases. Type of injury could be co-related with weapon more commonly used which is blunt/body part in this study. The findings are in agreement with Swarnkar M et al,[5] Hazra et al,[12] Taware A.A. et al,[13] Shrestha S. et al,[14] Sanjay kumar Sah et al,.[15] While results not matched with study conducted by Kokatanur et al[16] in which, chop injuries were most frequent and in other studies by HR Thube et al,[17] Kavita Dwivedi et al,[18] lacerations were most common. The differences could be due to difference in nature and aggressiveness of assailant and also the intention. Also the weapons used may differ in other similar studies.

Greater number of the assaulted victims sustained injuries on head and neck (n=301, 32.08%) (out of 938 injuries) as assailant more likely to strike accessible vital parts of the body so that injury will be more serious and it is also associated with the intention of assailant. Next common site is upper limb (n=275, 29.32%), this might be due to its use in defensive act. Same findings are seen in studies by Swarnkar M et al,[5] Shepherd et al,[6] Ole brink et al,[7] Hazra et al,[12] Taware A.A. et al,[13] Kavita Dwivedi et al.[18] Findings are not consistent with Neha Gupta et al[11] where chest was the most common site sustaining injuries.

Most of the injuries were simple in nature (n=825, 85.76%) and maximum victims (n=105, 40.08%) presented in OPD of forensic medicine department. These findings are concordant with most other similar studies.

CONCLUSION AND RECOMMENDATIONS

There was preponderance of use of blunt weapon. In urban region use of body parts were most commonly reported then lathi/danda/wooden stick. Desi katta was used in only 1 case. In rural areas most prevalent weapon was lathi/danda/wooden stick. Use of kulhadi, barchi and chosagi was reported from rural areas only. Injuries to case ratio turned up 3.58:1 indicating multiple injuries seen in single victim. Abrasions were most common type of injury. Head and neck region was the preferred site for attack by assailant. Larger number of injuries were simple in nature. Educational programs, restricting availability of alcohol, training health professionals to deal with interpersonal violence, development of support, and guidance groups, and prevention-oriented policies are recommended as successful or promising interventions.

Limitations

Results obtained from this study could not be generalized as it involved a small geographical area. Underreporting of interpersonal violence cases. Education level and occupation of participants, which may have a major contribution to interpersonal violence, were not included in this study. Lack of follow up was another major point which may had affected opinion of some injuries.

Conflict of Interest: Nil

REFERENCES

1. Reddy KSN and Murty OP. The essentials of Forensic Medicine and Toxicology, 35th ed. New Delhi: Jaypee Brothers Medical Publishers (P) Ltd.; 2022 ; 133.
2. Organization WH. News-room: fact-sheets – injuries and violence. World Health Organization; 2021.
3. Organization WH. News-room: fact-sheets – youth-violence. World Health Organization; 2023.
4. World Health Organization (WHO). World Health Rankings-violence death rate by country; 2020.
5. Swarnkar M, Pal G, Lilhare S. Assault and self-harm injuries: pattern, severity, and etiology of injuries in victims attending emergency department of teaching hospital in central India. Int Surg J. 2016 Aug;3(3): 1618-22.
6. Shepherd JP, Shapland M, Pearce NX, Scully C. Pattern, severity and aetiology of injuries in victims of assault. J R Soc Med. 1990 Feb;83(2):75-8.
7. Brink O, Vesterby A, Jensen J. Pattern of injuries due to interpersonal violence. Injury. 1998 Nov;29(9):705-9.

8. P. Praveen Kumar, K. Priyatharsini, S. Balasubramanian. Estimation of Pattern of Skull Fractures in Homicidal Deaths: An Autopsy Based Cross Sectional Study Conducted in a Tertiary Care Hospital. Indian J of Forensic Medicine and Toxicol. 2024;18(1):45-9.
9. Kumar R. Study of the pattern of homicidal deaths in Varanasi region of India. J of Evolution of Medical and Dental Sciences. 2013 Oct 28;2(43):8393-418.
10. Hugar BS, Girish Chandra YP, S. Harish, Jayanth SH. Pattern of homicidal deaths. J of Indian Academy of Forensic Medicine. 2010;32(3):194-8.
11. Gupta N, Aggarwal N, Verma SK. Pattern of homicidal deaths in North East Delhi and NCR. J of Forensic Medicine and Toxicol. 2018;35(1):70-5.
12. Hazra D, Nekkanti AC, Prabhakar Abhilash KP. Injury pattern and outcome of assault victims: An emergency department perspective. Arch trauma res. 2020;9: 154-9.
13. Taware AA, Khade RV, Tatiya HS, Jadhav VT, Punpale SB. Profile of Homicidal Deaths: An Autopsy Based Study. Indian J of Forensic Medicine and Pathology. 2018;11(3):171-8.
14. Shrestha S, Nepal SP, Gurung S. Pattern, Severity and Etiology of Injuries on Physical Assault cases at Emergency Department of Bir Hospital, Kathmandu. Nepal Med Jor. 2021;4(2):7-12.
15. Sah SK, Pandey C, Prasad SB, Chaurasiya AK. Pattern of injuries in physically assaulted victims in mid Southern Region of Nepal. Int J Health Sci Res.2023;13(8):220-5.
16. Kokatanur C, Basagoudar S, Havanur B, Devadass. Pattern of Fatal Cases of Assault Autopsied at Victoria Hospital. Indian J of Forensic Med & Toxicol. 2015;9(2):115-20.
17. Thube HR, Chikhalkar BG, Nanandkar SD. A prospective study of injury pattern in victim of assault attended in South Mumbai Government Hospital. J of Indian Academy of Forensic Medicine. 2015;37(1):37-40.
18. Dwivedi K, Kesharwani L, Khan G, Chauhan CR. Study on Pattern of Injuries among Assault victim (survivors) Aged 15 years and above in Central U.P. International journal of scientific research. 2019;8(6):46-7.
19. Oberoi SS, Aggarwal KK, Bhullar DS, Aggarwal AD, Walia DS, Singh SP. Profile of assault cases in Patiala. J Punjab Acad Forensic Med Toxicol. 2012;12(1):17-21.
20. Kulshrestha P, Sharma RK, Dogra TD. The study of sociological and demographical variables of unnatural deaths among young women in South Delhi within seven years of marriage. J Punjab Acad Forensic Med Toxicol. 2002;2:7-17.

Table 1: Distribution of Study Population According to type and Number of Weapons Used.

Type of Weapon	Number of Weapons N (%)		Total
	Male	Female	N (%)
Blunt	202 (94.39%)	49 (94.23%)	251 (94.36%)
Sharp	9 (4.2%)	1 (1.92%)	10 (3.75%)
Firearm	1 (0.46%)	0	1 (0.37%)
Teeth Bite	0	1 (1.92%)	1 (0.37%)
Dry Flame	2 (0.93%)	0	2 (0.75%)
Hot Liquid	0	1 (1.92%)	1 (0.37%)
Total	**214 (80.45%)**	**52 (19.54%)**	**266**

Table 2: Distribution of Study Population According to Name of Weapon as Stated and Residence.

Name of Weapon	Number of Weapons N (%)		Total
	Urban	Rural	N (%)
Wooden Stick/Lathi/ Danda	60 (27.15%)	37 (16.74%)	97 (29.39%)
Iron rod	15 (6.79%)	14 (12.84%)	29 (8.79%)
Iron pipe	5 (2.62%)	7 (6.42%)	12 (3.64%)
Body part	72 (32.58%)	12 (11%)	84 (25.45%)
Knife/Sharp object	4 (1.81%)	2 (1.83%)	6 (1.82%)
Brick	12 (5.43%)	0	12 (3.64%)
Fibre stick/ Plastic stick	15 (6.79%)	5 (4.59%)	20 (6.06%)
Stone	5 (2.62%)	1 (0.92%)	6 (1.82%)
Petrol/Hot mustard oil	2 (0.9%)	1 (0.92%)	3(0.91%)
Barchhi	1 (0.45%)	6 (5.5%)	7 (2.12%)
Kulhadi	0	10 (9.17%)	10 (3.03%)
Teeth bite	0	2 (1.83%)	2 (0.61%)
Scuffle/Push	10 (4.52%)	5 (4.59%)	15 (4.55%)
Slipper	1 (0.45%)	0	1 (0.3%)
Chosangi	0	5 (4.59%)	5 (1.52%)
Belt	3 (1.36%)	2 (1.83%)	5 (1.52%)
Kada/Bracelet	3 (1.36%)	0	3 (0.91%)
Drag on Road	1 (0.45%)	0	1 (0.3%)
Bike Tyre/ Four Wheeler	2 (0.9%)	0	2 (0.61%)
Iron Axle	2 (0.9%)	0	2 (0.61%)
Sua	2 (0.9%)	0	2 (0.61%)
Datali	1 (0.45%)	0	1 (0.3%)
Favda	3 (1.36%)	0	3 (0.91%)
Desi Katta	1 (0.45%)	0	1 (0.3%)
Hammer	1 (0.45%)	0	1 (0.3%)
Total	**221 (66.97%)**	**109 (33.03%)**	**330**

Table 3: Distribution of Study Population According to type and Number of Injuries.

Type of Injury	Number of Injuries N (%)		Total
	Male	Female	N (%)
Abrasion	300 (37.78%)	48 (33.33%)	348 (37.1%)
Bruise	200 (25.19%)	48 (33.33%)	248 (26.43%)
Laceration	138 (17.38%)	10 (6.94%)	148 (15.78%)
Incised Wound	10 (1.26%)	3 (2.08%)	13 (1.39%)
Stab Wound	2 (0.25%)	0	2 (0.21%)
Gun Shot	1 (0.13%)	0	1 (0.11%)
Ill-Defined Swelling	130 (16.37%)	31 (21.53%)	161 (17.16%)
Burn	13 (1.64%)	3 (2.08%)	16 (1.71%)
Teeth Bite	0	1 (0.69%)	1 (0.11%)
Total	**794 (84.65%)**	**144 (15.35%)**	**938**

Table 5: Distribution of Study Population According to Legal Classification of Injuries.

Classification	Number of Injuries N (%)		Total
	Male	Female	N (%)
Simple	685 (83.84%)	140 (96.55%)	825 (85.76%)
Grievous	100 (12.24%)	4 (2.75%)	104 (10.81%)
Dangerous	32 (3.92%)	1 (0.7%)	33 (3.43%)
to Life			
Total	**817 (84.93%)**	**145 (15.07%)**	**962**

Table 4: Distribution of Study Population According to Site of Injury and Its Type.

Site of Injury	Head & Neck	Upper Limb	Lower Limb	Chest	Abdomen
Type	N (%)	N (%)	N (%)	N (%)	N (%)
Abrasion	107 (35.54%)	117 (42.55%)	68 (34.52%)	31 (35.23%)	25 (32.47%)
Bruise	62 (20.59%)	54 (19.64%)	61 (30.96%)	39 (44.32%)	32 (41.56%)
Laceration	92 (30.56%)	30 (10.91%)	24 (12.18%)	0	2 (2.59%)
Incised Wound	2 (0.66%)	2 (0.73%)	2 (1.02%)	4 (4.55%)	3 (3.89%)
Stab Wound	0	0	1 (0.51%)	0	1 (1.29%)
Gun Shot	0	0	1 (0.51%)	0	0
Ill-defined Swelling	36 (11.96%)	67 (24.36%)	36 (18.27%)	10 (11.36%)	12 (15.58%)
Burn	2 (0.66%)	5 (1.82%)	4 (2.03%)	3 (3.41%)	2 (2.59%)
Teeth Bite	0	0	0	1 (1.13%)	0
Total	**301 (32.08%)**	**275 (29.32%)**	**197 (21%)**	**88 (9.38%)**	**77 (8.21%)**

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00046.X

Review Article

Criminal Procedure (Identification) Act, 2022: Key Features and Challenges

1. **Shalender Kumar,** Associate Professor*
2. **Sanjeev Buri,** Professor*
3. **Arun Sharma,** Assistant Professor*
4. **Rajendra Kulhari,** Assistant Professor*
5. **Karamveer,** PG Resident*
6. **Mohit Chauhan,** Assistant Professor - Department of Forensic Medicine and Toxicology, Lady Hardinge Medical College & Associated Hospitals, New Delhi

*Department of Forensic Medicine and Toxicology, Sardar Patel Medical College, Bikaner, Rajasthan

ABSTRACT

Identification is a crucial step in criminal investigation to link a person in the commissioning of a crime. The Criminal Procedure (Identification) Act, 2022 has repealed the 102 year old colonial law, the Identification of Prisoners Act, 1920. It specifies the manner of obtaining information from suspected individuals, along with the procedure of collecting, storing, sharing and disposal of records in this regard. This review strolls the readers through genesis of this repealment, salient features, the current challenges, and the way ahead regarding the scope and implications of this statute vis-à-vis the repealed Act. The interpretative deliberation of this statute as embarked upon in this paper is expected to add to a critical contextual appraisal on this topic of utmost medico-legal relevance.

Corresponding Author :
Dr. Mohit Chauhan (Assistant Professor)
Department of Forensic Medicine and Toxicology,
Lady Hardinge Medical College and Associated Hospitals,
Connaught Place, New Delhi.
E-mail: chauhandrmohit@gmail.com
Contact : +919953300275

Article History:
Received: 01 December 2024
Received in revised form: 03 January 2025
Accepted on: 03 January 2025
Available online: 15 April 2025

Keywords: Crime; Convict; Identification; Measurements; Samples; Statute.

INTRODUCTION

Identification is the determination or fixation of the individuality of a person based upon physical characteristics. The police or law enforcement agencies strive to establish the identity of a person in criminal and civil cases. Obtaining data for personal identification also serves to be helpful in tracking serial offenders and for statistical purposes. In some cases, doctor may supply certain scientific facts, which help the police to complete the process of identification of an individual.[1]

The Criminal Procedure (Identification) Act, 2022, came into force on August 04, 2022. The rules in this regard were notified by the Ministry of Home Affairs on September 19, 2022. This Act authorises for obtaining bio-physical measurements of convicts and suspects for the purpose(s) of identification and investigation in criminal matters and to preserve records and for matters connected therewith and incidental thereto.[2]

The main objective of this amended act is to broaden the scope of bio-physical measurements of convicts, along with preservation of records for the purpose of identification and investigation in criminal matters. It aims to ensure the exact identification of those involved with crime and to help the investigating agencies insolving the related cases.

Need for Criminal Procedure Identification Act, 2022

The Identification of Prisoners Act, 1920, in its present form, provides access to limited category of persons whose body measurements can be taken. In this Act, 1920, there is no provision that binds the accused to provide his specimens required by the investigating agency to prove the crime.[3] It also does not provide for taking such body measurements as the newer techniques were un-developed at that point of time. The latest and recognized measurement techniques being used in advanced countries for the purpose of identification are giving

reliable results.

It was thus essential to approve modern techniques regarding identification so as to capture and record appropriate body measurements and collect biological samples in place of existing limited provisions in this regard. The Law Commission in many instances, has recommended for the amendments in the provisions of the Identification of Prisoners Act, 1920 in order to bring it in line with modern technological advancements.[4] Therefore, it was considered necessary to expand the ambit of measurements that should be retrieved by investigating agencies to gather legally admissible evidence and establish the nature of crime committed by the accused.

Salient Features

- It repeals the Identification of Prisoners Act, 1920.
- It has redefined and broadened the scope of measurements regarding personal identification.
- It includes analysis of physical and biological samplesalong-with their behavioral attributes.
- It includes any other examination referred in section53 or 53A of CrPC 1973 (section 51 or 52 of BNSS 2023).
- In the interest of prevention, detection, investigation and prosecution of any offence defined under law, it empowers the NCRB of India to collect, store, preserve, share and disseminate such records with anylaw enforcement agency, ina manner as may be prescribed by rules.
- The record of measurements shall be retained in digital or electronic form for a period of seventy-five years from the date of collection of such measurements.
- It empowers a Magistrate to direct any person to give measurements.
- It also empowerspolice or prison officer to obtain measurements of any person who resists or refuses in this regard. Resistance or refusal to allow taking of measurements under this Act shall be deemed to be an offence under S.186 of the IPC (S.221 of the BNS) and punishment is imprisonment up to 3 months or fine up to INR 2500 or both.
- It has provisions to collect samples even from protestors engaged in political protests.
- It empowers the Central Government or the State Government to make rules for carrying out the purposes of the Criminal Procedure Identification Act, 2022.
- No suit or any proceeding against any person who in good faith does or intends to do anything under this Act or any other rule.

Measurements that can be retrieved as per Criminal Procedure Identification Act, 2022.

1) Finger-impressions;
2) Palm-print impressions;
3) Foot-print impressions;
4) Photographs;
5) Iris and retina scans.

Samples that can be retrieved as per Criminal Procedure Identification Act, 2022.

- Physical, biological samples and their analysis - Provided that any person arrested for any offence committed under any law for the time being inforce (except for offence committed against a woman or a child or that punishable withimprisonment for a period not less than seven years) is not under obligation to allow taking of histological samples under the provisions of this Act.
- Retrieving information about the behavioral attributes of the culprit i.e. signature, handwriting, including psychometric evaluation expanding its ambit to brain mapping and lie detector test.
- It includes any other examination referred to in section 53 or 53A CrPC (section 51 or 52 BNSS 2023)

Key feature of rules of the Criminal Procedure Identification Act, 2022- In September 2022, the Criminal Procedure (Identification) Rules were notified under the Act to specify the manner of taking information from individuals, the manner of collecting, storing, sharing such records, and the disposal of such records.[5] Brief about the rules is as follows -

1. Taking measurements: Under the Act, all the convicts, arrested persons, persons detained under any preventive detention laws and persons ordered to furnish surety for his good behaviour or maintaining peace may be required to furnish their measurements. The rules specify that for certain persons, measurements will not be taken unless they have been charged or arrested in connection with any other offence. These persons include those violating prohibitory orders under S.144 or 145 of CrPC (S.163 or

164 of BNSS)or arrested under preventive detention law under S.151 of CrPC (S.170 BNSS)

2. Persons authorised to take measurements: The Act provides that measurements will be taken by a police or prison officer. The rules specify that an authorised user, or any person skilled in taking the measurements, or a registered medical practitioner, or any person authorised in this behalf may obtain such measurements. An authorised user has been defined as a police officer (in charge of a police station, or at least of the rank of a head constable) or a prison officer (not below the rank of head warden) who has been authorised by the NCRB to access the database.

3. Storage of Measurement Records: The rules specify that NCRB will issue SOPs for taking measurements which include specifications and the format of measurements to be taken, devices to be used for taking these measurements, method of handling and storing these measurements, digital format to which each measurement should be converted before uploading them on to the database and encryption method.

4. Sharing of Records: To match the record of measurements of a person, an authorised user will forward the request to NCRB. NCRB will match the record and provide report to the authorised user through a secure network. The SOPs will provide guidelines for processing and matching of the records.

5. Destruction of Records: The Act provides that records will be destroyed in case of persons whohave not been previously convicted of an offence with imprisonment; who have been released without trial, discharged; or acquitted by the court, unless directed otherwise by the magistrate or court. As per the rules, SOPs will detail the procedure for destruction and disposal of records.

The state or central government or UT administration will nominate a nodal officer to whom requests for destruction of such records of measurements will be made. The nodal officer will recommend for destruction of records to NCRB after verifying that such records are not linked with any other criminal cases. The rules put the onus on the person concerned in this regard to request for the destruction of such records.

Rules going beyond the scope of the Act-The Supreme Court held that Rules cannot alter the scope, provisions, or principles of the parent Act.[6-8] There are several instances where these Rules may be altering the scope of the Act as below -

1. Restricting instances where measurements may be taken - Under the Act, all convicts, arrested persons, as well as persons detained under any preventive detention law may be required to give their measurements. Further, the Magistrate may order collection of measurements from any person to aid investigation. The Rules specify that for certain persons measurements will not be taken unless they have been charged or arrested in connection with any other offence. These persons include those violating prohibitory orders under Sections 144 or 145 of CrPC (Sections 163 or 164 of BNSS) or arrested under preventive detention law under Section 151 of CrPC (Section 170 of BNSS). Thus, the Rules are restricting the grounds under which a person's data may be collected. By doing so, they may be altering the grounds specified in the Act, and thus going beyond the scope of the Act.

2. Expanding the list of persons who may take measurements - The Act provides that the measurements will be taken by a police officer or prison officer. The Rules expand this to also allow any person skilled in taking the measurements or a registered medical practitioner or any person authorised in this behalf to take such measurements. In adding these new categories of persons not specified in the Act, the Rules may be going beyond the scope of the Act. The Act or the Rules also do not define who is a person skilled in taking measurements.

3. Restricting the list of persons who can take measurements - The Act permits the collection of measurements by either a prison officer or a police officer. The Rules specify that an authorised user may take measurements under the Act. As per the Rules, an authorised user has been defined as a police officer or a prison officer, who has been authorised by the NCRB to access the database. Thus, the Rules are restricting the category of officers who may take measurements and access the database. The Act does not allow the NCRB or any other entity to prescribe such restrictions. It also does not delegate the power to prescribe such restrictions to the central or state governments. Therefore, in prescribing such restrictions, the Rules may be going beyond the scope of the Act.

4. Excessive delegation - The Act empowers the NCRB to collect (from state governments, union territory (UT) administrations, or other law enforcement agencies), store, process, share, disseminate and destroy records of measurements as may be prescribed by rules. NCRB delegates the power to make Rules to the central and state

government. The Rules specify that NCRB, through SOPs, will specify the guidelines and procedure for taking measurements, handling and processing of these records. In allowing the NCRB to specify these guidelines, the Rules may be further delegating rule making powers of the government to the NCRB.

The Supreme Court (2014) when examining a case on excessive delegation had noted that "Subordinate legislation which is generally in the realm of Rules and Regulations dealing with the procedure on implementation of plenary legislation is generally a task entrusted to a specified authority. Since the Legislature need not spend its time for working out the details on implementation of the law, it has thought it fit to entrust the said task to an agency. That agency cannot entrust such task to its subordinates, it would be a breach of the confidence reposed on the delegate.[9]"

5. Records to be destroyed on request of person - While the Act requires destruction of records in some cases, the Rules put the onus on the individual to request for such destruction. In some other laws, the onus of destroying personal information is on the authority maintaining the information or on the courts to direct the authority to delete such information when it is no longer required. For example, the Juvenile Justice (Care and Protection of Children) Act, 2015 provides that records of a child who has been convicted and has been dealt with under the law should be destroyed (except for heinous offences).[10] In such cases, the Juvenile Justice Board directs the police or the court and its own registry to destroy the records. The Rules under the Act also specify that such records be destroyed (after expiry of the appeal period) by the person-in-charge, Board, or the Children's Court.[11] The Identification of Prisoners Act, 1920 also provided that records of a person who has been acquitted be destroyed. Here also the Rules may be going beyond the scope of the Act.

Key Challenges

- The terms such as 'analysis', 'biological samples' and 'behavioral attributes' used under the definition of 'measurements', do not have a set threshold, leaving them open to wide interpretation.
- This Act restricts the fundamental right of privacy.
- For resistance or refusal by any person to allow taking measurements, thereby amounting to forcible extraction of testimonial response. Such criminalization is violation of an individual's right against self-incrimination.
- By empowering a Magistrate to pass an order directing any person to give measurements, the 2022 Act makes it discretionary on the part of such Magistrate to provide any reason for it.
- It leaves the door open for abuse of powers by providing discretionary powers to the police or prison officials to take measurements, if so required.
- It does not make any distinction between the categories of accused persons based on the nature of offences and thus, it makes a person accused of any petty offence to be treated at par with a person accused of heinous crimes.
- By issuing SOPs, the NCRB will be issuing guidelines for itself for collecting, storing and processing of measurements. This may violate the principle of separation of roles between the entity that issues guidelines and the entity that has to follow such guidelines.
- It may give rise to conflicts with State authorities who are also empowered to make rules under this Act.

Issues need to be resolved

1. The Act has several provisions that may violate a person's right to privacy under Article 21 of the Constitution of India. It may also fail the Article 14 requirement of a law to be fair and reasonable, and for equal treatment.[12]
2. There is no mention of proper safeguards for protection of records of measurements which are a pre-requisite whenever dealing with sensitive information.
3. It is unclear as to why such drastic measures were taken to identify each and every person who has been convicted or arrested. Also, since these records are to be stored for 75 years, the law deems disproportionate.
4. Issue of excessive collection and storage of data.

CONCLUSION

The Criminal Procedure Identification Act, 2022 is a welcome piece of legislation which is targeted towards advanced identification techniques and more efficient investigation process. It also redefined and broadened the scope of measurements. The Act will definitely enhance criminal justice delivery system and help the State to

maintain law and order so that citizens can enjoy peace and security. It also stimulates citizen to be a 'good citizen' in the eyes of the criminal justice system. It is evident that the new law is aimed to improve the identification procedure in the country with the help of modern technology but some issues need to be resolved.

Way Forward

- Better scrutiny and data protection law, measures need to be taken for better implementation of the Act.
- The need is to have more experts to collect measurements from the scene of crime, more forensic labs, and equipment to analyze them to identify possible accused involved in a criminal case.

REFERENCES

1. Reddy, K.S.N.: The essentials of Forensic Medicine and Toxicology (34th) edition, The health sciences publishers, (2017); p-55.
2. The Criminal Procedure (Identification) Act, 2022 NO. 11 OF 2022 www.mha.gov.in/sites/default/files/2022-11/CriminalPro_14112022%5B1%5D.pdf. Retrieved on Feb 13th 2025.
3. The Identification Of Prisoners Act, 1920 (act No. 33 of 1920) https://www.indiacode.nic.in/bitstream/123456789/18472/1/ identification_of_prisoners_act%2C_1920.pdf. Retrieved on Feb 13th 2025.
4. Committee on Reforms of Criminal Justice System Government of India, Ministry of Home Affairs www.mha.gov.in/sites/default/files/2022-08/criminal_justice_system%5B1%5D.pdf. Retrieved on Feb 13th 2025.
5. The Criminal Procedure (Identification) Rules, 2022, Ministry of Home Affairs, September 19, 2022.
6. Agricultural Market Committee vs Shalimar Chemical Works Ltd, 1997 Supp (1) SCR 164, May 7, 1997.
7. State of Karnataka vs Ganesh Kamath, 1983 SCR (2) 665, March 31, 1983.
8. Kerala State Electricity Board vs Indian Aluminium Company, 1976 SCR (1) 552, September 1, 1975.
9. Siddharth Sarawagi vs Board of Trustees for the Port of Kolkata and others, special leave petition (civil) no.18347/2013, Supreme Court of India, April 16, 2014. Retrieved on Feb 13th 2025
10. The Juvenile Justice (Care and Protection Of Children) Act, 2015 No. 2 Of 2016 https://cara.wcd.gov.in/pdf/jj%20act%202015.pdf. Retrieved on Feb 13th 2025
11. The Juvenile Justice (Care and Protection of Children) Model Rules, 2016, Ministry of Women and Child Development, September 21, 2016.
12. Issues for Consideration: Criminal Procedure (Identification) Bill, 2022, PRS Legislative Research, April 4, 2022.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00047.6

Review Article

Comprehensive Overview of Indian Cultural Tattoos and Their Forensic Perspective

1. **Pompi Boruah,** M.Sc. Forensic Science Student, Parul University, Vadodara, Gujarat
2. **Dr. Debesh Nilendu,** Co-Author, Assistant Professor, Parul University, Vadodara, Gujarat

ABSTRACT

Introduction: This review article explores the forensic significance of Indian cultural tattoos, emphasizing their role in identifying individuals, understanding community affiliations, and providing insights into personal histories. Tattoos have been integral to many cultures, serving not only as art forms but also as markers of identity, status, and beliefs. In India, traditional tattoos continue to hold cultural and symbolic importance, particularly among tribal communities.

These tattoos can reveal vital information about and individual's social background, religious beliefs, and even health conditions, making them valuable tools in forensic investigations. They are particularly useful in cases involving decomposed bodies or unidentified victims, where tattoos can help establish identity, linking individuals to specific communities or regions.

The review discusses the historical background of tattooing in India, from its roots in ancient traditions to its evolution under colonialism and in contemporary society. It also addresses the role of tattoos in criminal investigations, including their use to identify gang affiliations or mental health conditions. Despite the decline of traditional tattooing practices due to globalization and modernization, tattoos remain a crucial aspect of forensic science. However, challenges such as the fading of tribal cultures, lack of a standardized tattoo database, and insufficient forensic training complicate their use.

The article concludes with suggestions for future research, advocating for the creation of comprehensive tattoo databases, better preservation of cultural traditions, and enhanced forensic training to ensure the continued relevance of tattoos in forensic identification. This review highlights the untapped potential of tattoos in forensic science, encouraging further exploration of their cultural, psychological, and criminal significance.

Corresponding Author :
Ms. Pompi Boruah, M.Sc. Forensic Science Student,
Parul University, Vadodara, Gujarat
E-mail: pompiboruah2000@gmail.com
Contact : +919101534144

Article History:
Received: 21 January 2025
Received in revised form: 15 February 2025
Accepted on: 15 February 2025
Available online: 15 April 2025

Keywords: Indian Cultural Tattoos, Forensic Identification, Indian Tribes, Criminal, Activity and Gang Tattoos, Psychological Implications of Tattoos, Tattoo Inks.

INTRODUCTION

Since ancient times, communities worldwide have used cultural tattoos for self-expression, tribe identification, and storytelling. These intricate inscriptions, deeply rooted in tradition and symbolism, reflect their ancestors' rich cultural heritage and history. Cultural tattoos, ranging from the complex patterns of Indian mehndi to the symbolic motifs of Maori moko and Polynesian tatau, showcase the customs, beliefs, and values shaping these enduring art forms.[1]

They express the unique identities and stories of the societies that have preserved them for generations. Tattoos, created by injecting pigments into the skin's epidermis, are also used for positive identification and play a role in forensic science. In India, a blend of modern and traditional customs persists, and traditional tattoos remain common among various tribal tribes and reserved castes. These tattoos can indicate tribal affiliations and assist in forensic identification.[2]

Indian cultural tattoos, with their personal and local significance, can provide crucial clues about the owner's identity. Specific names, symbols, or patterns unique to these tattoos can help link individuals to particular communities, aiding forensic investigations. This study aims to provide valuable information about a person's identity, cultural background, and affiliations through their tattoos. These marks can be used in forensic investigations to identify individuals, especially if they are distinctive to a certain community.

Additionally, cultural tattoos can reveal information about a person's social circles, birthplace, and religious beliefs, offering forensic analysts a more comprehensive understanding of the subject's history.[3]

HISTORICAL BACKGROUND

Tattooing, derived from the Tahitian "ta-tau," has a rich history, with evidence like Ötzi the Ice Man's Neolithic tattoos. Ancient Greeks used tattoos to signify social status, while major religions like Islam and Christianity forbade them, viewing the body as sacred. In the 18th century, European aristocratic women embraced tattoos.

In India, tattooing dates back thousands of years, deeply rooted in culture and traditions. Prehistoric rock art in central India, over 10,000 years old, suggests early tattoo practices. The Indus Valley Civilization (3300-1300 BCE) hinted at body art through figurines and seals. During the Vedic and medieval periods, tattoos served as identity markers, status symbols, and talismans in tribal and rural communities.

Under British rule (1858-1947), colonial authorities dismissed native tattoo customs as "primitive," yet these practices endured. After independence, tattoos remained prevalent in rural areas and gained urban popularity in the late 20th century. The cultural revolutions of the 1960s and 1970s revised traditional arts, shaping India's vibrant modern tattoo culture.[4]

KINDS OF BODY ART

Tattoos fall into three categories: decorative, symbolic, and pictorial. The American Board of Dermatology (ABD) classifies them based on durability, content, and hierarchy as follows:

Durability: Temporary tattoos, drawn, painted, airbrushed, or needled, use ink that dissolves in the blood after six months. Permanent tattoos remain indefinitely.

ILLICIT TATTOOS

Illicit tattoos represent gang affiliations, criminal histories, or defiance of social conventions and are frequently seen among criminals and inmate populations.[5] Personal information like crimes committed or a person's position within a gang might be encoded in these tattoos.[6]

For instance, certain symbols are employed for secret communication, such as playing cards in Russian prisons or digits like "13" (for gang involvement).[6] These tattoos act as forensic indicators, assisting detectives in determining a person's criminal history, connections, and actions.[5-6]

Types

Amateur Tattoos: Single-colored, applied at home with simple tools and varied penetration depths.

Professional Tattoos: Multi-colored, applied uniformly by skilled artists in salons or tattoo parlors.

Cosmetic Tattoos: Cosmetic tattoos are applied for aesthetic reasons, like hiding scars and flaws or simulating makeup (lips, eyeliner, or eyebrows).[7] These tattoos, which are done precisely to produce results that look natural, are becoming more and more popular as a way to improve physical appearance.[7] Cosmetic tattoos can help forensic scientists identify people when typical facial features are unidentifiable because of injuries or decomposition.[8]

Medical Tattoos: Provide practical information, such as blood type or medical details, or mark specific body parts.

Traumatic Tattoos: Result from foreign objects entering the dermis, often unintentional and irreversible, like coal dust in coal workers.[7,9]

CULTURAL SIGNIFICANCE

Tattoos hold cultural significance as symbols of status, identity, protection, and healing. Modern communities focus on individualism and fashion, while indigenous groups use tattoos to signify social roles and clan affiliation.[10] In India, tribal groups like the Bhils, Santhals, and Naga tribes carry a rich tattoo tradition, with designs representing bravery, cultural identity, and religious meanings.

Over time, tattoos have evolved, with modern perspectives emphasizing cultural pride, while older generations may view them differently. Tattoos also served as punishment during British colonization. The style, size, color, and placement of tattoos symbolize identity and life experiences.[11]

GEOGRAPHICAL VARIATIONS, MEANING & SYMBOLISM

Indian cultural tattoos, deeply tied to regional traditions, offer forensic investigators insights into identity and custom. Tribal tattoos like gudna served as protective symbols and markers of cultural identity, especially in regions prone to tribal conflicts and abductions.

Apatani Tribe

The Apatani tribe, locally called Tanu, lives in Lower Subansiri, Arunachal Pradesh, practicing agriculture and owning forests and streams.[12] They worship the sun, moon, and forest spirits, following animism.[12] Women

tattooed their faces with dark blue lines to deter kidnappings, using thorns and charcoal, though a 1970s ban reduced this practice.[13] Men sometimes have small "T" tattoos on their chins.[13]

Wancho Tribe

The Wancho of Arunachal Pradesh use tattoos, or hu, to mark life stages and signify status. Only the village queen performs tattoos, using ink from the zing tree and a bamboo tattoo comb. Head hunters and leaders' families have unique tattoos, while commoners cannot receive them.[14-15]

Santhal Tribe

The Santals, the largest tribe in South Asia, inhabit sections of Assam as well as the eastern and northeastern states of West Bengal, Bihar, Jharkhand, Odisha, and Tripura.[16] Santals in India, Bangladesh, and Nepal tattoo for afterlife survival. Using carbon ink and needles, they tattoo single girls on the right hand and married women on the left, with designs like Nekkii Khuda (comb) and Kadam Baha (flower).[17-18]

Baiga Tribe

Baiga women tattoo symbols like fire and crops to prevent infections, starting at 4-5 and continuing after marriage, seeing pain as childbirth preparation.[19] Godharins use ink from sesame seeds, Bija wood, or Malwan juice with oils and burned snake skin, piercing skin with needles for permanence.[20] They apply ramtila oil, cow dung, turmeric, or soapy water for healing. These tattoos reflect identity, class, beliefs, and protection.[21-22]

Bhil Tribe

The Bhil tribe, spread across Madhya Pradesh and nearby states, is India's third-largest tribal group. Among Madhya Pradesh Adivasis, tattoos carry social significance.[23] Bhil women receive the Chirlya tattoo before marriage, symbolizing identity and afterlife security. Tattoo artists or sorcerers' wives use vegetable dye, with traditional ink from lamp-black and linseed oil now less common.[24-25]

Rabari Tribe

The nomadic Rabari tribe of Gujarat gets "Trajva" tattoos, which, though painful, are seen as permanent symbols of power.[1] Rabari tattoos, featuring snakes and scorpions, symbolize abilities and fertility. Single girls can tattoo anywhere except their legs, reserved for married women. The Karavad community uses soot and green sap, and tattoos mark a rite of passage for Rabari girls.[21]

Toda Tribe

The Toda tribe in South India creates geometric tattoos resembling their needlework, unlike the facial tattoos of the Apatani and Konyak tribes.[1] The Toda tattoo for cultural identity, using thorns and animal fat with soot as ink. Both men and women receive identical geometric tattoos on their palms, calves, and shins, without intentionally infecting the wounds.[26]

TATTOO INKS

Tattoo inks frequently contain metals like titanium, aluminum, lead, copper, nickel, cobalt, zinc, iron, and trace amounts of arsenic and chromium, raising concerns about long-term exposure and potential toxicity.[22,27] These metals pose health risks because they can migrate to other organs or lymph nodes. For example, lead in inks can exceed safe exposure limits, leading to long-term health issues such as cancer, reproductive harm, skin irritation, allergic reactions, or systemic toxicity, even if immediate injury is rare.[22,27]

Inks containing iron oxide pigments can cause oxidative stress, inflammation, and cellular damage. Because ink components are not standardized, it becomes difficult to assess long-term impacts, under-scoring the need for stronger regulations and increased awareness.[22]

PRESENT SITUATION

Indian tattoo culture today is a blend of Western and traditional styles. Globalization, urbanization, and exposure to pop culture and social media have all contributed to the rise in popularity of tattoos across all socioeconomic strata. Western styles like realism and minimalism are frequently combined with traditional elements like Sanskrit characters, mandalas, and deities. Individuality, relationship memorialization, and self-expression can all be accomplished through tattoos.

Though industrialization is slowly undermining ancient customs, traditional tattoos still have cultural and symbolic value in rural communities.[28] Additionally, tattoos are of significant forensic significance as markers of criminal associations, personal histories, and health hazards; designs like poppies, spiders, or genies may indicate drug usage, while mysterious symbols like "8" or "13" may indicate heroin or marijuana.[29]

Tattoos from prison, such as cobwebs or teardrops, can be a sign of long terms, gang membership, or murderous participation.[5] Tattooing in prisons is a serious health risk because of unregulated methods that allow blood-borne

pathogens like hepatitis C to spread.[5]

Additionally, tattoos can be a reflection of mental health issues, as they are strongly linked to personality disorders, drug misuse, and impulsivity.[30] Tattoo patterns, placements, and designs are used by forensic specialists to analyze behavioral characteristics, diagnose mental health issues, and understand criminal subcultures.[31-33]

FORENSIC SIGNIFICANCE AND INVESTIGATIONS

In modern India, tattoos play a crucial role in forensic science as identifiers of individuals, linking them to specific communities and offering insights into their personal histories. Tattoos, which combine Western and traditional styles, can provide information about a person's identity, occupation, religion, health conditions, and even criminal affiliations.[28] Forensic investigations use tattoos to identify victims, particularly in cases of decomposed bodies or missing persons.

Tattoos from prison, for example, can indicate gang affiliations, while others might suggest mental health issues or criminal behavior.[31] Despite the decline of traditional tattooing practices, tattoos remain valuable forensic tools in criminal investigations.[33] In India, tribal customs are closely linked to cultural tattoos, which provide forensic professionals with vital information for identifying people and comprehending their social and cultural histories. People from tribes like the Apatani, Bhil, and Rabari have tattoos that are significant identifiers that connect them to particular groups and areas.[13,21,24]

Particularly when there is decomposition or the body is unrecognizable, these tattoos assist forensic experts in identifying victims and reconstructing their life stories. Thus, cultural tattoos help forensic investigations by offering crucial information about an individual's background, medical history, and heritage.[34-35]

Tattoos are crucial in the Indian criminal justice system under Section 9 of the Indian Evidence Act of 1872, which permits identity-establishing facts as evidence. Tattoos help identify individuals, especially in cases of decomposing bodies or unique tattoos, highlighting their importance in criminal cases.[36] In Shankar Mahto v. State of Bihar, the deceased's daughter identified a decomposing body by a tattoo.[37] In Joginder @ Danny v. State (NCT of Delhi), the father identified headless bodies using height, color, and tattoos.[38]

In the Dattatraya case, tattoos helped confirm close-range shots despite contradictions in the prosecution's story.[39]

The Uddhav case involved identifying a decomposed body through a unique tattoo, aiding in victim identification.[40]

Section 9 of the Indian Evidence Act of 1872 supports tattoo identification as vital evidence in criminal cases.[36] Despite urbanization and the decline of tribal tattooing, tattoos still play a crucial role in forensic identification.[35]

CHALLENGES AND FUTURE DIRECTIONS

Forensic analysis of Indian cultural tattoos faces challenges such as fading tribal culture, psychopathological gaps, and a lack of standardization. Government bans and Western influence are causing a decline in tribal tattoos, making it harder to identify sociocultural and psychological traits.

The absence of a uniform database complicates tattoo identification, and some tribal traditions may vanish, reducing their forensic value. Forensic experts may also lack sufficient training to interpret these tattoos accurately.

Future research will focus on building a comprehensive database of Indian tattoos, improving identification accuracy, and preserving cultural practices. By incorporating forensic psychology, researchers aim to better understand the tattoos' sociocultural significance. Detailed autopsy studies will help identify patterns valuable for forensic analysis, ensuring tattoos contribute to more accurate forensic investigations.[1,34-35]

DISCUSSION

Indian cultural tattoos play a crucial role in forensic research by revealing details about a person's identity, community ties, and past. Investigators use tattoos to identify victims in cases involving decomposition or missing persons. Tattoos can indicate religious beliefs, professions, cultural origins, or even criminal associations.

However, several challenges hinder their full potential. Modernization has led to a decline in traditional tattooing techniques. Additionally, the lack of a standardized tattoo database and limited forensic training complicate their analysis. In prison populations, tattoos often signify gang affiliations, criminal activity, or mental health issues.

To address these issues, researchers must focus on creating comprehensive databases, preserving traditional tattooing practices, and improving forensic training. By maintaining their cultural significance, tattoos will continue to serve as a valuable tool in forensic investigations.

CONCLUSION

In conclusion, Indian cultural tattoos hold great forensic significance as they provide information about a person's identity, community ties, and past. Traditional tattoos remain essential in criminal investigations, especially for victim identification in cases involving decomposing bodies or distinctive markings, despite their declining popularity due to modernization. However, the lack of a standardized tattoo database and the diminishing ethnic customs complicate their forensic use. Future initiatives should focus on preserving cultural customs, creating extensive tattoo databases, and improving forensic training to ensure that tattoos continue to support accurate investigations.

CONFLICTS OF INTEREST

The author declares no conflicts of interest regarding the publication of this review article. The study is conducted independently, with no financial or personal relationships influencing its content.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my guide, Dr. Debesh Nilendu, for his valuable guidance, encouragement, and insights throughout the preparation of this review article. I also extend my thanks to Parul Institute of Applied Sciences for providing the necessary resources and support. Lastly, I am grateful to my family and peers for their unwavering support and motivation.

REFERENCES

1. Rohith MM, Belcher WR, Roy J, Abraham SO, Chakraborty P, Nandaniya NJ, et al. Tattoo in forensic science: An Indian perspective. J Forensic Leg Med. 2020 Aug;74:102022.
2. Martí J. Tattoo, cultural heritage, and globalization. Scientific Journal of Humanistic Studies. 2010 Nov 1;2(3):1-9.
3. Kuwahara M. Tattoo: an anthropology. 1st ed. London: Routledge; 2020.
4. Park P. Tattooing in India: A Cultural Canvas Inked in Tradition and Modernity. Xtreme. 2023 July 7 [Accessed 06/12/2024].
5. Phelan MP, Hunt SA. Prison gang members' tattoos as identity work: The visual communication of moral careers. Symbolic Interaction. 1998 Nov;21(3):277-98.
6. Gregg W. Etter Sr. EdD, StaciaNP 8. S, and VEUBS. Decoding the Tattoos of the Russian Mafia. Journal of Gang Research. 2018;25(4):1 21.
7. AS Savitha, BM Shashikumar, DV Lakshmi, MS Sukesh. TATTOO-The Invaluable Compendium for Dermatologists. 1st ed. AS Savitha, BM Shashikumar, Reddy R Raghunatha, editors. New Delhi: Jaypee Brothers Medical Publishers (P) Ltd.; 2017.
8. K. Lakshmi Pragna, Pranav Goswami. Analyzing the Forensic Significance of Tattoos and their Relevance in India. Indian Journal of Forensic Medicine & Toxicology. 2023 Jul 4;17(3):72 9.
9. Böhler K, Müller E, Huber-Spitzy V, Schuller-S, Knobler R, Neumann R, Seidl K. Treatment of traumatic tattoos with various sterile brushes. Journal of the American Academy of Dermatology. 1992 May 1;26(5):749-53.
10. WD Hambly. The History of tattooing. New York: Dover Publications. Inc.; 2009.
11. Kale S.A look at India's tribe and its traditions of tattoos. HOMEGROWN.
12. Sen T, Mallick S, Kipgen N. Tattooing, Cultural Change, and the Indigenous Apatanis of Arunachal Pradesh. Society. 2023 Oct;60(5):761-71.
13. Bharadwaj S, Boruah U. Inking the Identity: A Study of the Apatani Tradition of Tattooing through Bakhtinian Chronotope. Rupkatha Journal on Interdisciplinary Studies in Humanities. 2020 Sep 1;12(5):1-7.
14. Bandhu S, Singh NK, Sharma VN. A study of the Baiga women's tradition of tattoos, modernization of this art, and situation of tattoo industry in India. Int J Multidiscip Res. 2024 May;6(3):1-11. doi:10.36948/ijfmr. 2024. v06i03.20492. of
15. Gogoi S. Tattoo Culture among the Wancho of Longding District, Arunachal Pradesh. Skylines

Anthropology. 2022;2(2):157-164.

16. Kshatriya GK, Kumari S. Determinants of First Birth Interval among the Santal Women of Purbi Singhbhum District, Jharkhand. Indian Journal of Research in Anthropology. 2016 Mar 31;2(2):101 7.
17. Tripathy DrM, editor. Trends in Sociology, Psychology and Anthropology (Volume - 3). AkiNik Publications; 2023.
18. Hajela SC. Construction of the self in the folklores of the Santhals. Int J St Theresa J Humanities Soc Sci. 2016;2(1):7.

19. Goswami MP. Tattoo Culture of the Baiga Women. Srotaswini. 2019;4:136-45.
20. Bandhu S, Kumar Singh N, Nath Sharma V.A Study of the Baiga Women's Tradition of Tattoos, Modernization of this Art, and Situation of Tattoo Industry in India. International Journal for Multidisciplinary Research. 2024 May;6(3).
21. Paul Kanchan. Study of tattoo making of the baiga tribe of central india. [vadodara]: the maharaja sayajirao university of baroda; 2019.
22. Kumar A, Thakur A. The study of social and cultural values of Baiga tribes in the state of Madhya Pradesh, in India. Arch Psychiatr Ment Health. 2022;6:13-16.
23. Ahmed S. An overview of tribal tourism in India. Indian Journal of History and Archaeology. 2020 Jan-Feb;1(5):65-9.
24. Dwivedi J. Indian tribal ornaments; a hidden treasure. IOSR Journal of Environmental Science, Toxicology and Food Technology. 2016 Mar;10(3):01-16.
25. Srivastava VK. CULTURAL HERITAGE OF MADHYA PRADESH AND CHHATTISGARH. Cultural Heritage of Indian Tribes. 2007:243.
26. Ling C.F. Dawn in Toda Land: A Narrative of Missionary Effort on the Nilgiri Hills, South India. 1st ed. Vol. 1. Vepery: SPCK Press; 1919. 3 78 p.
27. Ghosh Payel. Antrocom Journal of Anthropology. Antrocom Journal of Anthropology. 2020;16(1).
28. Dey A, Das K. Why we tattoo. Exploring the motivation and meaning. Anthropol. 2017;5(1):2-6.
29. Borokhov A, Bastiaans R, Lerner V. Tattoo designs among drug abusers. Israel Journal of Psychiatry and Related Sciences. 2006 Jan 1;43(1):28.
30. Hellard ME, Aitken CK, Hocking JS. Tattooing in prisons not such a pretty picture. American journal of infection control. 2007 Sep 1;35(7):477-80.
31. Bhargava S, Singh R, Kumari K. Significance of tattoo marks in forensic psychology: a review. Int J Curr Adv Res. 2016 Apr;5(4):857-9.
32. Symbolism In Russian Criminal Tattoos. Listaháskóli Íslands Department of Design and Architecture Graphic Design department; 2012.
33. Palermo GB. Tattooing and tattooed criminals. Journal of Forensic Psychology Practice. 2004 Apr 5;4(1):1-25.
34. Bardale R, Ninal N. Analysis of tattoos in an autopsy population: A two-year study. Journal of Indian Academy of Forensic Medicine. 2020;42(4):296-9.
36. Section 9 in the Indian Evidence Act, 1872 [Accessed 30/11/2024].
37. Shankar Mahto v. State of Bihar, (SC) BS863 [Accessed 11/12/2024].
38. Joginder @ Danny v. State (NCT) of Delhi. 2018 Dec 19. LAWS(DLH)-2018-12-216.
39. Sunil Dattatraya Vaskar & Anr vs State Of Maharashtra on 17 September, 2008 [Accessed 12/12/2024].
40. Siddharam Satlingappa Mhetre vs State Of Maharashtra And Ors on 2 December, 2010.
41. Savetanii. Why did Apatanis practiced tattooing and nose-plugs (Tiipey-Yaping)? [Internet]. [cited 5 July 2024].
42. Goldby D. The Wancho People, Arunachal Pradesh, India [Internet]. Dylan Goldby - Photographer. 2020 [cited 5 July 2024].
43. Hembram D, Hembram D. Santal Tribal Tattoos- The Wealth of afterlife. - Santals.com [Internet]. Santals.com - Preserving Tribal Heritage. 2024.
44. Godna : Tattoo Art by women of the Baiga tribe | INTACH Intangible Cultural Heritage.
45. Arjel Amit (@bluebloodtreetattoo). Instagram photos and videos.
46. Limited A. India, Gujarat, Rabari woman with tribal tattoos [Internet]. Alamy Images.
47. Thakur M. Toda tribal tattoo. EdgyMinds. 2016 Dec 27 [cited 2024 Jul 5].
48. Prison tattoos: 15 tattoos and their meanings [Internet]. Corrections1. 2024.

Figure 1: Photographs of Indian Tribal Tattoos of (A) Apatani face tattoo[41], (B) Headhunters from the Wancho tribe in Arunachal Pradesh[42], (C) Santhal tribe[43], (D) Traditional Biga women's tattoos[44], (E) Bhil tribe body art[45], (F) Gujarati Rabari woman with tattoos[46], (G) Tattoos from the Toda Tribe.[47]

Figure 2: Photographs of Prison Tattoos of (A) Cobweb (B) Teardrop (C) Cross on the Chest (D) Three Dots (E) Playing Cards.[48]

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00048.2

Review Article

Navigating the Impact of Artificial Intelligence (AI) Technologies On Medical Academic Practices: Opportunities and Challenges

1. **Satinder Pal Singh,** Assistant Professor*
2. **Sumeet Kaur,** Assistant Professor, Department of Biochemistry, Dr B R Ambedkar State Institute of Medical Sciences, Mohali, Punjab, India
3. **Akash Deep Aggarwal,** Professor & Head*
4. **Didar Singh Walia,** Associate Professor*
5. **Preetinder Singh,** Associate Professor*

*Department of Forensic Medicine, Government Medical College, Patiala, Punjab, India

ABSTRACT

Artificial intelligence (AI) is rapidly transforming academia, offering both unprecedented opportunities and significant challenges. This paper examines the dual nature of AI's impact on educational institutions, highlighting its potential to enhance personalized learning, streamline administrative processes, and facilitate innovative research methodologies. However, these advancements are accompanied by challenges, including ethical concerns, the digital divide, and the need for robust data privacy measures. Additionally, the integration of AI into curricula poses questions about the future of teaching and learning dynamics. To mitigate these challenges, the paper proposes a framework for the responsible AI implementation that includes stakeholder collaboration, comprehensive policy development, and training of students, faculty, and researchers. By embracing these solutions, academia can harness the transformative power of AI while mitigating its risks, ultimately enriching the educational landscape for future generations.

Corresponding Author :
Dr. Satinder Pal Singh, Assistant Professor
Department of Forensic Medicine,
Government Medical College, Patiala, Punjab, India
E-mail: docsp423@gmail.com
Contact : +919988008723

Article History:
Received: 22 November 2024
Received in revised form: 23 January 2025
Accepted on: 23 January 2025
Available online: 15 April 2025

Keywords: Artificial Intelligence; ChatGPT; Large Language Model; Disruptive Technology; Medical Education.

INTRODUCTION

Artificial intelligence (AI) technologies have evolved rapidly in multiple sectors, from education and scientific research to law enforcement. One significant category of these innovations is shown with generative AI models, including ChatGPT, Google Gemini, Microsoft Copilot, NotebookLM Junia, SciSpace, etc., which have now been established to be highly effective tools that can produce human-quality text for the purposes of communication, learning and research.[1,2]

However, the increasing use of these materials in academic settings also carries important forensic implications that require careful consideration. In this review paper, we explore the academic implications of these AI tools: the potential benefits of using them and the risks associated with their unwarranted deployment. These kinds of instances beg the question of what happens to academic integrity, authorship or the validity of student submissions when AI tools have been used.[3-5]

The possibility of confirming the authenticity of such academic work is dwindled. This paper also focuses on the importance of having strong frameworks to tackle risks associated with it.[6,7] Our exploration is ultimately aimed to inform the ongoing debates surrounding the ethical deployment of AI within educational settings as well as what that means for the future of higher education [3,8]. In addition, the authors also recommend some ways in which the use of AI in academic and research work can be better monitored to maintain authenticity.

Benefits of AI technologies In Academia

1. Quick Research Assistance: AI has the potential to provide immense benefits in medical institutions. For instance, it can help researchers to generate literature reviews, summarize articles or even suggest research questions.[4,9] Furthermore, it enables educators to expedite the research process and enhance productivity. The ease of statistical analysis for research activities is an added advantage.

2. Writing Aid: Students and academics with all sorts of text-based written work can use AI to help them draft, edit, and polish.[4,5,9,10] It supports in polished academic writing by suggesting structure, style, and grammar.

3. Accessibility: AI tools can make the academic content most accessible for students with learning disabilities or encountering language barriers and support them in a way best suited for their needs.

4. Medical Education: Using AI tools in classroom settings can make medical education more interactive. The medical professionals can keep up with the recent advances in their respective fields of expertise with this technology. AI tools like ChatGPT can act as a live one to one tutoring assistant helping in explaining, resolving queries, and clearing doubts in real-time.

This allows for delivering discussions, role-playing scenarios, and simulations that lead to better student engagement.[5,11] In addition, AI tools can assist in formulating multiple choice questions (MCQs), preparing roster for faculty and students, and designing of curriculum.

5. Brainstorming: These AI applications can help kickstart your thought process when it comes to generating ideas for projects, presentations, or papers. Especially when it comes to brainstorming, this way students and researchers get variety of opinions.

6. Time Management: Thanks to its ability to automate time-consuming, routine work in areas like note-taking and data organization, as well as finding basic information, these intelligent softwares can help students (and even academics) focus on more abstract thinking and advanced problem-solving.[5]

7. Variety in Learning Formats: AI tools have the ability to reach students across a broad spectrum of learning modes through immediate dialogue or posting both summarizing and extended explanations, assisting with the idiosyncratic needs of a broader range of recreational learners.

8. Collaboration: AI platforms can help teams in organizing thoughts together, communicate and co-create content that will improve the dynamic of the group as a whole.[12]

9. Educators: In the professional development arena, educators can explore new teaching methodologies; create course materials or stay informed about industry elevations and changes all in a bid to grow professionally.[12]

Challenges with Artificial Intelligence in Academia

1. Plagiarism and Authenticity: Using AI tools raises academic integrity issues with plagiarism concerns; what exactly does the student submit as their own if using a pre-trained language model? It is difficult to identify AI-generated content submitted as original work by students, compromising the academic soundness of assessments.[3]

2. Reliability: These automation tools can write coherent English, but do not know what is factually correct[13] or even up to date. The factually incorrect information generated is referred to as the 'AI hallucinations'. Failure to verify the accuracy and relevance of AI-generated content raises questions about the reliability of information and data.[14] The complete dependence on AI for research or academic writing, without checking about its authenticity can spread false, deceptive information.[3,10]

3. No Critical Thinking: If students use AI to solve problems or generate ideas for them, it could prevent the kind of critical thinking and analytical skills development that can occur when they engage deeply with the material.[3,9] These skills are essential for theses and research work.

4. Ethical use of AI: Determining the ethical boundaries of using AI tools in academic settings is complex. Educators must navigate issues related to fairness, transparency, and the implications of using AI-generated content in assessments.[4,6]

5. Equity and Accessibility: A significant population of students lack equal opportunities to use the AI tools or are equipped with limited necessary technical skills. This can further aggravate pre-existing education inequities leading to inequalities in learning experience.

6. Data Privacy and Security: The use of AI in academia seems to mirror the issues of data privacy, and handling sensitive information.[15,16] To do this in a safe and ethical way, institutions need to make sure that student data is being protected consistently.[3,7]

7. Technology Dependence: The overuse of intelligent technologies in academics has the potential to promote undue dependence these tools, which may decrease the academic abilities of students over time.

8. Standardization of Learning: AI interactions may lead to standardized learning, potentially missing essential human factors such as empathy, trust, communication skills, and body language, when compared to live

educators.[17] This could lead to lacking student engagement and the important mentorship, necessary for academic prosperity.

9. Regulatory Challenges: AI in education gets adopted quickly but regulatory frameworks are left far behind. Institutions may have difficulty setting standards for ethical use and hammering out repercussions for misuse. Even in the developed world, the regulations are not in place in most institutions, the situation being worse in developing countries like India.

These challenges require careful policy development, educator and student training, and a continued discourse about the implications of AI in academia.

Solutions to the challenges of use of AI tools in Academia

1. Establish Guidelines: Institutions must establish policies detailing proper use of AI tools on campus.[17] These policies should encompass matters related to academic integrity, questions of authorship, and proper citation.

2. Curriculum Integration of AI Literacy: Currently, most medical colleges in India and other countries lack a structured AI curriculum.[18] Inclusion of AI in curriculum or arranging workshops on AI literacy shall engage students toward the exposure of abilities and limitations to tools like ChatGPT, SciSpace so that the students are empowered with the knowledge of AI, to use it responsibly and critically.[1,3,19]

3. Creativity: Use assignments that become more challenging for the students to plagiarize, since they require creativity and personal insights and examples are like case studies, novel problems to solve.

4. Utilize Plagiarism Detection Software: Use sophisticated plagiarism detection softwares that could trace AI-generated content. Instruct students that such tools should be used to ensure academic integrity.

5. Encourage Collaborative Learning: Create tasks that need students to collaborate with each other rather than solely with the help of AI. Group collaborative efforts promote critical thinking through discussions and debates.

6. Faculty Training: The faculty should be trained about the potential and limitations of AI-based tools. This training will enable them to align their teaching style with AI, addressing all their concerns while developing support for its adoption.[15]

7. Ethical Framework: Institutions can develop ethical frameworks for the use of AI in a learning space.[19,20] Such frameworks address issues of data privacy, consent, and the ethics of the material produced by AI. Additionally, erroneous diagnosis and subsequent treatment advise by AI tools may have liability and medicolegal consequences for health care professionals.[14,21]

8. Critical Engagement Development: Tasks can be designed to elicit critical review of AI-generated material, and so improving analytic and critical thinking skills by greater engagement with course content.

9. Open Discussion of the Use of AI in the Academy: Holding open discussions between students, faculty, AI experts and administration concerning roles involving AI will help identify issues and share best practices and community approaches to AI adoption.[2,7,22]

10. Policymaking on the Use of AI in Academia: Monitor and review policies on the use of AI as trends and technologies unfold.[23-27] This will enable an academy to remain responsive to emerging challenges and opportunities. The Indian Council of Medical Research (ICMR), in its document titled Ethical Guidelines for the Application of Artificial Intelligence in Biomedical Research and Healthcare, has established comprehensive guidelines for the integration of AI into biomedical research, aligning with core ethical research principles.

For example, the incorporation of the 'Human in the Loop' model underscores the importance of human oversight to preserve human autonomy. Furthermore, the guidelines prioritize patient/participant safety, as well as accountability and liability for ethical use of AI technologies.[28]

CONCLUSION

The integration of AI-based systems in academia offers benefits such as enhanced learning support and creative opportunities, fostering independent thinking. However, challenges like academic integrity, information quality, and over-reliance on AI tools must be addressed. Educational institutions must set guidelines for AI use, promote AI literacy among students and faculty, and encourage critical engagement with the technology. Developing ethical frameworks will ensure AI's positive impact while maintaining academic standards.

Ultimately, while AI presents challenges, institutions that remain proactive can balance innovation and integrity, using AI to create a dynamic and inclusive educational

environment.

REFERENCES

1. Fitzek S, Choi KA. Shaping future practices: German-speaking medical and dental students' perceptions of artificial intelligence in healthcare. BMC Med Educ. 2024 Aug 6;24(1):844.
2. Salvagno M, Cassai AD, Zorzi S, Zaccarelli M, Pasetto M, Sterchele ED, et al. The state of artificial intelligence in medical research: A survey of corresponding authors from top medical journals. PLoS ONE. 2024;19(8): e0309208.
3. Uygun Ilikhan S, Özer M, Tanberkan H, Bozkurt V. How to mitigate the risks of deployment of artificial intelligence in medicine? Turk J Med Sci. 2024 May 20;54(3):483-492.
4. Dinis-Oliveira RJ, Azevedo RMS. ChatGPT in forensic sciences: a new Pandora's box with advantages and challenges to pay attention. Forensic Sci Res. 2023 Nov 10;8(4):275-279
5. Dave T, Athaluri SA, Singh S. ChatGPT in medicine: an overview of its applications, advantages, limitations, future prospects, and ethical considerations. Front Artif Intell. 2023 May 4;6:1169595.
6. Jeyaraman M, Balaji S, Jeyaraman N, Yadav S. Unraveling the Ethical Enigma: Artificial Intelligence in Healthcare. Cureus. 2023 Aug 10;15(8):e43262.
7. Franco D'Souza R, Mathew M, Mishra V, Surapaneni KM. Twelve tips for addressing ethical concerns in the implementation of artificial intelligence in medical education. Med Educ Online. 2024 Dec 31;29(1): 2330250.
8. Hulsen T. Literature analysis of artificial intelligence in biomedicine. Ann Transl Med. 2022 Dec;10(23):1284.
9. Cheng J. Applications of Large Language Models in Pathology. Bioengineering (Basel). 2024 Mar 31;11 (4):342.
10. Lee SW, Choi WJ. Utilizing ChatGPT in clinical research related to anesthesiology: a comprehensive review of opportunities and limitations. Anesth Pain Med (Seoul). 2023 Jul;18(3):244-251.
11. Mokmin NAM, Ibrahim NA. The evaluation of chatbot as a tool for health literacy education among undergraduate students. Educ Inf Technol (Dordr). 2021;26(5):6033-6049.
12. Ueda D, Kakinuma T, Fujita S, Kamagata K, Fushimi Y, Ito R, Matsui Y, Nozaki T, Nakaura T, Fujima N, Tatsugami F, Yanagawa M, Hirata K, Yamada A, Tsuboyama T, Kawamura M, Fujioka T, Naganawa S. Fairness of AI in healthcare: review & recommendations. Jpn J Radiol. 2024 Jan;42(1):3-15.
13. Briganti G. How ChatGPT works: a mini review. Eur Arch Otorhinolaryngol. 2024 Mar;281(3):1565-1569.
14. Choudhury A, Chaudhry Z. Large Language Models and User Trust: Consequence of Self-Referential Learning Loop and the Deskilling of Health Care Professionals. J Med Internet Res. 2024 Apr 25;26:e56764
15. Zawacki-Richter O, Marín VI, Bond M, Gouverneur F. Systematic review of research on artificial intelligence applications in higher education-where are the educators? International Journal of Educational Technology in Higher Education 2019;16(1):1-27.
16. Watters C, Lemanski MK. Universal skepticism of ChatGPT: a review of early literature on chat generative pre-trained transformer. Front Big Data. 2023 Aug 23;6:1224976.
17. Hasan HE, Jaber D, Khabour OF, Alzoubi KH. Ethical considerations and concerns in the implementation of AI in pharmacy practice: a cross-sectional study. BMC Med Ethics. 2024 May 16;25(1):55.
18. Imran N, Jawaid M. Artificial intelligence in medical education: are we ready for it? Pakistan J Med Sci. 2020;36(5):857-59.
19. Weidener L, Fischer M. Artificial Intelligence in Medicine: Cross-Sectional Study Among Medical Students on Application, Education, and Ethical Aspects. JMIR Med Educ. 2024 Jan 5;10:e51247.
20. Sallam M. ChatGPT Utility in Healthcare Education, Research, and Practice: Systematic Review on the Promising Perspectives and Valid Concerns. Healthcare (Basel). 2023 Mar 19;11(6):887.
21. Dolunay A, Temel AC. The relationship between personal and professional goals and emotional state in academia: a study on unethical use of artificial intelligence. Front Psychol. 2024 Mar 27;15:1363174.
22. Jebreen K, Radwan E, Kammoun-Rebai W, Alattar E, Radwan A, Safi W, Radwan W, Alajez M. Perceptions of undergraduate medical students on artificial intelligence in medicine: mixed-methods survey study from Palestine. BMC Med Educ. 2024 May 7;24(1):507.
23. Salvagno M, Cassai A, Zorzi S, Zaccarelli M, Pasetto M,

Sterchele ED, Chumachenko D, Gerli AG, Azamfirei R, Taccone FS. The state of artificial intelligence in medical research: A survey of corresponding authors from top medical journals. PLoS One. 2024 Aug 23;19(8):e0309208.

24. Gao CA, Howard FM, Markov NS, Dyer EC, Ramesh S, Luo Y, Pearson AT. Comparing scientific abstracts generated by ChatGPT to real abstracts with detectors and blinded human reviewers. NPJ Digit Med. 2023 Apr 26;6(1):75.
25. Mehta N, Harish V, Bilimoria K, Morgado F, Ginsburg S, Law M, Das S. Knowledge and attitudes on artificial intelligence in healthcare: a provincial survey study of medical students. Med Ed Publish. 2021;10:75.
26. Paranjape K, Schinkel M, Nannan Panday R, Car J, Nanayakkara P. Introducing artificial intelligence training in medical education. JMIR Med Educ. 2019 Dec 03;5(2):e16048.
27. Lee J, Wu AS, Li D, Kulasegaram KM. Artificial intelligence in undergraduate medical education: a scoping review. Acad Med. 2021 Nov 01;96(11S): S62–70.
28. Indian Council of Medical Research. Ethical guidelines for application of artificial intelligence in biomedical research and healthcare [Internet]. New Delhi: Indian Council of Medical Research; 2023 [cited 2025 Jan 22].

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00049.9

A Case Report

Amalgamated, Burnt and Disposed Off - An Unusual Case Report of Homicide

1. **Priti Singh,** Senior Resident*
2. **Vikas Verma,** Senior Resident*
3. **Kamal Singla,** Associate Professor**
4. **S. K. Dhattarwal,** Senior Professor and Head*
5. **Subhash Sharma,** Junior Resident*

* Department of Forensic Medicine, Pt. B. D. Sharma PGIMS, Rohtak, Haryana, India -124001

**Department of Forensic Medicine, Al Falah School of Medical Sciences and Research Centre, Faridabad, Haryana, India - 121004

ABSTRACT

Introduction: This case report presents a unique and complex instance of homicide involving the amalgamation, burning, and disposal of the victim's body, highlighting the challenges faced in forensic investigation. The case details the discovery of charred human remains in a remote area, and referred from the civil hospital to PGIMS Rohtak. Comprehensive examination of the scene and meticulous autopsy procedures revealed critical evidence, including mercury in the stomach and antemortem burn which was further confirmed by the histopathological examination. This case underscores the importance of interdisciplinary collaboration in forensic investigations, integrating expertise from forensic pathology, anthropology, and toxicology to unravel complex scenarios. The report also discusses the legal and ethical implications of handling such intricate cases, considering the profound impact on the victim's family and the pursuit of justice. Ultimately, this case serves as a significant contribution to forensic medicine literature, providing insights into the methodologies and challenges encountered in the investigation of highly convoluted homicides. It underscores the critical role of forensic science in elucidating the truth and supporting the legal system in delivering justice.

Corresponding Author :
Dr. Vikas Verma, Senior Resident
Department of Forensic Medicine, Pt. B. D. Sharma PGIMS, Rohtak, Haryana, India -124001
E-mail: vikverma1819@gmail.com
Contact : +918529228004

Article History:
Received: 18 July 2024
Received in revised form: 05 January 2025
Accepted on: 05 January 2025
Available online: 15 April 2025

Keywords: Mercury; Homicide; Burn; Anthropology.

INTRODUCTION

Section 101 of the BNS categorizes culpable homicide as murder, outlining specific scenarios where an act resulting in death becomes classified as murder. These scenarios include: Intention to Cause Death, Intention to Cause Fatal Bodily Injury, Bodily Injury Sufficient to Cause Death, Imminent Danger with Knowledge.[1] Homicide can be caused by any weapon, firearm, burn or poison. According to the World Health Organization (WHO), poisons are substances that cause disturbances to organisms, usually through chemical rection or other activities on the molecular scale.[2]

The heavy, silvery liquid known as metallic or elemental mercury (Hg°) is inherently non-toxic, but at room temperature it vaporizes to release mercuric mercury, a poisonous fume. Heating substantially enhances volatilization. When in its solid state, mercury is a ductile, tin-white metal that may be easily sliced with a knife. The alveolar membrane allows elemental mercury to easily enter the bloodstream after inhalation.

A slower rate of absorption is linked to the consumption of mercury salts. In the blood, mercury is quickly transformed into mercuric ions (Hg++), which can cause renal tubular injury when it is excreted. Mercury primarily affects the cerebellum, temporal lobe, basal ganglia, and corpus callosum in the central nervous system. Mercurial that is both organic and inorganic can be absorbed through intact skin. Ingestion of mercuric salts produces corrosion leading to abdominal pain, vomiting, diarrhea, and shock. The mucosa of the GI tract usually appears greyish.

There may be hematemesis. In severe cases there is onset of renal failure, pulmonary oedema, and coma. Urine may

appear pinkish.[3] The mucosal lining of the gastrointestinal tract exhibits signs of inflammation, congestion, coagulation, and erosion. Should the individual endure for several days, the large intestine may present with necrosis resulting from the re-excretion of mercury into the large bowel. Additionally, acute tubular and glomerular degeneration, as well as hemorrhagic glomerular nephritis, are observed.[4]

CASE REPORT

The present case was brought to the Mortuary of Department of Forensic Medicine, PGIMS, Rohtak for postmortem examination as referred by Civil Hospital of Haryana. The dead body was completely charred and burnt off **(Figure 1)**.

Figure 1. Charred and Burnt off Dead Body of Male Individual.

The body was showing dark discoloration and third degree (deep) burns as per Wilson classification. On exploration, the underlying muscles were burnt off at places along with commensurate bones which were showing deep charring and bone marrow was dried up due to heat effect.

On internal examination, the solid viscera were severely burned, emitting an odor reminiscent of roasted meat. The whole solid viscera i.e. lungs, liver, spleen and kidneys become shrunken in size, firm and hard in consistency due to flame burns. The stomach and intestinal wall were leathery in touch and were harder and tent like due to the burn effect. On general exploration, there were some shining silvery thick semi liquid droplets of some metallic substance found in vicinity of liver, spleen and stomach **(Figure 2)**.

On further exploration and dissection, the same metallic semi liquid droplets were found in the stomach, adherent to the mucosa along with reddish tinged food material. The nature and type of metal was confirmed by Forensic

Figure 2. Shiny, Silvery Metallic Drops of Mercury in the Vicinity of Liver, Spleen and Stomach.

Science Laboratory, Haryana as Mercury.

If the presence of mercury were an artifact-potentially introduced from an external source during or after the burns-this possibility was ruled out by dissecting the small intestine, specifically the duodenum near the pyloric end of the stomach. The discovery of identical metallic droplets inside confirmed ingestion, as shown in **Figures 3** and **Figure 4**.

The burns were found to be antemortem on gross as well as histopathological examination. The cause of death was

Figure 3. Droplets of Mercury in Stomach and Near the Pyloric Sphincter.

Figure 4. Droplets of Mercury in the Duodenum, First Part of Small Intestine.

opined as burns and its complications. However, the manner of burns as well as ingestion of mercury was kept pending till receiving of crime scene report, thorough investigation report and circumstantial evidences gathered by the concerned investigating officer of the case.

After receiving of all the reports as mentioned supra vide, the manner of death was concluded as homicide as the alleged accused had admitted that he had mixed pure mercury in the food of deceased during partying. And when deceased fell unconscious due to ethanol, accused set the victim to fire by his own clothes. Therefore, the investigation report having narrated by the accused confirmed the scientific findings gathered by the postmortem examination.

DISCUSSION

Mercury exists in various forms: elemental (pure mercury), inorganic mercury salts, and organic mercury compounds. Elemental mercury, often encountered in its liquid state, is poorly absorbed by the gastrointestinal tract when ingested.[5] While elemental mercury is not readily fatal by ingestion, mercury salts (such as mercuric chloride) are highly toxic.

Mercury salts are readily absorbed through the gastrointestinal tract and cause severe damage to organs such as the kidneys, intestines, and the nervous system. They act as potent corrosive agents, leading to cell necrosis and renal failure.[6] The presence of mercury in the stomach and small intestine during an autopsy is indeed suspicious. Mercury droplets found in the gastrointestinal tract suggest that ingestion occurred prior to death.

However, given that elemental mercury is not easily absorbed, the finding alone does not confirm poisoning as the cause of death. This requires further toxicological analysis to rule out any fatal absorption via other pathways, such as inhalation of vaporized mercury.[7]

In India burn related dowry death is most commonly encountered and it has been one of the leading causes of Medico legal cases. Fire is also used for destruction of body of crime which encounter very frequently during post-mortem examination.[8] According to depth of injury burns can be of first degree, second degree or third degree and according to causative agent can be of chemical or thermal.[9]

Burns are classified as antemortem if there is evidence of tissue reaction (vital reaction) before death, such as soot in the airways, elevated levels of carbon monoxide in the blood, or specific changes in the skin's histology. The presence of such indicators can rule out postmortem burning and support the hypothesis that the victim was alive when set on fire.[10]

The consumption of alcohol leading to a semiconscious or unresponsive state may have facilitated the second phase of the homicide, in which the accused set the victim on fire. According to forensic studies, individuals with high blood alcohol content (BAC) are less likely to respond to stimuli, including pain. This would explain why the victim did not resist the burning process.[11]

Cases involving mercury poisoning are rare, and forensic investigators must carefully interpret toxicological findings. In the current case, the discovery of mercury droplets in the gastrointestinal tract, while significant, does not conclusively indicate that mercury poisoning was the direct cause of death. The lack of significant absorption suggests that the ingestion may have been part of a broader homicidal strategy that ultimately failed.[12]

Typically, single-person household deaths involving fire may initially be suspected as suicides, especially if there is no clear evidence of foul play. However, the presence of mercury, the potential incapacitation of the victim due to alcohol, and the antemortem nature of the burns suggest otherwise in this case. A thorough investigation of the victim's psychological history, forensic evidence, and motive of the accused is crucial in differentiating between suicide and homicide.[13]

Although, the accused was unaware of the effect of pure form of mercury i.e. ingestion of mercury is neither absorbable to gastric mucosa nor fatal on ingestion in its pure form, however the intent was clear i.e. to kill the victim by poisoning. But he failed to do so, then the accused burnt the victim alive in semiconscious or unresponsive state due to heavy dose of alcohol. Definitely deceased was not a medical professional as it is known fact mercury salts are fatal to the life rather its pure form. Usually, a single person living in a house found dead due to antemortem burns over his body is supposed to be suicidal in manner apparently until proved otherwise by the police officials. But these mercury droplets found in stomach and adjoining part of small intestine made this case suspicious and raised speculation of homicide.

CONCLUSION

Not every case of burn is suicidal as perceived by investigating agencies on prima facie until the victim or

deceased had not given any live statement. Every case of burn should be examined thoroughly and meticulously with greater credence to be given to the autopsy findings as well as circumstantial evidences, properly correlated and interpreted to come any conclusion in respect to manner of death.

REFERENCES

1. THE BHARATIYA NAGARIK SURAKSHA SANHITA, 2023
2. Reddy KSN. The essentials of forensic medicine and toxicology. 28th ed. Hyderabad, India: K Suguna Devi; 2001.p.407-11.
3. Pillay VV. Modern Medical Toxicology. Jaypee Brothers Medical Publishers (P) Ltd New Delhi. 4th ed. 2013; P. 91-92
4. Reddy KSN. Murthy, OP. The Essentials of Forensic Medicine and Toxicology. The Health Sciences Publishers. New Delhi. 34th ed. 2017; P. 543
5. Clarkson, T. W., & Magos, L. The toxicology of mercury and its chemical compounds. Critical Reviews in Toxicology. 2006; 36(8), 609-662.
6. Chang, L. W., Dyer, R. S., & Berlin, M. Neurotoxicology of mercury—human exposure and environmental concerns. Environmental Toxicology and Pharmacology. 1996. 1(3); p. 207-230.
7. Tchounwou, P. B., Yedjou, C. G., Patlolla, A. K., & Sutton, D. J. Heavy metal toxicity and the environment. Molecular, Clinical and Environmental Toxicology, 2012; 101. P. 133-64.
8. Kumar V, Kumar G, Bhutia TZ, Saha S, Prasad R, Kumar A. An Autopsy Study of Deaths Due To Burn Injuries in North Bengal Region. J Punjab Acad Forensic Med Toxicol 2020;20(1). P. 67-71.
9. Gupta S, Jaura N, Gupta P, Ahi KS. Study of Demographic and Clinical Profile of Burns in a Tertiary Care Hospital. J Punjab Acad Forensic Med Toxicol 2023;23(1) p. 49-52.
10. Spitz, W. U. Spitz and Fisher's Medicolegal Investigation of Death: Guidelines for the Application of Pathology to Crime Investigation. Charles C Thomas Publisher. 2006.
11. Drummer, O. H., & Gerostamoulos, D. Postmortem drug analysis: Analytical and toxicological aspects. Therapeutic Drug Monitoring, 2002; 24(2), 199-209.
12. Stohs, S. J., & Bagchi, D. Oxidative mechanisms in the toxicity of metal ions. Free Radical Biology and Medicine. 1995; 18(2), p. 321-336.
13. Litman, R. E. Suicide and Homicide-Suicide. Journal of Forensic Sciences. 1995; 40(4), p. 626-630.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00050.X

A Case Report

Penetrating Abdominal Trauma with Knife In-Situ : A Case Report

1. **Varun Modgil,** Assistant Professor, Departments of Forensic Medicine*
2. **Kunwar Aggarwal,** Assistant Professor, Department of General Surgery*
3. **Vaishali,** Post-graduate Junior Resident, Department of General Surgery*

* Dayanand Medical College & Hospital (DMCH), Ludhiana, Punjab-141001 (India)

ABSTRACT

Introduction: Drug related violence is on the rise in several regions of India. Physical proximity to the golden crescent further aggravates the problem of antisocial activity. Penetrating injury by a knife with retained weapon creates unique medico-legal and surgical problems and is often rare.

Case Presentation: We report a case of a 37-year-old male, presenting with an abdominal stab wound with the weapon in situ. Internal injuries included corresponding cuts over gastrocolic omentum, transverse colon and posterior portion of stomach. Weapon was removed by laparoscopic approach.

Discussion: In the emergency care setting, such injuries with retained weapon are rare. A proper surgical approach planned well in time is crucial and post-operative care is vital to limit morbidity or mortality.

Conclusion: The article describes a case of abdominal stab wound with weapon in-situ. Along with surgical management, medico-legal protocol is vital especially, the recovery, handling of the weapon and ultimate hand-over to the investigative agencies maintaining the chain of custody of evidence.

Corresponding Author :
Dr. Varun Modgil, Assistant Professor, Departments of Forensic Medicine, Dayanand Medical College & Hospital (DMCH), Ludhiana, Punjab-141001, India
E-mail: varunmodgil27@gmail.com
Contact : +917973123291

Article History:
Received: 26 December 2024
Received in revised form: 11 March 2025
Accepted on: 11 March 2025
Available online: 15 April 2025

Keywords: Drug Related Violence; Stab Wound; Chain of Custody; Weapon in-situ.

INTRODUCTION

Drug abuse is prevalent among the youth in the state of Punjab, especially so in the rural belt.[1,2] There is a rampant rise in the incidence of intravenous drug abuse and subsequent hospital admissions owing to life threatening manifestations. Drug users are predominantly young males who are found to indulge in violence either for procuring the illicit substance or because of it's after effects or the lack of it.

Interpersonal violence because of drug abuse may manifest in various forms including extreme form of physical trauma e.g. beating or assaulting with the use of objects or weapons. Here we have reported a clinical scenario of stab wound involving the abdominal region with retained knife which is a rare entity in the existing literature.[3]

CASE REPORT

A 37-year-old male presented to the emergency department with stab wound over left side of upper abdomen and presence of a retained knife in-situ. The patient told that he was assaulted by his brother, who was under influence of illicit drugs. On admission, the blood pressure was 110/70 mm Hg, the heart rate was 72 per minute, respiratory rate 22 per minute and arterial oxygen saturation 96%. Local examination revealed a stab wound of 3 cm x 2 cm with omentum protruding out **(Figure 1)**. On chest X-ray, the sharp weapon, its lateral extent and direction is clearly visible **(Figure 2)**.

A multi-detector CT scan of the chest and abdomen showed a sharp metallic foreign object in the left upper abdomen, near the anterior abdominal wall, causing a streak artifact. The object had pierced the abdominal wall, entered the peritoneal cavity, and its tip was near the fundus of the stomach. Mild subcutaneous emphysema was noted in left upper abdomen.

A high density hematoma measuring 15mm was seen along greater curvature of stomach and another hematoma of size 2.5 x 2.2cm was seen adjacent to splenic flexure. High density fluid was seen extending along few of jejunal

loops in left lumbar region which appeared thickened. There was fluid buildup and inflammation (stranding) in the surrounding mesentery.

These findings were consistent with mesenteric tear. Fracture of the left sided eighth rib was detected **(Figure 3)**. Liver did not show any signs of parenchymal damage. No evidence of any peripancreatic collection was seen. Spleen and both the kidneys showed normal morphology. CT Chest did not demonstrate any pathology.

The patient was shifted to the operating room after pre-anaesthetic evaluation and stabilization within few hours of admission. Laparoscopic removal of the weapon was planned. Intra-operatively, a sharp handle less weapon was found in the left thoraco-abdominal region passing in front of the spleen and piercing the gastrocolic omentum. Weapon was removed by laparoscopic approach **(Figure 4)**.

But open laparotomy was needed on detecting faecal spillage. Gastrocolic omentum was opened after standard midline laparotomy incision. Transverse colon was mobilised. A tear of size 3cm x 2cm was found in the corresponding posterior portion of mid transverse colon and serosal tears in the posterior portion of the stomach. Primary repair was done followed by a double barrel ileostomy. Abdomen was closed in layers. After stabilization, patient was shifted to the surgical ward.

The clothes of the patient were air dried and carefully handed over to the police after labelling with unique Medico-legal case (MLC) number and initialling. The retrieved weapon was similarly initialled with a diamond pencil, sealed in a cloth and handed over to the investigating officer along with the medico-legal report.

DISCUSSION

Penetrative thoraco-abdominal trauma has been reported in the literature previously.[4,5,6] Majority of the impalement injuries happen with large blunt pointed objects encountered in the setting of an accidental trauma. In our case, the patient had come with a retained knife in the left abdominal region because of assault. Biomechanical analysis of sharp force trauma suggests that the sharpness of the tip of knife and its structure is directly proportional to its penetrative power.[7]

In our case, the tip was reasonably sharp and its later descent to the abdominal cavity is usually smooth after the initial resistance offered by intact skin barrier. An analysis into the causes of death due to sharp force trauma is mainly

Figure 1: Penetrating Abdominal Injury with Knife in-situ

Figure 2: Radio-Opaque Shadow of the Knife

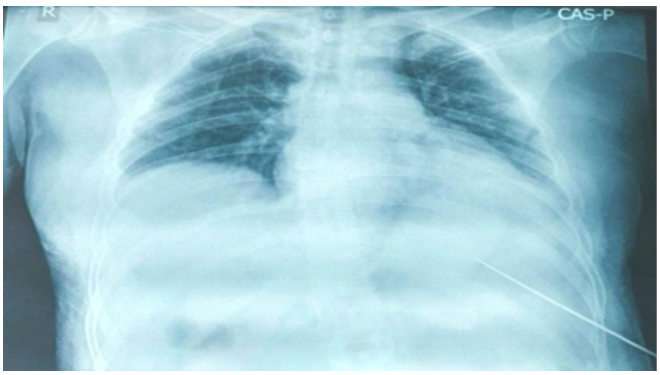


Figure 3: Axial Contrast-Enhanced MDCT Showing Streak Artefact and Haemo-Peritoneum

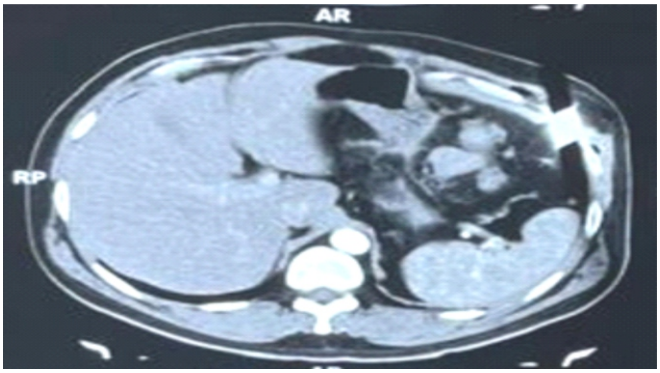


Figure 4: Sharp Weapon after Removal from the Abdominal Cavity

due to injury to major blood vessels e.g. any of the branches of the abdominal aorta.[8]

In our case, the proximity of the invading weapon to middle colic branch of superior mesenteric artery could have proven to be life threatening in the event of breach of the vessel. Fortunately, due to the relative obliquity of the weapon none of the solid organs (liver, pancreas, kidney and spleen) were damaged. The tip of the weapon was positioned few cm from the spleen, which escaped the injury.

The medico-legal aspects of a case of assault although are secondary to the immediate life saving treatment but go hand-in-hand with the surgical management. Forensic medicine experts are required to perform a detailed examination in assault cases and record the findings to come to conclusions regarding queries of the police. Criminal code in India defines Grievous hurt under section 106 of the Bharatiya Nyaya Sanhita, 2023.[9]

The initial part of clause 'h' refers to "any hurt which endangers life," which applies to the stab injury seen in our case. Herein, any medical treatment to lessen the seriousness of the injury is immaterial. Further, clause (2) of section 118 of the Bharatiya Nyaya Sanhita, 2023 provides punishment for voluntarily causing grievous hurt by dangerous weapon (clause i of this section construes any instrument used for stabbing included in the definition of a dangerous weapon).[10]

A carefully structured medical opinion on the nature of injury should consider all the parameters e.g. the hemodynamic stability of the patient, the amount of blood loss and risk of septicaemia from perforation peritonitis. In our case, the vitals of the patient were relatively stable since admission and hence a cross sectional CT scanning approach was followed prior to surgery. Surgery was started with laparoscopic approach but on detection of spillage, primary repair of the bowel and stomach was done by open laparotomy.

CONCLUSION

The article describes a case of abdominal stab wound with weapon in-situ. Along with surgical management, medico-legal protocol is vital especially, the recovery, handling of the weapon and ultimate hand-over to the investigative agencies maintaining the chain of custody of evidence. Clinical forensic medicine involves corroboration and cooperation with the medical management so that the crucial evidence is not lost.

REFERENCES

1. Sharma B, Arora A, Singh K, Singh H, Kaur P. Drug abuse: Uncovering the burden in rural Punjab. J Family Med Prim Care. 2017 Jul-Sep;6(3):558-562.
2. Oberoi, S.S. & Aggarwal, K.K. & Bhullar, D.S. & Aggarwal, Akash & Walia, Didar & Singh, Satinder. (2012). Profile of assault cases in Patiala. Journal of Punjab Academy of Forensic Medicine and Toxicology. 12. 17-21.
3. Kong V, Cheung C, Buitendag J, Rajaretnam N, Xu W, Varghese C, Bruce J, Laing G, Clarke D. Abdominal stab wounds with retained knife: 15 years of experience from a major trauma centre in South Africa. Ann R Coll Surg Engl. 2023 May;105(5):407-412.
4. Dajenah M, Ahmed F, Thabet A, Ghaleb K, Badheeb M, Dajenah Z. Thoraco-abdominal impalement injury with an iron rod: A case report. Int J Surg Case Rep. 2023 Mar;104:107930.
5. Alsabek M.B., Badi M.N., Khatab M. Multiple impalement injuries of the torso with two metal bars: A case report. Ann Med Surg (Lond). 2021;63.
6. Mohan R., Ram D.U., Baba Y.S., Shetty A., Bhandary S. Transabdominal impalement: absence of visceral or vascular injury a rare possibility. J. Emerg. Med. 2011;41:495–498.
7. Sharma, Mukesh & Khajja, B.S. & Jha, Satya & Mathur, G.K. & Mathur, V.N.. (2011). Forensic interpretation of injuries/wounds found on the human body. Journal of Punjab Academy of Forensic Medicine and Toxicology. 11. 105-109.
8. Neblett A, Williams NP. Sharp Force Injuries at the University Hospital of the West Indies, Kingston, Jamaica: A Seventeen-year Autopsy Review. West Indian Med J. 2014;63(5):431–5
9. Taxmann. Taxmann's Bharatiya Nyaya Sanhita (BNS) 2023 | [Diglot Edition] – Comprehensive Legal Resource featuring Bare Act | Comparative Study of BNS & Indian Penal Code | Section-wise Tables | Subject Index. Taxmann Publications Private Limited; 2024.
10. New Criminal Laws Past and Present Bharatiya Nyaya Sanhita, 2023 With Ipc 1860. N.p., OrangeBooks Publication, 2024. 235-238.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00051.6

A Case Report

Illegal Transportation of Country Made Firecrackers Blast Due to Increased Temperature and Friction Produced – A Case Report

1. **Sunil Subramanyam,** Head of Department & Professor, Department of Forensic Medicine and Toxicology, Pondicherry Institute of Medical Sciences, Puducherry, India
2. **Varun Krishna,** Assistant Professor, Department of Forensic Medicine and Toxicology, Pondicherry Institute of Medical sciences, Puducherry, India

ABSTRACT

Fireworks related deaths in India are not an unusual occurrence. The fatalities frequently occur from incorrect handling of chemicals during the manufacturing process of fireworks. This case series highlights the single tragic incidence of father and son died due to explosion of country made cracker while travelling in two wheelers with high humidity and recorded atmospheric temperature of 38 Celsius. And this case highlights the dangers of country made crackers when it is handled without any precautions for transportation.

Corresponding Author :
Dr. Varun Krishna, Assistant Professor, Department of Forensic Medicine and Toxicology, Pondicherry Institute of Medical sciences, Puducherry
E-mail: krish9t2@gmail.com
Contact : +919894117050

Article History:
Received: 10 August 2024
Received in revised form: 18 February 2025
Accepted on: 18 February 2025
Available online: 15 April 2025

Keywords: Country Made Firecrackers; Blast Injuries; Illegal Transportation; Marshall Triad.

INTRODUCTION

Humans have been using firecrackers for centuries and they are employed in many different festivals and celebrations. When used responsibly, crackers are the most fascinating and provide hours of entertainment for kids, but when handled carelessly, they may be dangerous.[1] Although firecracker injuries have been the subject of numerous case studies but there aren't many case series on this topic in the literature.[2]

However, the majority of these fatalities typically happen in the sectors that manufacture crackers, mostly as a result of incorrect handling of the chemical mixtures. Generally, unintentional burns to the hands, eyes, and face are most common in firecrackers burst. It is a rare phenomenon death arising due to cracker burst while travelling in two wheelers at public place. Here we would like to highlight a single tragic incidence of father and son died due to explosion of country made cracker while travelling in two wheelers with high humidity and recorded atmospheric temperature of 38 Celsius.

Case Report Presentation

A 36 year old man was carrying approximately 20 kg of tightly packed country made crackers in the plastic bag and was placed on footboard of two wheeler. His 7 year old son was made to sit upon the bag packed with country made crackers on the bike **(Figure 1)**. The deceased drove the two wheelers almost 8 km with crackers in a high humid temperature. There was a sudden explosion of crackers in moving two wheelers. The investigating officer arrived at the crime scene and the corpse was shifted to the Department of Forensic medicine and Toxicology, Pondicherry of medical sciences, Puducherry. And a medicolegal postmortem examination was conducted.

Case 1 (Father)

A 36-year-old man body was brought as three separate

Figure 1: CCTV footage showing victims (father & son) carrying country made cracker in two wheeler packed in a cover (Black arrow)

Figure 2: CCTV footage showing victim (father) carrying country made cracker in two wheeler (Red circle) (Figure 2a), Sudden explosion of the cracker (Figure 2b).

Figure 3: Traumatic amputation of both lower limbs seen in Case 1 (Father).

masses - one torso, and two lower limbs there were black coloured stains at several places of the body **(Figure 3 & Figure 4)**.

External Examination

1. Traumatic amputation of both lower limbs at the level of hip and partially shattered into multiple pieces attached to each other with skin tags.
2. Superficial to deep thermal burns present over patchy areas of face, front of chest, abdomen, and patchy areas over inner aspect of both upper limbs. Scalp hair, eyelashes and eyebrow hairs shows singeing.
3. Swelling deformity of middle 1/3rd of left arm with fracture displacement of left humerus at its middle one third with extravasation of blood in to surrounding tissues.
4. Laceration, measuring 12 cm x 15 cm, present over inner aspect of middle 1/3rd of right forearm with underlying fracture of both bones.

Case 2 (Son)

A 7 year old boy was brought as one separate body part torso with head and both upper limbs. There were black coloured stains at several places of the body. All the clothes were partially burned, charred, & torn in places **(Figure 5)**.

External Examination

1. Traumatic amputation of body was seen at the level of lower abdomen and pelvis with amputated lower part of the body including pelvis missing. The amputated end showed extensive laceration of the skin,

Figure 4: Traumatic amputation of both lower limbs seen in Case 1 (Father).

Figure 5: Traumatic amputation of body at the level of lower abdomen and pelvis seen in case 2 (Son).

Figure 6: Prototype of country made cracker.

underlying muscles and tissues and intestinal loops contused and protruding out of abdominal cavity.

2. Superficial to deep thermal burns present over patchy areas of face, front of chest, abdomen, and patchy areas over medial surface of both upper limbs. Scalp hair, eyelashes and eyebrow hairs shows singeing.
3. Laceration, measuring 1cm x 1cm, present over left forehead, situated1 cm above medial end of left eyebrow.
4. Laceration, measuring 4cm x 3cm, present over left parietal region, situated 6cm above upper attachment of left ear.

DISCUSSION

Because of crackers sound, sparkle, and unexpected explosion of colour, firecrackers are frequently utilized at festivals to convey the festive spirit. In UK during Halloween there is peak rise in cracker burst injuries.[3] Injuries caused by fireworks are common worldwide. Both developing and developed countries face the numerous problems regarding fireworks related injury.

At extremely high temperatures, even sparklers with negligible danger can cause burn injuries.[4] Burns were the most prevalent injury seen in firecrackers blast associated with tendon damage and amputations of limbs as a result of blast effect.[5-6] The classic triad of abrasion, contusion and punctuate lacerations are Marshall triad characteristically seen in explosion injuries.[7]

Another observation concerned lighting gunpowder gathered from dispersed or discarded pyrotechnics.[8-9] Not only may gunpowder cause injuries from fireworks, leads to tattooing.[9] As per explosive act 2008 any individual is restricted from transporting class 7 chemical (fireworks) in any vehicle containing its own means of ignition/ initiation. They also made mandatory for industrial license for the purpose of manufacture, possession, sale and transport firework chemicals outside factory premises.

The explosive act rules 2008 restricts employment and engagement of children less than 18 years of age in manufacturing, storage, sale, loading, unloading or transport of Class 7 chemicals (Fireworks).[10]

CONCLUSION

Our case report highlights one of rare manner of death occurred due to cracker burst. We assume that the tightly packed plastic bag had come in contact with the road for a few kilometers which was unnoticed by the two-wheeler rider. Because of the produced friction by coming in contact with the rough road and compression effect due to which cracker bag exploded, in which the father and son along with bike were shattered into multiple pieces.

Transportation of crackers plays an important role in accidental bursting of crackers. It must be understood that firework not only brings joy during festival and there is lot of risks involved from manufacturing crackers, transporting them with proper safety protocols and until it is sold commercially.

Conflict of Interest/Funding: None declared.

Table 1: Case of Father and Son

Internal Examination	Case 1 (Father)	Case 2 (Son)
Cranium & Spinal	Scalp & Skull: Sub scalpal hemorrhage were present over the entire scalp. A fissured fracture of length 6 cm present over left temporal bone with fracture line radiating over left anterior cranial fossa. Brain: Sub arachnoid haemorrhage was present.	Scalp & Skull: Sub scalpal hemorrhage were present over the entire scalp. A fissured fracture of length 4.5 cm present over left parietal bone. A fissured fracture of length 5cm is present over the right temporal bone. Brain: Sub arachnoid haemorrhage was present. Spinal Cord: Traumatic Fracture of body of lumbar vertebrae L4 and L5 with traumatic severing of spinal cord at this level was seen with extravasation of blood in to surrounding tissues.
Thorax	Fracture of 2nd to 3rd ribs were present over the front of chest on the right side. Fracture of sternum was noted. Right side pleural cavity contained 100 ml of blood. Multiple contusion associated with contusion were present over the right lung at several places.	Fracture of the sternum at its upper one third was present.

REFERENCES

1. Tandon R, Agrawal K, Narayan RP, Tiwari VK, Prakash V, Kumar S, Sharma S. Firecracker injuries during Diwali festival: The epidemiology and impact of legislation in Delhi. J Plast Surg. 2012;45(1):97-101.
2. Kumar R, Puttanna M, Sriprakash KS, Rathod BS, Prabhakaran VC. Firecracker eye injuries during Deepavali festival: A case series. Indian J Ophthalmol. 2010; 58(2):157-9.
3. Firework injury data year. London: Consumer safety unit (Department of Trade and Industry); 1996.
4. Berger LR, Kalishman S, Rivara FP. Injuries from fireworks. Paediatrics. 1985 May;75(5):877–82.
5. Greene MA, Joholske J. 2004 fireworks annual report: fireworks related deaths, emergency department-treated injuries, and enforcement activities during 2004.
6. See LC, Lo SK. Epidemiology of fireworks injuries: the National Electronic Injury Surveillance System, 1980-1989. Ann Emerg Med. 1994 Jul;24(1):46–50.
7. Kislov MA, Chauhan M, Krupin KN, Kildyushov EM, Zotkin DA. Forensic pathological characteristics of explosion trauma in confined space terrorist mass fatalities classified with a 3-dimensional model. Leg Med Tokyo Jpn. 2022 Sep; 58:102090.
8. Pallua N, Schneider W, Berger A. Treatment of traumatic facial tattoos caused by black gunpowder. Injury. 1993 Apr;24(4):227–30.
9. P. Devnath G, Sukumar S, Kandasamy S. Head Injury due to Cracker Blast. Arab J Forensic Sci Forensic Med. 2019 Jun 15;1(9):1268–71.
10. The Indian Explosive rules; 2008.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00052.2

A Case Report

When Artifacts Deceive: Internal Decomposition Findings Mimic Firearm Injury - A Case Report

1. **Divya Arora,** Post Graduate Resident*
2. **Ajay Kumar,** Professor*
3. **Rattan Singh,** Associate Professor*
4. **Jyoti Barwa,** Additional Professor*

* Department of Forensic Medicine and Toxicology, All India Institute of Medical Sciences, Bathinda, Punjab, India

ABSTRACT

Introduction: Artifacts are physical marks or changes that occur postmortem or as a result of the handling or preservation of the body, rather than being directly related to the injury or disease process that occurred during the individual's life. However, these artifacts can often be mistaken for antemortem injuries—wounds or trauma sustained before death.

Case Report: A 35-year-old male who left his home in anger following heated argument with his wife. A missing person report was subsequently filed by his family members at a nearby police station the next day. After 4 days of search operation carried out by the police and family members, foul play was suspected and police interrogated wife of the deceased following which dead body was recovered from the backyard of the individual's own residence. As a body decomposes, Gas formation under the skin can create blistering or ruptures that resemble the appearance of gunshot injuries (pellet injuries or Bullet injury), similarly artifacts can be present over external surface further confusing the examiner.

Conclusion: It is necessary to distinguish between actual gunshot wounds and their potential mimics to avoid misinterpretation and improve the reliability of forensic findings and enhance the accuracy of death investigations.

Corresponding Author :
Dr. Ajay Kumar, Professor
Department of Forensic Medicine and Toxicology, All India Institute of Medical Sciences, Bathinda, Punjab, India
E-mail: iamdrajay@gmail.com
Contact : +919646121575

Article History:
Received: 30 November 2024
Received in revised form: 30 December 2024
Accepted on: 30 December 2024
Available online: 15 April 2025

Keywords: Artifacts; Gunshot Mimics; Advanced Decomposition Changes; Lytic Lesions.

INTRODUCTION

Postmortem artifact is any change or a feature introduced in the dead body, that is likely to lead to misinterpretation of medico-legally significant antemortem findings.[1] They may result from handling/mishandling or preservation of the dead body, rather than being directly related to the injury or disease process that occurred during the individual's life. However, these artifacts can often be mistaken for antemortem injuries-wounds or trauma sustained before death.

Such findings can often mislead investigations into the cause, nature, or manner of death, often resulting in misinterpretations that can affect medico-legal outcomes. Postmortem artifacts are classified into several categories, including those caused by physiological changes, third-party actions, environmental factors, and other external influences.[2]

They can also be categorized based on when they occur: during resuscitative measures, between death and autopsy, or during the post-mortem examination. Understanding these artifacts is crucial for forensic professionals to differentiate between true signs of injury and those that are the result of postmortem processes or external influences.[1,2]

A variety of injuries and processes which may mimic gunshot wounds including postmortem insect activity, medical therapy, blunt force trauma, sharp force trauma and embalming artifact (trocar puncture site).[3]

Penetrating or perforating gunshot wounds to the neck and chest region are considered one of the most dangerous and life-threatening injuries[4] and hence, needs to be distinguished accurately from the artefacts on these sites. Mimics of skull entrance-type defects and skull exit-like defects have been reported because of heat-induced skull fractures.[5]

Finally, remote(old) projectiles from previous incidents can cause a great deal of confusion when evident on radiologic examination in cases where the cause of death is

related to recent firearms-related injuries.[6] We present a case report where Postmortem decomposition lytic lesions in the intercostal muscle mimics gunshot wounds.

CASE REPORT

A man aged 35 years left his home in anger following a heated argument with his wife. A missing person report was subsequently filed by other family members at a nearby police station. After 4 days of search operation carried out by the police and family members, foul play was suspected and police interrogated wife of the deceased.

She confessed to the crime and revealed that after killing by means of a knife, she buried the body in the backyard of their house. As confessed, body was recovered from the site and sent for post-mortem examination. A Board of Medical Experts consisting of two forensic experts and one pathologist was constituted for conducting post mortem examination. The post mortem on dead body of an average built, middle aged, male, with an alleged history of assault with a heavy sharp weapon was performed.

Decomposition changes were noted throughout body along with slippage of skin and loss of scalp and eyebrow hair. Face was disfigured due to changes of decomposition and eyes bulging out of the sockets and flabby, shrunken.

Loss of tooth, upper central and lateral incisors, lower canines with partial dislocation of right upper lateral canine were noted. Multiple incised wounds were present over face and neck with fracture of mandible. Incised looking Lacerated wound bone deep was present over occiput region. Organs were liquified including brain matter, pancreas, spleen and eyes. Scrotum distended due to putrefactive gases.

On reflection of the skin from the front of the chest and abdomen, multiple punched out lesions were found on right side of chest mimicking pellet injuries due to gunshot wounds **(Figure 1** and **2)**. An artifact of size 10mm in diameter was present over right chest above 6th intercostal space in mid clavicular line mimicking bullet injury **(Figure 3)**.

As the defects were same as those caused by the pellets or bullet, it gave rise to the suspicion of firearm injury. Since the skin over the lesions was decomposed and peeled off, the likelihood of a gunshot wound was possible. X-rays of the entire body were still performed to detect any firearm projectiles, pellets, or bullets.

The lesions were excised and sent for histopathology to rule out any malignant or inflammatory condition.

DISCUSSION

"Gunshot mimics" occur when non traumatic processes produce lesions or marks that resemble gunshot wounds, making it crucial for investigators to carefully differentiate between them.

Figure 4 is the gunshot entry wound in the intercostal muscleswith damage to the upper portion of the 6th rib by bullet of a rifled firearm while **Figure 5** image of the gunshot mimic of presented case.

Insect activity during decomposition can create post-mortem artifacts, such as circular, punched-out lesions

Figure 1, 2, and 3: Postmortem Images of Right Side of Chest with Visible Artifacts.

Figure 4:

Figure 5:

that resemble gunshot entry wounds. Similarly, puncture wounds from bites by scavenging animals may mimic entry or exit wounds, especially if they appear in isolation or are infested with maggots. Maggot activity itself can lead to skin defects resembling burr holes. As decomposition progresses, the combined effects of insect activity, animal interactions, arthropod activity, and environmental factors may cause the body to present with injuries that resemble gunshot wounds.[7-9] In our case there were no maggots present over the body.

Imitations of gunshot wounds may occur due to artifacts arising from decomposition and postmortem animal feeding activity (e.g., rodent predation, fly infestation, larval depositions, migration of maggots, etc.). Also, undertaker-induced trauma may lead to misinterpretation (e.g., defects caused by trocars and cannulas for injecting of embalming solutions).[15]

It is also recognized that medical therapy can occasionally result in defects that may mimic gunshot injury.[10-12] Typical examples, such as iatrogenic trauma, include associated defects by inserting a suction drain, an intercostal and intraosseous catheter, an intravenous cannula, or an intracranial pressure monitor.[13] In addition, burr holes or surgically created external openings of the gastrointestinal or urinary tract onto the body surface may also resemble entrance or exit wounds.[14] No such kind of history was given by the relatives of the deceased.

Localized punched-out lesions in the intercostal muscles are relatively uncommon but can be associated with a range of pathological conditions. The differential diagnosis of punched out lesions can be Neoplastic, Infectious, or autoimmune in nature. Neoplastic conditions like primaries in the lung, breast, melanoma, and renal cell carcinoma, can lead to lytic lesions involving soft tissues.[16] Multiple Myeloma-Although primarily a bone disease, it can extend into adjacent soft tissues, including intercostal muscles.[17] Soft Tissue Sarcomas of the intercostal muscles such as rhabdomyosarcoma or liposarcoma, may present as destructive soft tissue masses.[18-19]

Infectious Causes like Cold Abscess or Tubercular Myositis can cause localized muscle necrosis, often with adjacent rib destruction.[20-21] Similarly, pyogenic abscess (Bacterial Myositis) by staphylococcus aureus or other pathogens can cause localized muscle necrosis and appear as punched-out lesions.[22] Inflammatory and Autoimmune Causes like dermatomyositis, polymyositis or Eosinophilic Fasciitis can also cause localized muscle destruction or localized soft tissue changes, sometimes mimicking lytic lesions.[23] The histopathology report ruled out any neoplastic or inflammatory condition, no vital reaction was present and changes corresponding to decomposition were present.

CONCLUSION

This case illustrates that post-mortem artifacts are likely to depict a spectrum of injuries which may mislead the investigation. It highlights the necessity for a thorough examination of all potential factors contributing to their emergence, especially information regarding the treatment of the body prior to its arrival for post-mortem examination, in order to avoid misinterpretation during the autopsy.

REFERENCE

1. Reddy KSN. The essentials of forensic medicine and toxicology. 28th ed. Hyderabad, India: K Suguna Devi; 2001.p.407-11.
2. Aggarwal A. Textbook of Forensic Medicine and Toxicology. second edition:2021
3. Viero A, Montisci M, Pelletti G, Vanin S. Crime scene and body alterations caused by arthropods: implications in death investigation. Int J Legal Med. 2019 Jan;133(1): 307-316.
4. Singh R, Barwa J, Patra A, Peer S, Kumar A. A Medical Miracle: Surviving a Perforating Gunshot Injury to the Neck. Cureus 2025 17(1): e77713.
5. Kaliszan M, Dalewski W, Dawidowska J, Gos T, Jankowski Z. Fake gunshot wounds in the skull—post-mortem artifact caused by steel probe during police search for a missing body. Forensic Sci Int. 2020;313:110397.
6. Prahlow. Artifacts and Mimics in Forensic Pathology. Recent Advances in Forensic Medicine & Toxicology: Volume 3. 2021 May 31:223.
7. Parikh RS. Parikh's Color Atlas of Medicolegal Postmortems and Forensic Pathology. 3rd ed. New Delhi: Jaypee Brothers Medical Publishers; 2013.
8. Viero A, Montisci M, Pelletti G, Vanin S. Crime scene and body alterations caused by arthropods: implications in death investigation. Forensic Sci Int. 2018;288:133-139.
9. Tsokos M. Post mortem injuries. In: Madea B, editor. Handbook of Forensic Medicine. 1st ed. Chichester: Wiley Blackwell; 2014. p. 116-133
10. Knight B. Forensic Pathology. New York: Oxford University Press 1991:35-36 3.
11. DiMaio D J, DiMaio V J M. Forensic Pathology. Boca Raton FL: CRC Press 1993:327-345.
12. Knight B. Forensic Pathology. New York: Oxford University Press 1991:68 70
13. Dodd MJ. Terminal ballistics. A text and atlas of gunshot wounds, 1st edn. Boca Raton, FL: CRC Press, 2006
14. Safr M, Hejna P. Gunshot wounds. Prague, Czech Republic: Galen, 2010
15. DiMaio VJM. Gunshot wounds: practical aspects of firearms, ballistics, and forensic techniques. Boca Raton, FL: CRC Press, 1998
16. Watt AJ. Chest wall lesions. Paediatr Respir Rev. 2002 Dec;3(4):328-38.
17. Andrew J.B Watt. Chest wall lesions Paediatric Respiratory Reviews 2002: 3(4); 328-38
18. Sbaraglia, M., Dei Tos, A.P. The pathology of soft tissue sarcomas. Radiol med 124, 266–281 (2019).
19. Vincent Thomas-de-Montpréville, Alain Chapelier, Élie Fadel, Sacha Mussot, Elisabeth Dulmet, P. Dartevelle, Chest wall resection for invasive lung carcinoma, soft tissue sarcoma, and other types of malignancy. Pathologic aspects in a series of 107 patients. Annals of Diagnostic Pathology 2004: 8(4); Pages 198-206
20. Leonard, M.K., Jr. and Blumberg, H.M. (2017). Musculoskeletal Tuberculosis. In Tuberculosis and Nontuberculous Mycobacterial Infections, D. Schlossberg (Ed.) 2017 Pg 371-92.)
21. Vuyst, D.D., Vanhoenacker, F., Gielen, J. et al. Imaging features of musculoskeletal tuberculosis. Eur Radiol 2003:13; 1809–1819
22. Reinus, W.R. Imaging Approach to Musculoskeletal Infections. In: Bonakdarpour, A., Reinus, W., Khurana, J. (eds) Diagnostic Imaging of Musculoskeletal Diseases. 2009 Humana Press.
23. Marinos C. Dalakas, Autoimmune inflammatory myopathies, Handbook of Clinical Neurology,Elsevier, 2007 vol 86,Pages 273-301

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00053.9

A Case Report

Forensic Odontology's Role in Determining the Age of an Infanticide Victim Using Dental X-Rays – A Case Report

1. **Indah Maydila Sandi***
2. **Yudy****
3. **A Winoto Suhartono***
4. **Anthon Gamaliel Fonataba****
5. **Elza Ibrahim Auerkari***

* Forensic Odontology Specialist Study Program, Department of Oral Biology, Faculty of Dentistry, University Indonesia, Jl. Salemba Raya No. 4 Central Jakarta, 10430 Indonesia

** Department Forensic and Medicolegal, Faculty of Medicine, University Indonesia, Jl. Salemba Raya No. 6, Central Jakarta, 10430, Indonesia

ABSTRACT

Introduction: Infanticide, as mentioned in the Common Law, can be described as an intentional killing of an infant or a child under one year of age by their biological mother. The application of dental science by the forensic odontologist is vital to determine the age of the deceased infant and provide the crucial insights for justice.

Case Report: At 1:50 PM on August 28th, 2024, a deceased, unidentified female infant was brought to the forensic authority by the Cengkarang Police Station. The deceased infant was registered as 2974A/SKII/VIII/2023. There were multiple bruises found around the body and there were not any deciduous or natal teeth around the oral cavity.

Discussion: The age estimation of the infant was conducted by forensic odontologist using dental radiography using The Al-Qahtani method and the result showed that she was 34 t0 42 weeks at gestational age. The examination carried out by the forensic pathologist showed that the infant had the potential to survive outside the womb, however, there was not any sign of postnatal care.

Conclusion: The case reported a deceased, unidentified female infant, aged 34 to 42 weeks at gestational age, showing signs consistent with asphyxia.

Corresponding Author :
Dr. Elza Ibrahim Auerkari, Forensic Odontology Specialist Study Program, Department of Oral Biology, Faculty of Dentistry, University Indonesia, Jl. Salemba Raya No. 4 Central Jakarta, 10430 Indonesia
E-mail: eiauerkari@yahoo.com
Contact : +6281284392420

Article History:
Received: 07 November 2024
Received in revised form: 11 January 2025
Accepted on: 11 January 2025
Available online: 15 April 2025

Keywords: Forensic Odontology; Infanticide; Age Estimation; Dental X-ray.

INTRODUCTION

Child homicide can be described as an intentional killing of individuals under the age of 18.[1,2] This includes a range of offenses, like neonaticide, infanticide, and filicide.[3,4] Infanticide as explained in Common Law, can be defined as the act of an intentional killing of an infant or a child under one year of age by their biological mother. This act often motivated by the shame and the fear of rejection of getting discovered due to the illicit affair or an unplanned pregnancy.[5,6]

The motive for killing a newborn is often linked to shame, fear of rejection, abandonment by loved ones, and the social stigma of an illegitimate birth 90-95% cases of infant deaths in Jakarta were caused by asphyxia. The remaining 5-10% of cases result from blunt force trauma, while sharp force trauma is a rare occurrence.[1,5,7] Infanticide can occur through direct actions or neglect. Direct actions include strangulation, smothering, head trauma, multiple injuries, drowning, and poisoning.

In cases of infant strangulation, typical signs of asphyxia may be missing, likely because infants are highly vulnerable and succumb easily.[8] Asphyxia is defined as the disruption of oxygen intake and carbon dioxide elimination, which typically presents symptoms such as cyanosis (skin discoloration), petechiae (bruising), and blood fluidity. However, it should be noted that these

indicators are not exclusive to asphyxiation-related deaths.[9,10] The Indonesian Criminal Code (Articles 341-342) establishes the legal framework surrounding infanticide.[11]

In accordance with Article 341, a mother who, driven by fear of discovery following childbirth, intentionally takes the life of her child during or shortly after birth is liable to a maximum sentence of seven years imprisonment. If the act of killing was driven by the fear of being discovered, the Article 342 prescribes a more severe penalty up to nine years of imprisonment.[5,12] One of significant challenges faced by the forensic investigators on child homicides is discovering the identity of the victim and the suspect by examining the evidence.[3,13]

The role of forensic odontology is critical in this context. The application of dental science such as dental record analysis, bite marks examination and discovering any dental anomaly is important in the identification process.[14,15] There are several methods that are critical to estimate an infant's age and reconstructing the sequence of events leading to infanticide. Forensic odontologist uses the assessment of dental development stages, patterns of teeth eruption, and third molar parameters to estimate a child's age.[14–18]

There are some popular methods that are usually used by forensic odontologist to estimate a child's age, such as: Schour and Massler's modification of Kronfeld's table method which offered a detailed chronological order of tooth eruption; Al Qahtani's London Atlas that has been used to study tooth development and eruption for children and adolescents.[17]

The collaboration between forensic sciences and odontology approaches emphasized the significance of multidisciplinary techniques to resolve cases of child homicide. The thorough investigation process can be achieved by the support of forensic odontologist with advanced methodologies to estimate the age of a child or an infant to contribute to the pursuit of justice.[14,15,19]

CASE REPORT

An unidentified body of a female infant was delivered to the forensic authority by the Cengkareng Police on August 28th, 2023, at 1.50pm. The body was registered under the number 2974A/SK II/VIII/2023. The body displayed postmortem stiffness in the fingers and toes but allowed some movement. The infant, identified as female, exhibited a fair skin tone and appeared to be in a state of moderate nutritional condition. She measured 50cm in length and weighed 2450 grams.

No identifying features or birthmarks were observed on the body. Notably, bruises were observed on the buttocks, back, and thighs, with the back exhibiting a solid red discoloration that did not blanch upon pressure, indicative of lividity. A bluish-purple bruise, measuring 2cm x 0.5cm, was observed between the nose and upper lip. A purple bruise measuring 1.5cm x 0.5cm was observed on the right side of the neck, while a larger reddish-purple bruise measuring 5cm x 4cm was present on the right cheek. Both upper and lower eyelids exhibited purple bruises measuring 2cm x 0.6cm. Additionally, the lips displayed a blackish-brown discoloration. **(Figure 1)**

A comprehensive examination of the oral cavity revealed a pale appearance of the gingiva on both the upper and lower jaws, with no deciduous or natal teeth present. A fresh red lesion, measuring 2cm x 0.5cm, was observed on the left mandibular ridge, specifically located above the buccal frenulum and extending toward the central frenulum.

DISSCUSSION

In forensic science, human age estimation, particularly through dental analysis, is crucial. The small amount of variability on teeth makes them more reliable tool to estimate the age of an individual compared to the skeletal indicators. The primary and permanent dentition stages are developing in a consistent sequence, starting with the sixth week of gestation to the early adulthood period. This chronological process of tooth development can be used as a key tool for forensic identification.

Al-Qahtani developed the Atlas London method to estimate the age of an individual based on dental radiographs. This method was developed using data from white populations and Bangladeshi populations in London and has been widely adopted in diverse populations. This atlas analyses the relationship between alveolar bone and the tooth eruptions stages. Atlas London by Al-Qahtani can be used for individuals from 23 weeks in utero until 23 years of age with simple and non-invasive method, so it does not need any specialized training. **(Figure 2)**

A periapical X-ray taken during autopsy revealed that the crowns of the permanent anterior teeth were three-quarters complete, with the maxillary cusps fully developed, suggesting an age of approximately 38 weeks in utero using the Al-Qahtani method.

The Schour-Massler atlas, however, estimated the age at

Figure 1. Oral Cavity of 2974A/SK II/VIII/2023

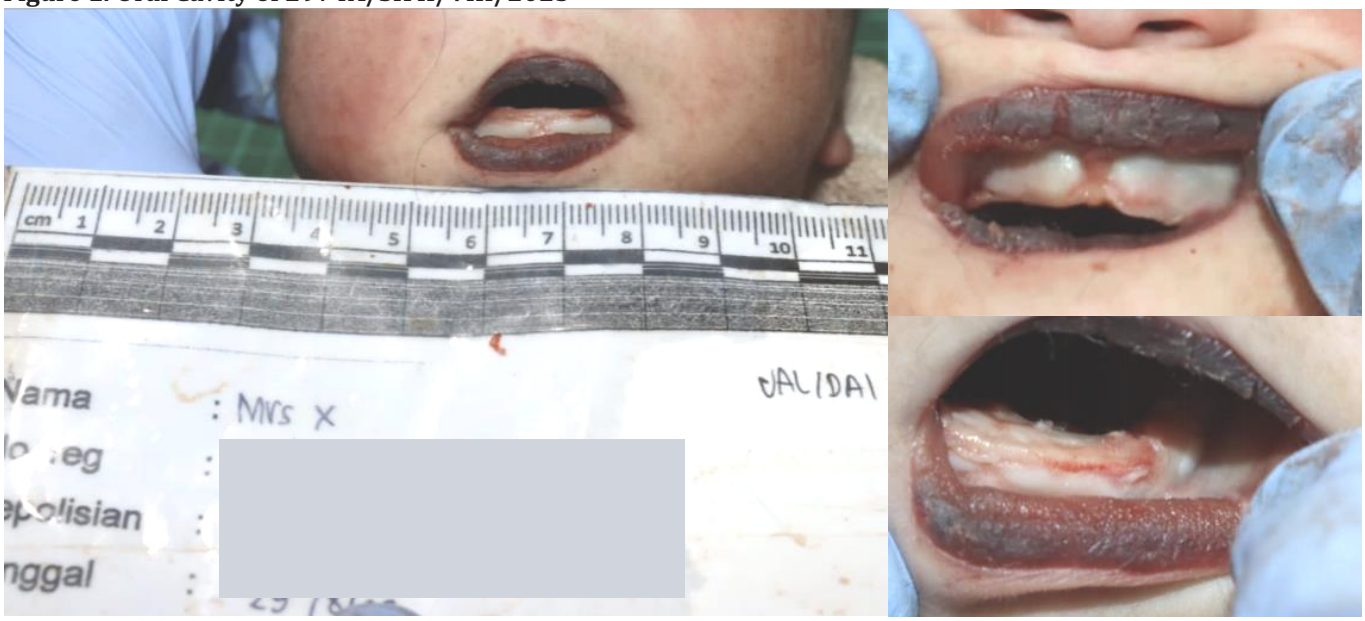
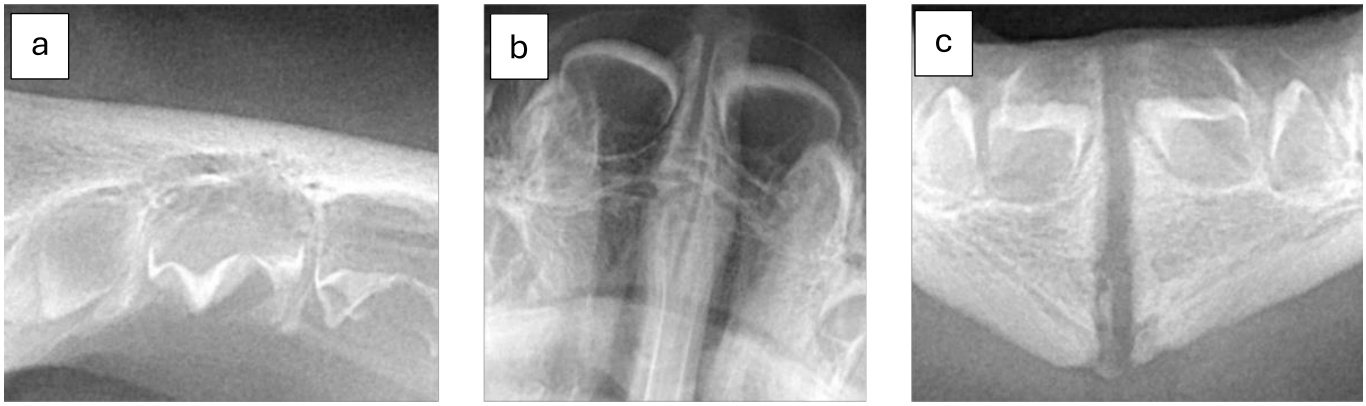


Figure 2. Radiographic images a. Left maxillary; b. Anterior maxillary; c. Anterior Mandible.



birth. Forensic pathology confirmed the body's age as 36 to 40 weeks. A positive floating lung test indicated the infant had breathed outside the womb, with no signs of care. Bruising on the face and neck, along with blackish-brown lips, pointed to asphyxia. The combination of external bruising and the presence of a shackle suggests that mechanical asphyxia, likely due to strangulation, was the cause of death.

Asphyxia can be described as the condition where there is a lack of oxygen supply in blood and tissue due to disrupted oxygen and carbon dioxide exchange during breathing, resulting in death [20].

CONCLUSSION

Forensic odontology plays a pivotal role in determining the gestational age of the unidentified infant. Dental radiographs and the application of the Atlas London method have enabled estimation of the age to be between 34 and 42 weeks. This assessment supported the forensic pathology findings, confirming the infant's viability at birth. The combined use of forensic odontology and pathology provided a thorough evaluation of physical evidence, indicating potential causes of death, including mechanical asphyxia. Through a multidisciplinary approach, forensic odontology helped establish key timelines and contributed to a deeper understanding of the case, ultimately aiding the investigation and legal processes.

REFERENCES

1. Afandi D, Hertian S, Surya Atmadja D, Riyanto Widjaja I, Riau U. Pembunuhan Anak Sendiri (PAS) Dengan Kekerasan Multipel. 2008.
2. Razali S, Jaris NH, Muuti MZ, Abdullah NC. Child Homicide Amounting to Murder in Malaysia: Descriptive Analysis of the Statistics and Causes. Front Psychol 2022;13.

3. Khanagwal VP, Sharma N, Khanna K, Giri SK, Dagar T, Autopsy Study on Feticide, Neonaticide & Infanticide, J Punjab Acad Forensic Med Toxicol 2022;22(2): 133-136.
4. Jung KH, Kim H, Lee E, Choi I, Lim H, Lee B, et al. Cluster Analysis of Child Homicide in South Korea. Child Abuse Negl 2020;101.
5. Parinduri AG, Malau O, Sanggam R, Tambunan P, Purba ED. Infanticide: A Case Report. Intertional Journal of Research Publication [Internet] 2021;72(1):157–63. Available from: www.ijrp.org
6. Pirmansyah R, Martindo M, Tri M, Akbar N. Penangggulangan Tindak Pidana Pembunuhan Bayi oleh Ibu Kandung (Infanticide) [Internet]. 2021.
8. Sharma N, Khanna K, Yadav G, Dhattarwal SK, Innocent Female Neonate has been A Victim of The Discrimination. J Punjab Acad Forensic Med Toxicol 2024;24(1), 167-169.
9. Das S, Jena MK. Homicide by a Combination of Three Different Asphyxial Methods. Egypt J Forensic Sci 2016;6(3):298–302.
10. Kumar A, Jakhar JK, Soni JP, Dhattarwal SK, Dalal SS. Homicide by Smothering: A Case Report. Medico-Legal Update 2017;17(2):41–9.
11. I Made Jaya Palguna, I Nyoman Gede Sugiarta, I Made Minggu Widyantara. Tindak Pidana Pembunuhan oleh Seorang Ibu Terhadap Bayinya Setelah di Lahirkan. Jurnal Preferensi Hukum 2022;3(2):352–7.
12. Kementrian Hukum dan HAM. Criminal Code. Central Jakarta: 2021.
13. Ambica K, Subhedar A. Homicide Potrayed as Natural Death: A Case Report. Report Indian Journal of Forensic Medicine and Toxicology [Internet] 2023;17(4).
14. Kurniawan A, Chusida A, Atika N, Gianosa TK, Solikhin MD, Margaretha MS, et al. The Applicable Dental Age Estimation Methods for Children and Adolescents in Indonesia. Int J Dent2022;2022.
15. Emam NM. Role of Forensic Odontology in Identification of Persons: A Review Article. cureus 2024 Mar 20;16(3):e56570.
16. Ata-Ali J, Ata-Ali F. Forensic Dentistry in Human Identification: A review of The Literature. J Clin Exp Dent 2014;6(2).
17. Chaudhary R, Doggalli N. Commonly Used Different Dental Age Estimation Methods in Children and Adolescents. International Journal of Forensic Odontology 2018;3(2):50.
18. Nambiar P, Paul G, Swaminathan D, Nadesan K. Medico-Legal Implications Of Dental Prenatal Age Estimation With Reference To A Case Report. Ann Dent 2000;7(1):46-50.
19. Kurniawan A, Chusida A, Satigi LV, Romadhoni AD, Liandro MR, Margaretha MS, et al. Dentist's Role and Responsible in Identification and Investigation. Indonesian Journal of Dental Medicine 2021;4(2):36.
20. Karmakar SN, An Atypical Case of Homicide by Three Different Methods of Mechanical Asphyxia. J Punjab Acad Forensic Med Toxicol 2022;22(2): 158-161.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00054.5

A Case Report

Rare Bilateral First Rib Fracture in a High-Speed Collision - A Case Study

1. **Harnam Singh,** Professor and Head, Forensic Medicine Department, Muzaffarnagar Medical College, Muzaffarnagar, Uttar Pradesh
2. **Akash Deep Aggarwal,** Professor and Head, Forensic Medicine Department, Government Medical College, Patiala, Punjab

ABSTRACT

This paper presents a rare case of bilateral first rib fractures following a high-speed motor vehicle collision. The case discusses the clinical presentation, diagnostic findings, and management, emphasizing the rarity and potential complications of such injuries. First rib fractures are often associated with significant force and can result in severe complications, though this case demonstrated an uneventful recovery.

Corresponding Author :
Dr. Akash Deep Aggarwal, Professor and Head,
Forensic Medicine Department, Government Medical College, Patiala, Punjab
E-mail: toakashdeep@yahoo.com
Contact : +919815652621

Article History:
Received: 04 January 2025
Received in revised form: 05 January 2025
Accepted on: 05 January 2025
Available online: 15 April 2025

Keywords: Bilateral First Rib Fracture; Blunt Trauma; Motor Vehicle Collision; Cervical Spine Pain; Thoracic Trauma.

INTRODUCTION

Rib fractures are among the most common injuries in traffic accidents, occurring in up to 60% of cases.[1] The specific location of rib fractures serves as an important indicator of associated injuries. Rib fractures are typically categorized into three patterns based on their location: Firstly, Fractures of the first rib and those of the second to fourth ribs; Secondly, Fractures of the fifth to ninth ribs; and thirdly, Fractures of the 10th to 12th ribs.[2]

This classification highlights the unique pathophysiology and associated morbidity of each pattern. Fractures of the first rib, in particular, are rare due to its protected position behind the clavicle and are often indicative of severe trauma.

Case History

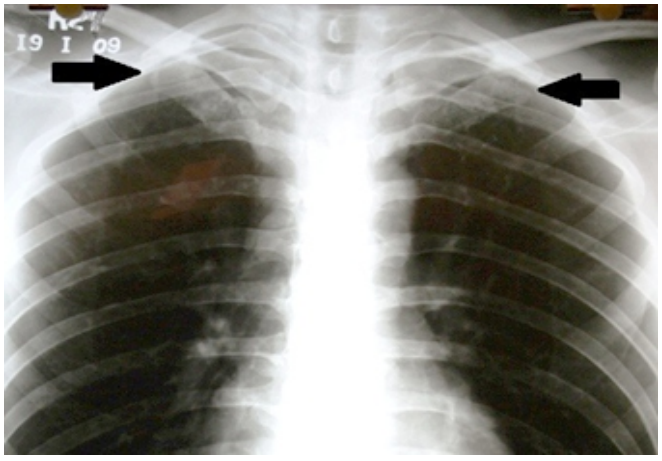
A 38-year-old thin, lean male was involved in a high-speed (approximately 70 km/h) sideways motor vehicle collision on a foggy night. The vehicle, after colliding with an unknown vehicle, struck a tree and was declared a total wreck. The patient was wearing a standard diagonal/lap seat belt restraint at the time.

Following the accident, he experienced momentary loss of consciousness and was extricated from the car, found trapped between the seat and steering wheel. At the local hospital, minor abrasions were noted, and no significant injuries were detected. He was discharged after evaluation, which showed, Glasgow Coma Score (GCS) of 15; spontaneous breathing and hemodynamic stability; no neck, chest, or spinal trauma and no neurological deficits

Two days post-accident, the patient reported increasing pain in the cervical spine, neck, and right shoulder. Examination revealed tenderness in the right supraclavicular fossa, but no neurological deficits in the shoulder or arm.

Chest radiography demonstrated bilateral first rib fractures with no other abnormalities **(Figure 1)**. There was no evidence of pneumothorax clinically or radiographically. He was prescribed rest and supportive

Figure 1: X-Ray Chest Showing Bilateral First Rib Fracture



treatment, with an uneventful recovery. Pain persisted for two months before complete resolution.

DISCUSSION

The first rib is seldom fractured due to its protected position beneath the clavicle. When fractured, it is often associated with severe trauma and potential complications involving the brachial plexus or subclavian vessels. Historically, first and second rib fractures have been linked to head and facial injuries more frequently than other rib fractures.[2]

Direct or indirect trauma, whiplash mechanisms, or seat belt restraints have been implicated.[3] Studies also highlight that trauma severity often correlates with the occurrence of first rib fractures, as indicated by recent reviews emphasizing its association with high-energy mechanisms.[4–6] Fractures of ribs 1-3 may signal associated injuries to major vessels and nerves, including the brachial plexus and subclavian vein.

Advanced imaging techniques are critical in detecting subtle vascular injuries.[7] Angiography or arteriography is advised in stable patients with suspected vascular compromise or brachial plexus injury. Contemporary evidence suggests the inclusion of CT angiography as a frontline diagnostic tool for assessing vascular injuries in rib fractures.[8]

Isolated first rib fractures are uncommon and are often secondary to muscular avulsion rather than direct trauma. They can also result from high-velocity mechanisms, as in this case, where the force distribution from the seat belt may have contributed. Most cases present with pain, though rare complications such as Horner Syndrome have been reported.[9–11]

A PubMed search reveals that about 35 cases of bilateral first rib fractures have been reported globally, further highlighting the rarity of this injury.[1,3,4,7] Each case underscores the importance of a detailed diagnostic approach and close monitoring for potential complications such as vascular injuries or thoracic outlet syndrome.

The present case highlights the importance of recognizing the potential severity of first rib fractures, despite the absence of initial clinical or radiographic findings. Early and comprehensive assessment, including imaging, is crucial for detecting subtle injuries and preventing complications. Emerging treatment strategies, including rib fixation and multimodal pain management, show promise in improving outcomes in rib fracture cases, especially those with significant trauma.[4,5,12]

CONCLUSION

This case demonstrates the clinical relevance of bilateral first rib fractures as indicators of significant trauma. Despite their rarity, timely diagnosis and management are essential to prevent complications.

Advances in imaging techniques and treatment strategies are improving the outcomes for such injuries. Future research is needed to further elucidate the long-term implications and optimal management approaches for patients with first rib fractures.

REFERENCES

1. Yao L, Gong X, Li W. Bilateral first rib fractures with multi-organ complications: A case report and literature review. Heliyon. 2024 Jun 15;10(11): e31310.
2. Sandri P de A, de Almeida JC, Sandri JL. Bilateral first rib fracture in a dive with life vest. Rev Bras Ortop. 2010;45(3):302–5.
3. Chatterjee S, Dey R, Guha P, Ray R, Sinha S. Isolated traumatic bilateral first rib fracture: a rare entity. Tanaffos. 2011;10(4):60–3.
4. Strouse PJ, Owings CL. Fractures of the first rib in child abuse. Radiology. 1995 Dec;197(3):763–5.
5. Gibson TW, Carson L. Acute Thoracic Outlet Syndrome Associated with Congenital Pseudarthrosis of the First Rib: A Case Report. JBJS Case Connect. 2021 Jul 30;11(3).
6. Olkhovsky V, Gubin M, Grygorian E, Khyzhniak V, Knigavko O. Actual Problems In Forensic Medical Assessment of Trauma of The Respiratory Organs: J Punjab Acad Forensic Med Toxicol. 2021;21(2):27–32.
7. Jaiswal A, Tanwar YS, Habib M, Jain V. First rib fractures: not always a hallmark of severe trauma - a report of three cases. Chin J Traumatol. 2013;16(4):251–3.
8. Ponte-Tellechea J, Kulkarni S, Bedford AF. Isolated bilateral first rib fracture associated with aortic valve tear. Injury. 1995 Jun;26(5):353–4.
9. Karuppal R, Kumaran CM, Marthya A, Raman RV, Somasundaran S. Isolated bilateral first rib fracture associated with congenital cervical block vertebra - A case report. J Orthop. 2013;10(3):149–51.
10. Ofri A, Malka V, Lodh S. Horner's syndrome in

traumatic first rib fracture without carotid injury; review of anatomy and pathophysiology. Trauma Case Rep. 2017 Apr;8:1–4.

11. Yasumura H, Tao K, Imada R, Yamashita Y, Tateishi N, Kinjo T. Horner's syndrome caused by the first rib fracture sustained during coronary artery bypass grafting: a case report and literature review. Gen Thorac Cardiovasc Surg Cases. 2024 Sep 10;3(1):41.
12. Chapman J, Congdon P, Shaw S, Carter YH. The geographical distribution of specialists in public health in the United Kingdom: is capacity related to need? Public Health. 2005 Jul;119(7):639–46.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00055.1

A Case Report

Skin Lesion Mimicking a Ligature Mark A Case Report

1. **Anjalika Gill,** Junior Resident*
2. **Ravdeep Singh,** Associate Professor*
3. **Rajiv Joshi,** Professor and Head*
4. **Karan Pramod,** Assistant Professor, Department of Forensic Medicine, Christian Medical College, Ludhiana, Punjab.

*Department of Forensic Medicine, GGS Medical College, Faridkot, Punjab, India

ABSTRACT

Introduction: Multiple skin disorders that produce lesions or patterns that mimic injuries with no present or past medical records pose a challenge to forensic experts. A systematic approach to distinguishing between mechanical injury and skin disease leads to an unnecessary panel of forensic investigations, a delay in formulating the actual cause of death, and undue stress to the family of the deceased. Multiple expert opinions are required from other scientific and medical fields to conclude the investigation.

Case Presentation: A 35-year-old female brought for autopsy under suspicion of a ligature mark over her neck after an alleged quarrel with family members, was found to have no infiltration underneath on dissection, and combined opinions from histopathology, microbiology and dermatology departments prepared and revealed an unforeseen cause of death.

Conclusions: The forensic autopsy surgeon has to take multiple expert opinions at times when suspicion of foul play and unknown circumstantial evidence exists to conclude the cause of death and aid in justice.

Corresponding Author :
Dr. Karan Pramod, Assistant Professor, Department of Forensic Medicine, Christian Medical College, Ludhiana, Punjab.
E-mail: karanthekp@gmail.com
Contact : +919878987826

Article History:
Received: 11 January 2025
Received in revised form: 02 February 2025
Accepted on: 02 February 2025
Available online: 15 April 2025

Keywords: Skin Lesion; Injury; Acanthosis Nigricans; Fungal Infection; Antemortem.

INTRODUCTION

The dilemma of distinguishing between intentional injuries and pathological lesions is a common problem for forensic professionals and physicians, both in the clinician's office and in the court.[1] The job requires differentiating antemortem injuries from postmortem injuries as well as any pathological conditions of the body and skin. One such important aspect is Forensic Dermatology which specializes in the examination of skin to study patterns of injuries inflicted upon, signs of internal disease, or clues to identify the identity and habits of the deceased.[2]

The problem is being able to distinguish non-accidental injury from diseases that either produce similar signs or predispose to actual injury.[3] Different types of dermatoses can have lesions that look like non-malicious injuries. Patients who have active skin conditions or their remaining/post-injury spots can create false alarms or suspicions of burns, abuse or battery, sexual assault, or other medicolegal matters. Not being able to tell the difference can create unnecessary stress and complicate medicolegal investigations. Misdiagnosis can occur during clinical examination of patients as well as during autopsy if the morphology of the skin lesion is similar to a mechanical injury mark.[1]

Skin lesions may mimic inflicted injury to investigating personnel and lead to false interpretations while concluding about the circumstances, manner, and cause of death. We present an autopsy case where a skin disease was a falsely interpreted ligature mark by relatives and police.

Case Report

The dead body of a 35-year-old female was brought for postmortem examination to the mortuary of a tertiary care institute in north India. There was a history of sudden loss of consciousness and fits just before death. The deceased was unmarried and mentally challenged and used to live with one of her relatives. After hearing about the death of the lady, one of her neighbours called the police and alleged

mistreatment of the deceased by relatives and suspected foul play regarding the manner of death. When police inspected the dead body there was discoloration of the skin of the neck and owing to this discoloration the neighbour alleged that the lady was strangulated. Allegedly there have been multiple instances of verbal arguments over shared areas of land in the past.

On examination, it was a dead body of a well-built and nourished female. Rigor mortis was fully developed. Postmortem staining was present over the whole of back sparing areas of pressure contact. Clothes were intact and without any visible stains. There was a peculiar dark velvety band of blackish-purple discolouration of skin at the back and sides of the neck **(Figure 1 & Figure 2)**. No discoloration was present on the front of neck. On layer-by-layer dissection of the neck, there was no sign of internal injury or infiltration of blood underneath the dark band seen externally.

Figure 1: Dark Blackish-Purple Velvety Band of Skin on the Back of Neck

Figure 2: Dark Blackish-Purple Velvety Band Extending to Sides of Neck

The hyoid bone, tracheal cartilage, and thyroid cartilage were unremarkable there was no other injury on external examination. The internal organs were congested. Viscera was collected for Chemical analysis and Histopathological examination. Special consideration was given to the discoloured skin and a dissected piece of it was subjected to Dermatology examination, Histopathological examination and Microbiological examination to rule out microscopic infiltration of blood or any skin pathology or fungal disease.

The dermatology opinion sought suggested a differential diagnosis of Acanthosis Nigricans from the gross examination of skin. Microbiological examination ruled out any fungal infection of skin that could lead to this discoloration and the Histopathological examination of the skin piece revealed no infiltration of blood and also suggested a differential diagnosis of Acanthosis nigricans.

Chemical analysis of viscera was declared as negative for any poison and drugs. Surprisingly gross and histological examination of both coronary arteries revealed both lumens to be occluded with a diagnosis of severe atherosclerosis. After perusal of all findings, the cause of death was given as heart failure consequent upon severe atherosclerosis of both coronaries.

CONCLUSION

Any abnormal discolouration or abnormality may be reported as injury specially if the same is alleged. A variety of dermatological conditions that mimic physical injuries have been documented in the past. Pruritic skin conditions like Psoriasis and Lichen Planus display the Koebner phenomenon, where new lesions develop at sites of skin trauma and mimic antemortem injuries, however, the timing of development for pattern and extent would be different than the time since actual trauma.

The violaceous, polygonal papules of lichen planus may coalesce on the flexor surface of the wrists, mimicking ligature injury.[4] Herpes Zoster another painful and pruritic dermatomal eruption associated vesicles that can erode and be mistaken for linear abrasion injuries at autopsy and the subsequent scar as well can be confused with healed traumatic injuries.[1]

Ulcerating skin conditions like Pyoderma gangrenosum, ulcerated skin cancer, and decubitus ulcers may look like burns or abrasions. However, the external trauma if caused will lead to more geometric shapes with angulated borders but organic processes are more often round, arcuate, scalloped, or symmetrically distributed.[2]

Steven Johnson Syndrome (SJS), which involves less than 10% of the body surface versus Toxic Epidermal Necrolysis (TEN), which involves more than 30% area are both mucocutaneous disorders misdiagnosed as burn injuries in some cases. Both most commonly caused by idiosyncratic drug reactions involve apoptotic keratinocyte cell death, resulting in separation of the epidermis from the dermis.[5]

Conditions mimicking cigarette burns, include dermatitis, bullous impetigo, small abscesses, and other focal lesions of pyoderma. Classically appearing as circular lesions eight to ten millimetres in diameter, with a central crater surrounded by a rolled margin are the common features.

The skin of children show features that lead to wrong diagnoses of child abuse like Congenital birthmarks such as dermal melanosis (Mongolian spots), especially when they occur in body sites most often associated with abuse, like the back and buttocks. Diaper dermatitis, a type of irritant contact dermatitis, may mimic sexual abuse or burn injury in children. Anogenital warts which may occur naturally also lead to suspicion of sodomy.

Age-related changes can be confused with inflicted trauma in the elderly. Decreased skin elasticity, decreased collagen, decreased epidermal proliferation, flattened dermal-epidermal junction, vascular fragility, and weakened supporting structures all predispose aging skin to show minor trauma. Petechial haemorrhages caused pathologically as a result of increased vascular pressure, such as from coughing, emesis, and lower extremity stasis, especially in upper areas of the body may make one consider asphyxia to be the cause of death. Multiple adverse drug reactions like minocycline-induced skin hyperpigmentation have been mistaken for ecchymoses in case reports. Warfarin-induced skin necrosis can manifest as a necrotic eschar and full-thickness skin loss, most commonly seen in areas of increased subcutaneous fat such as the breasts, buttocks, thighs, and abdomen.[6]

Acanthosis nigricans (AN) is a disorder where the skin is thickened which is characterized by a dark, coarse, velvety texture, being symmetrically distributed on the neck, the axillae, antecubital and popliteal fossae, and groin folds, histopathologically characterized by papillomatosis and hyperkeratosis of the skin.[7]

In the case we have presented the skin lesion was present on the neck and it took the shape that appeared like a ligature mark. It created doubt about the cause and manner of death in the minds of the police and neighbours of the deceased. However, investigations proved that it was just acanthosis nigricans that mimicked a ligature mark and was completely unrelated to the actual cause of death which was declared as severe atherosclerosis eventually concluding the manner of death to be a natural one.

Proper history, past medical records, and an open mind towards the various possibilities behind the cause and manner of death is required by forensic experts which preliminarily includes training and education of doctors working in field. Mortuary setup in a tertiary care health centre should include various specialities in the medical board while formulating the cause of death before making assumptions on the speculations made by police or relatives, to avoid false charges against any accused and to avoid possible ill motive of the relatives to acquire monetary benefits.

Ethical Clearance and Legal/Administrative Permission: Permission from relatives of deceased in a written informed consent and college authorities was taken, respecting privacy and confidentiality, balancing potential benefits with risks, and ensuring the dignity of the deceased and their family.

Funding/Competing Interests: Nil

LIST OF ABBREVIATIONS

SJS: Steven Johnson Syndrome

TEN: Toxic Epidermal Necrolysis

AN: Acanthosis nigricans

REFERENCES

1. Asati DP, Singh S, Sharma VK, Tiwari S. Dermatoses misdiagnosed as deliberate injuries. Med Sci Law. 2012 Oct;52(4):198-204.
2. Reddy, Kalpana & Lowenstein, Eve. (2011). Forensics in dermatology: Part I. Journal of the American Academy of Dermatology. 64. 801-8; quiz 809. 10.1016/j.jaad.2010.05.050.
3. Wheeler, D. M., & Hobbs, C. J. (1988). Mistakes in diagnosing non-accidental injury: 10 years' experience. British medical journal (Clinical research ed.), 296(6631), 1233–1236.
4. Stern RS. Psoriasis. Lancet. 1997 Aug 2; 350(9074):349-53
5. Abe R. Toxic epidermal necrolysis and Stevens- Johnson syndrome: soluble Fas ligand involvement in the pathomechanisms of these diseases. J Dermatol Sci. 2008 Dec; 52(3):151-9
6. Bradford, Jordan; Mark, Lawrence A.; Prahlow, Joseph A. (2013). Dermatological Conditions Mimicking Trauma. Academic Forensic Pathology, 3(4), 468–476. doi:10.23907/2013.057
7. Phiske MM. An approach to acanthosis nigricans. Indian Dermatol Online J. 2014 Jul;5(3):239-49.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00056.8

A Case Report

Evaluating the Proposal to Ban Mercury Thermometers in Pediatric Care: A Case Study

1. **Sahil Thakral,** Assistant Professor, Department of Forensic Medicine and Toxicology, Dr. S.S. Tantia Medical College Hospital and Research Center, Sri Ganganagar, Rajasthan.
2. **Ajay Kumar,** Professor*
3. **Akhilesh Pathak,** Professor and Head*
4. **Treasa James,** PG Resident*

* Department of Forensic Medicine and Toxicology, All India Institute of Medical Sciences, Bathinda, Punjab, India

ABSTRACT

Mercury, a well-known toxic heavy metal, exists in various forms, including organic, inorganic, and elemental mercury. There is growing concern that India could potentially become a focal point for mercury poisoning. Mercury's shiny, silver appearance often piques children's curiosity and playfulness when they encounter it in thermometers. In 2013, WHO and Health Care initiated a campaign to remove mercury from medical measuring devices by 2020. Despite the Minamata Convention's allowance for limited use until 2030 under special circumstances, both organizations stressed the need for a complete phase-out due to significant health risks. A 7-year-old boy was brought to the hospital's emergency room due to a cough and breathing difficulties. He had a recent history of fever and, while at a local hospital, accidentally ingested mercury and a piece of glass when a mercury thermometer broke in his mouth. A chest x-ray and x-ray abdomen confirmed the presence of radiopaque metallic particles in the body. Mercury thermometer in healthcare devices poses a high toxicity risk to children. Ensuring that devices containing mercury are kept away from children is crucial for their safety. Phasing out mercury thermometers and promoting the use of infrared thermometers is recommended.

Corresponding Author :
Dr. Ajay Kumar, Professor
Department of Forensic Medicine and Toxicology, All India Institute of Medical Sciences, Bathinda, Punjab, India
E-mail: iamdrajay@gmail.com
Contact : +919646121575

Article History:
Received: 24 November 2024
Received in revised form: 13 December 2024
Accepted on: 13 December 2024
Available online: 15 April 2025

Keywords: Healthcare; Mercury; Pediatric; Thermometer.

INTRODUCTION

Mercury (Hg) is a unique silvery-white heavy metal that remains in a liquid state at room temperature. It is commonly referred to as quicksilver or hydrargyrum and possesses distinctive characteristics with an atomic number of 80, it stands as the only metal observed in a liquid form under standard conditions of temperature and pressure.[1] On a global scale, India ranks as the second-largest contributor of mercury emissions into the environment, estimated at approximately 144.7 tonnes of Hg per year.[2]

Mercury, as a metal, serves various purposes such as extracting gold and silver, acting as a catalyst in chlor-alkali production, being employed in manometers for pressure measurement and control, utilized in thermometers, electrical switches, fluorescent lamps, and dental amalgam fillings. Additionally, chemical compounds of mercury are employed in batteries, paints, pharmac-eutical antiseptics, and as reagents in laboratory settings.[3] Elevated levels of mercury have been documented in industrial settings, notably in thermometer factories and dental clinics. Unfortunately, the potential health risks of mercury exposure and its impact on the industrial work environment have not been given due attention. Hazardous work practices and inadequate waste management conditions persist in numerous mercury-related industries.[4]

Examination of water, sediment, and fish samples collected from Kodai Lake in the tourist destination of Kodaikanal, India, revealed increased mercury levels. These elevated levels persisted even four years after the cessation of mercury emissions from a thermometer factory that had been in operation for 18 years before its closure in 2001.[5] Children are deemed particularly susceptible to environmental hazards, with specific developmental stages during which exposure to chemical, physical, or biological agents can lead to adverse health effects.[6,7,8]

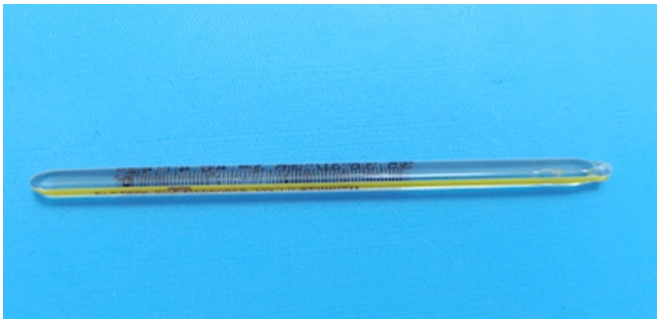
The utilization of glass mercury thermometers has the potential to cause pediatric injuries, particularly in

children under the age of 4.[9] Healthcare facilities are significant contributors to mercury emissions into the atmosphere, primarily through the incineration of medical waste. Efforts are underway to reduce mercury content in products and phase out items containing mercury. Within the healthcare sector, alternatives are being adopted to replace mercury-containing thermo-meters and sphygmomanometers.[10]

Case Presentation

A 7-year-old boy was admitted to the hospital's emergency room due to a persistent cough and breathing difficulties. He had recently experienced a fever and, while seeking care at a local hospital, accidentally ingested mercury and a piece of glass when a mercury thermometer broke in his mouth. The patient had no history of acute or chronic gastrointestinal or other systemic conditions **(Figure 1)**.

Figure 1: The Broken Mercury Thermometer.



Upon physical examination, the child appeared conscious, cooperative, and oriented.

Assessments of the respiratory and cardiovascular systems revealed no abnormalities, and the abdomen was soft and non-distended with no signs of tenderness, rebound tenderness, or hepatosp-lenomegaly. Neurological and other system examinations showed no issues. Blood tests, including a full blood count, electrolytes, and tests of renal and hepatic function, all returned normal results (e.g., Wbc: 10,100/µL, Sgot: 28 U/L, Sgpt: 15 U/L, Urea: 19.9 mg/dl, creatinine: 0.39 mg/dl).

A Chest X-ray and X-ray abdomen confirmed the presence of radiopaque metallic particles in the body **(Figure 2)**. The patient was closely monitored through biochemical, clinical, and radiological assessments. Throughout the monitoring period, clinical signs and biochemical parameters remained within normal ranges. The child was subsequently discharged with a thorough explanation of potential danger signs.

Figure 2: Xray Showed The Presence Of Radiopaque Metallic Particles

DISCUSSION

Mercury, a widely recognized toxic heavy metal, takes on different forms, encompassing organic, inorganic, and elemental states. Of particular concern is the burgeoning apprehension that India might be on the verge of becoming a potential hotspot for mercury poisoning. The gleaming, silver allure of mercury often incites the inquisitiveness and playful exploration of children, especially when they come into contact with it through devices such as thermometers. A case study conducted by Raghavendra K et al. in 1972 described the distressing case of a 17-day-old male infant, the firstborn child of non-consanguineous parents, who had been exclusively breastfed.

The child was brought to the medical facility due to a series of concerning symptoms, including the excretion of a shiny, metallic-like substance in the urine for four days, followed by vomiting and chemical burns on the lips, chin, cheeks, and oral cavity just one hour before admission.[11] Blumenthal's (1992) study delved into the consideration of whether mercury thermometers should be banned, primarily addressing the hazards and risks associated with cross-infection stemming from the use of mercury

thermometers. The study observed instances where thermometers broke and were retained in the rectum, leading to rectal perforation and peritonitis. Although Blumenthal's study did not report cases of glass breakage in the mouth resulting in poisoning from swallowed or aspirated mercury, our current case study involves the breakage of a mercury thermometer with the child accidentally swallowing a portion of the mercury.[12] Uysalol et al. (2016) reported a case titled 'A 3-year-old male child ingested approximately 750 grams of elemental mercury.'

The child had ingested 55cc of mercury from a 60cc bottle that had been in the possession of his uncle, who worked at a silver processing company. Remarkably, the child remained asymptomatic upon admission to the hospital after 2 days. Blood mercury levels were measured at 91 micrograms/L. Radiological investigations, including an X-ray of the abdomen, revealed the presence of dense particles in the intestines, which significantly decreased as the child was provided with a diet rich in fiber. The child defecated mercury particles spontaneously each day. In our study, although blood mercury levels were found to be normal, X-ray results exhibited similar findings.[13]

Gungor et al. (2019) conducted a study on the characteristics of mercury poisoning in a group of 29 pediatric cases who had been exposed to elemental mercury in a high school chemistry laboratory in Turkey. In this study, patients with a blood mercury level exceeding 10μg/L or a urine mercury level exceeding 15μg/L were diagnosed with mercury poisoning. The treatment provided to these patients included 2, 3-dimercaptopropane sulfonic acid or D-penicillamine.

Among the 29 children who were admitted to the hospital with mercury poisoning, the median duration of exposure was 58 minutes, ranging from 15 to 120 minutes. Notably, 19 (65.5%) of these children exhibited normal physical and neurological examination results. The most commonly reported symptom was headache, and the most frequent neurological abnormality observed was partly dilated or dilated pupils, present in 9 (31%) of the children.[14]

Balachandran et al. (2022) published a case series that included the report of a 3.5-year-old girl weighing 13kg. She was taken to the emergency department of a tertiary care center with suspected mercury ingestion. Approximately thirty minutes before her presentation, the child had accidentally bitten into a mercury thermometer, causing it to break and leading to a spill of metallic mercury on her clothing and the floor. Concerned about potential ingestion, her parents sought immediate emergency care. Chest and abdomen X-ray imaging unveiled radiodense material in the stomach area, and subsequent serial radiographs indicated the distal passage of this radiodense material. This case closely resembled one previously reported by our team.[15]

In response to these concerns, in 2013, the World Health Organization (WHO) and the organization Health Care initiated a concerted effort to eliminate the use of mercury in medical measuring devices by the year 2020. Even though the Minamata Convention provides a provision for limited mercury use in such devices until 2030 under specific circumstances, both organizations have emphatically underscored the imperative for a comprehensive phase-out.

This urgency is rooted in the substantial health risks associated with mercury exposure and its potential adverse impact on public health and the environment. This concerted action aims to mitigate these risks and promote safer alternatives for medical applications. This case study of a 7-year-old boy who was rushed to the hospital's emergency department due to a persistent cough and breathing problems. He had previously experienced a fever and, during a visit to a local clinic, inadvertently ingested mercury and a glass fragment after a mercury thermometer broke in his mouth.

Subsequent chest and abdominal X-rays confirmed the presence of radiopaque metallic particles in his body. Mercury thermometers used in healthcare devices are a significant cause for concern due to their high toxicity, particularly when it comes to the vulnerability of children. These devices can pose a substantial risk to the well-being of children who may come into contact with them. Therefore, it is of paramount importance to ensure that devices containing mercury are stored and handled in a manner that keeps them out of reach of children.

This protective measure is essential to safeguard their health and prevent any inadvertent exposure to this toxic substance. Furthermore, it is strongly recommended to gradually phase out the use of mercury thermometers in healthcare settings. This not only reduces the potential risks associated with accidental breakage but also aligns with the broader global efforts to reduce mercury usage and its environmental impact. In place of mercury thermometers, the adoption of safer alternatives such as infrared thermometers is encouraged.

Infrared thermometers not only offer precision and ease of

use but also eliminate the risk associated with mercury exposure, making them a more responsible choice for healthcare facilities aiming to prioritize the safety of their patients, particularly children.

CONCLUSION

Mercury thermometers in healthcare pose a substantial risk, especially for children. Safeguarding their well-being necessitates secure storage, ensuring these devices are out of reach. Gradually phasing out mercury thermometers in healthcare settings is highly recommended. This proactive approach aligns with broader efforts to reduce mercury usage, ensuring the safety of patients, particularly children.

REFERENCES

1. Senese F. Why is mercury a liquid at STP. General Chemistry Online at Frostburg State University.. Retrieved May. 2007 Apr;1.
2. Sharma BM, Bharat GK, Šebková K, Scheringer M. Implementation of the Minamata Convention to manage mercury pollution in India: challenges and opportunities. Environmental Sciences Europe. 2019 Dec;31:1-2.
3. Rustagi N, Singh R. Mercury and health care. Indian journal of occupational and environmental medicine. 2010 May 1;14(2):45-8.
4. Srivastava RC. Guidance and Awareness raising materials under new UNEP mercury Programs. Center for Environmental Pollution Monitoring and Mitigation, Nirala Nagar, India. 2008.
5. Karunasagar D, Krishna MB, Anjaneyulu YA, Arunachalam J. Studies of mercury pollution in a lake due to a thermometer factory situated in a tourist resort: Kodaikkanal, India. Environmental pollution. 2006 Sep 1;143(1):153-8.
6. Jarosinska D, Gee D. Children's environmental health and the precautionary principle. International journal of hygiene and environmental health. 2007 Oct 31;210(5):541-6.
7. Selevan s, kimmel c, mendola p. Windows of susceptibility to environmental exposures in children (excerpt from children's health and the environment: a global perspective). Everyday Environmental Toxins: Children's Exposure Risks. 2015 Mar 16:23.
8. Weiss B. Vulnerability of children and the developing brain to neurotoxic hazards. Environmental Health Perspectives. 2000 Jun;108(suppl 3):375-81.
9. Aprahamian N, Lee L, Shannon M, Hummel D, Johnston P, Kimia A. Glass thermometer injuries: it is not just about the mercury. Pediatric emergency care. 2009 Oct 1;25(10):645-7.
10. Bose-O'Reilly S, McCarty KM, Steckling N, Lettmeier B. Mercury exposure and children's health. Current problems in pediatric and adolescent health care. 2010 Sep 1;40(8):186-215.
11. Raghavendra K, Suresh Babu MT, Basavanthappa SP, Srinivasa V, Srinivasa Murthy RP, Nikhil PT. An Unusual Case of Acute Mercury Poisoning in a Neonate. Am J Med. 1972;53:219-32.
12. Blumenthal I. Should we ban the mercury thermometer? Discussion paper. Journal of the Royal Society of Medicine. 1992 Sep;85(9):553-5.
13. Uysalol M, Parlakgül G, Yilmaz Y, Citak A, Nedret UZ. A 3 year-old male child ingested approximately 750 grams of elemental mercury. Balkan Medical Journal. 2016 Jul 1;33(4):467-9.
14. Güngör O, Özkaya AK, Kirik S, Dalkiran T, Güngör G, Isikay S, Davutoglu M, Dilber C. Acute mercury poisoning in a group of school children. Pediatric emergency care. 2019 Oct 1;35(10):696-9.
15. Balachandran A, Jambugulam M, George K, Inturi S, Padankatti S, Alwan A, Mathew SS, Nellickal AJ, Zachariah A, Ralph R. Clinical Spectrum of Mercury Poisoning in India: Case-series from a Poison Control Center. The Journal of the Association of Physicians of India. 2023 Feb 1;71(2):11-2.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00057.4

A Case Report

Sudden Unexpected Deaths in Epilepsy with Concomitant Neuropathologies – A Case Series

1. **S. Janani,** Associate Professor, Forensic Medicine, KAP Vishwanathan Government Medical College, Trichy
2. **A. Gokulakrishnan,** Associate Professor, Forensic Medicine, Government Medical College, Nilgiris
3. **S.Balasubramanian,** Professor and Head, Forensic Medicine, Government Stanley Medical College, Chennai
4. **Mohammed Ghouse,** Post-Graduate, Forensic Medicine, Government Stanley Medical College, Chennai

ABSTRACT

Sudden death is one of the global health problems. There is no uniform definition to diagnose sudden death. According to the World Health Organization, (ICD 10) any death which is sudden, non-violent and not otherwise explained, occurring less than 24 hours from the onset of symptoms is classified as sudden death.[1] The most common cause of sudden deaths is cardiac cause. According to ICD 11 (for Morbidity and Mortality statistics) Sudden unexpected death in epilepsy (SUDEP) is a category of death in people with epilepsy in whom death occurs under benign circumstances and in the absence of known structural causes of death (i.e. not due to drowning, injury, intoxication and other internal or external factors).[2] Sudden deaths, more so in younger age group is common in individuals with epilepsy. Epilepsy, is defined according to the International League Against Epilepsy (ILAE), as at least two unprovoked seizures occurring more than 24 h apart or a single unprovoked seizure, with a recurrence risk of at least 60% over the next 10 years or an identifiable epileptic syndrome.[3] About 80 % of individuals with epilepsy are estimated to be living in lower and middle-income countries.[4] Sudden unexpected death in epilepsy (SUDEP) is a category of death in people with epilepsy occurring in the absence of a known structural cause of death and is most likely multifactorial with regard to mechanisms and circumstances.[5] The authors report autopsy findings seen in a series of sudden deaths in known epileptic individuals.

Corresponding Author :
Dr. S. Janani, Associate Professor,
Forensic Medicine,
KAP Vishwanathan Government Medical College, Trichy
E-mail: janyraj@gmail.com
Contact : +917338974399

Article History:
Received: 21 November 2024
Received in revised form: 11 January 2025
Accepted on: 11 January 2025
Available online: 15 April 2025

Keywords: Sudden Death; Epilepsy; Apnea; Arrhythmia; SUDEP.

INTRODUCTION

The National Crime Records Bureau (NCRB) defines sudden death as any unexpected death that is instantaneous or occurs within minutes from any cause other than violence. (for example heart attack, brain hemorrhage, etc.)[6] In the Annual statistics released for the year 2022, it was found that sudden deaths accounted for 13.4% of the total number of accidental deaths. Heart attack was the most common cause of death.

The state Maharashtra had the greatest number of cases followed by Kerala and Karnataka.[6] Even though sudden deaths are predominantly attributed to cardiac causes, deaths due to gastro-intestinal, pulmonary and neurological causes is not uncommon. We report a series of sudden deaths in individuals with epilepsy that were subjected to autopsy at Government Stanley medical college hospital during the period 2022-2023.

Case 1

A 30-year-old male, with history of epilepsy and hypertension on irregular medications, with no proper documentation was brought dead by his family members to the emergency. His family witnessed him having a generalized tonic-clonic seizure with eye-rolling and brought him to the nearest tertiary care hospital, where he was declared dead on arrival. At autopsy after inquest, hemorrhage was observed at the midbrain-pons area with generalized cerebral edema. **(Figure 1)**

Case 2

A 46-year-old male, with a history of epilepsy since childhood and on regular medication, was found unconscious and brought dead to the casualty. He had also been diagnosed with Parkinson's disease in the recent past and was on medications. Autopsy revealed no significant anomaly, except for loss of pigmentation in substantia nigra. **(Figure 2)**

Figure 1:

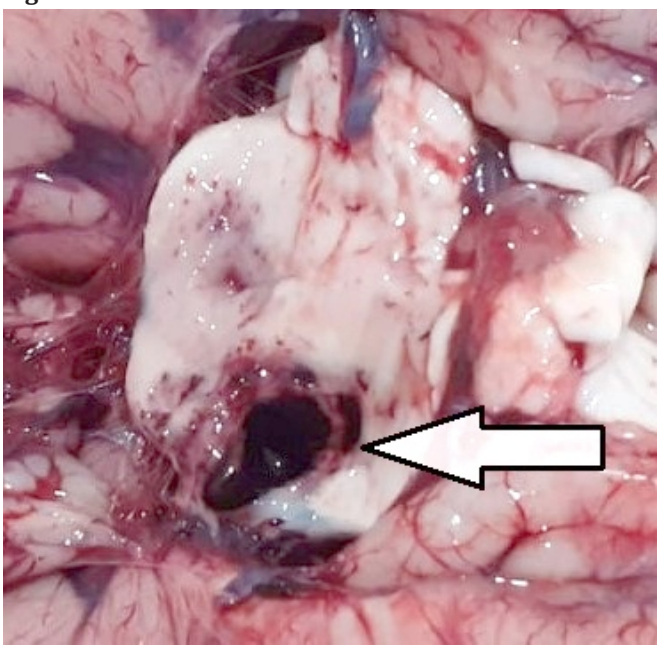
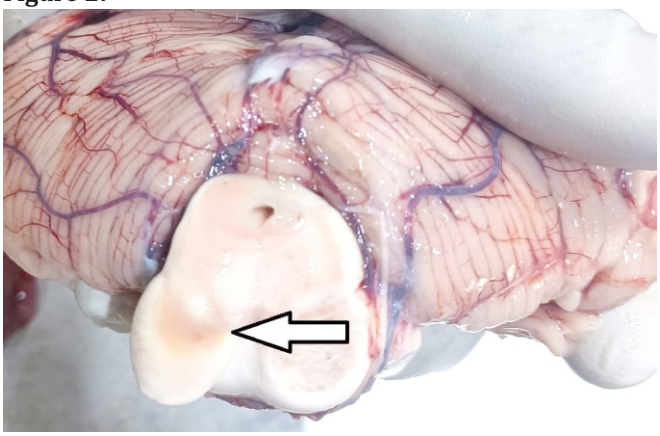


Figure 2:



Case 3

A 34-year-old married female on anti-epileptic medication was found dead at home. She was last seen alive a few hours earlier by a neighbour and she had no significant recent medical history and had been consistent with her medications. Autopsy revealed isolated intraventricular hemorrhage, predominantly affecting the lateral ventricles with no accompanying parenchymal lesions. **(Figure 3)**

Case 4

A 38-year-old female on anti-epileptic medication was brought to the emergency in an altered sensorium following an episode of a generalized seizure. She suffered a cardiac arrest and could not be revived. Autopsy revealed a unilateral intracerebellar hemorrhage with otherwise normal brain parenchyma. **(Figure 4)**

Case 5

A 49-year-old man with a history of head trauma 6 years ago was brought dead to the casualty. He had sustained a traumatic brain injury in a road accident, had intermittent seizures, was lost to follow-up, and had been on irregular medications. Autopsy showed diffuse scarring in the left temporal lobe with no recent parenchymal lesions. **(Figure 5)**

Figure 3:

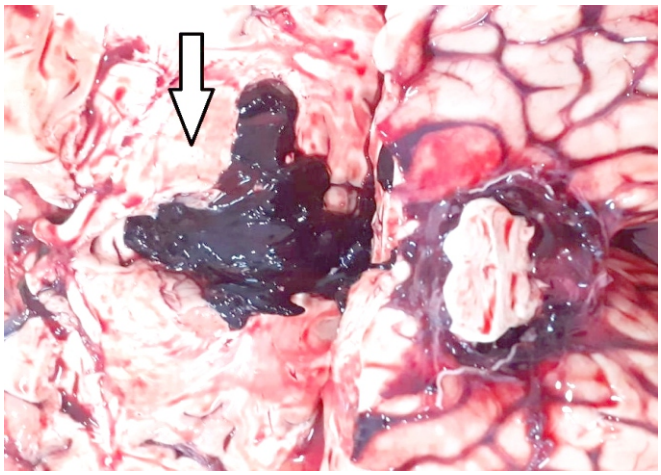


Figure 4:

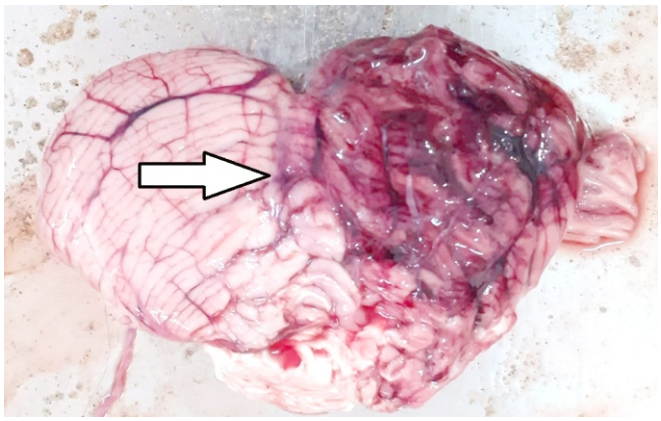
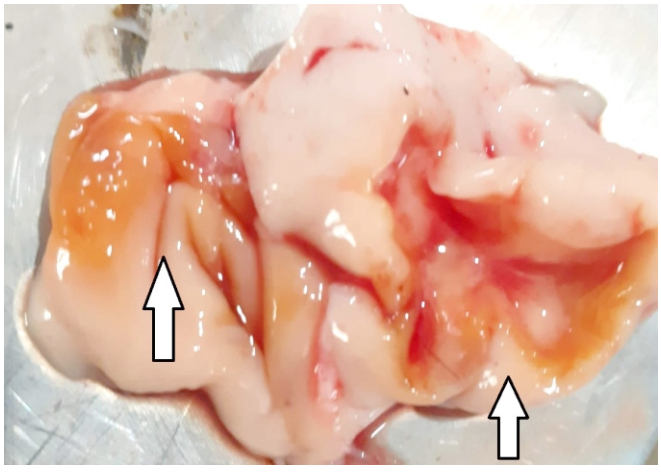


Figure 5:



Chemical analysis was negative in all the above cases, and histology confirmed the gross examination findings.

DISCUSSION

Sudden death is a leading cause of mortality worldwide, with coronary artery disease being the primary contributor.[7,8] Developing countries like India also report an increasing number of sudden deaths, as highlighted by annual statistics.[6] Sudden deaths due to non-cardiac causes may result from neurological, gastrointestinal, renal, respiratory, or metabolic conditions.[9-11]

Epilepsy is a common neurological condition affecting approximately 50 million people globally, according to the WHO. While there are similarities in clinical presentations of epilepsy across developing and developed countries, significant variations exist in diagnosis, investigation, and management. These differences can be attributed to demographics, sociocultural factors, economic conditions, and varying etiologies.[12,13] Individuals with epilepsy have a shorter life expectancy compared to the general population, often due to comorbidities, a higher risk of injuries during seizures, status epilepticus, and sudden unexpected death in epilepsy (SUDEP).

SUDEP has been defined as a sudden and unexpected death, which is either witnessed or unwitnessed. Deaths that cannot be attributed to trauma or drowning death in individuals with epilepsy, with or in the absence of a seizure, excluding documented status epilepticus. The definition also excludes toxicological or anatomical cause on postmortem examination.[5] Unified definitions of SUDEP, proposed in the 1990s, classify it into Definite SUDEP, Definite SUDEP Plus, Probable SUDEP, Possible SUDEP, and Near-SUDEP.[5,14]

Definite SUDEP involves sudden, non-traumatic, and non-drowning death in individuals with epilepsy, excluding status epilepticus, where postmortem examination reveals no clear cause. Definite SUDEP Plus includes cases where an additional condition might have contributed but is not definitively proven as the cause of death.

Probable SUDEP refers to similar scenarios as Definite SUDEP but lacks an autopsy. Possible SUDEP occurs when a competing cause of death is present, while Near-SUDEP refers to survival for more than one hour after resuscitation from a cardiorespiratory arrest without an identified structural cause. When a clear cause of death is ascertained, it is Not SUDEP. When information is incomplete and there is difficulty in classification, it is called unclassified deaths.

The causes of death among individuals with epilepsy often include traumatic brain injury, cerebrovascular diseases, brain tumors, accidental injuries, asphyxia, drowning, and status epilepticus. However, a significant proportion of deaths remain unexplained and are attributed to SUDEP.[12] The absence of a specific diagnostic marker and standardized investigation protocols limits the ability to identify SUDEP cases definitively. An international tool for death scene investigation and postmortem examination could provide better insights into SUDEP's pathophysiology.[15]

India, which accounts for a significant proportion of the global epilepsy burden, faces challenges in addressing epilepsy-related mortality. Studies reveal that while awareness of epilepsy is comparable to the West, negative societal attitudes persist, affecting education, marriage, employment, and social interactions. The stigma associated with epilepsy, combined with the absence of centralized patient registries, hampers follow-up and management. Notable initiatives, such as the Kerala Registry of Epilepsy and Pregnancy, have made strides in understanding reproductive issues in women with epilepsy.[16]

Given paucity of literature on SUDEP in India, meticulous autopsy practices are crucial for gaining insights into sudden deaths. In this series, the authors describe a set of cases initially considered as SUDEP, which were later reclassified based on further research. **(Table 1)**

Table 1: SUDEP Category Findings at Autopsy.

Case No.	Findings At Autopsy	SUDEP Category
1	Pontine Hemorrhage	Not SUDEP
2	Unilateral Diminished Pigmentation in Substantia Nigra	Definite SUDEP plus
3	Intra-ventricular Hemorrhage	Not SUDEP
4	Intra-Cerebral Hemorrhage	Not SUDEP
5	Temporal Lobe Scar Tissue	Definite SUDEP plus

CONCLUSION

The risk of Sudden Unexpected Death in Epilepsy (SUDEP) is a significant concern for individuals with epilepsy. According to the Centers for Disease Control and Prevention (CDC), risk factors for SUDEP include uncontrolled and frequent seizures, generalized seizures, early-onset seizures, living with epilepsy for an extended duration, missing medication, and alcohol consumption.[17]

Although the exact cause of such sudden deaths remains unclear, several theories have been proposed. These include apnea, arrhythmia, or a combination of both occurring during a seizure.[18] Efforts by governmental and non-governmental organizations are essential to raise awareness of SUDEP among individuals with epilepsy and their caregivers.

Establishing state-wise and national registries for epilepsy would facilitate data collection and research into the demographics of epilepsy in India. Regular follow-up with social health workers could help identify factors such as treatment defaulters, the use of mixed medications, and their contribution to sudden deaths. Additionally, standardized protocols for investigations, including crime scene analysis and postmortem examinations, would be instrumental in creating a comprehensive national database of sudden deaths in individuals with epilepsy.

Incorporating routine toxicological analysis and chemical testing of anti-epileptic drugs in such cases could help assess patient compliance and guide necessary interventions. Furthermore, future histochemical and genetic studies of the human brain may provide valuable insights into the pathophysiology of epilepsy-related deaths, paving the way for better prevention and management strategies.

REFERENCES

1. International classification of diseases (ICD-10.). Geneva, World Health Organization, 2005.
2. Pathak SJ, Yousaf MIK, Shah VB. Sudden Unexpected Death in Epilepsy. [Updated 2022 Dec 19]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan.
3. Fisher RS, Acevedo C, Arzimanoglou A, Bogacz A, Cross JH, Elger CE, Engel J Jr, Forsgren L, French JA, Glynn M, Hesdorffer DC, Lee BI, Mathern GW, Moshé SL, Perucca E, Scheffer IE, Tomson T, Watanabe M, Wiebe S. ILAE official report: a practical clinical definition of epilepsy. Epilepsia. 2014 Apr;55(4):475-82.
4. Garg D, Sharma S. Sudden unexpected death in epilepsy (SUDEP)—What pediatricians need to know. Indian pediatrics. 2020 Oct;57(10):890-4
5. Nashef L, So EL, Ryvlin P, Tomson T. Unifying the definitions of sudden unexpected death in epilepsy. Vol. 53, Epilepsia. 2012. p. 227–33.
6. Crime N, Bureau R. Accidental deaths and suicides in India 2022. 2023;
7. Suri AK, Bodal VK, Bal MS, Singh Y. Histopathological Findings in Coronary Atherosclerosis in 200 Autopsy Cases. J Punjab Acad Forensic Med Toxicol. 2016;16(1):48–54
8. Rao DS. Sudden and unexpected natural deaths-a four-year autopsy review. J Punjab Acad Forensic Med Toxicol. 2008;8(2):20–4
9. Aggarwal B, Singla S, Garg M, Gorea RK. Bullous Emphysematous Lungs-A Case Report. J Punjab Acad Forensic Med Toxicol.2012;12(1):48-9.
10. Shetty B, Rastogi P, Kanchan T, Palimar V. Postmortem Diagnosis of Esophageal Variceal Bleeding-A Case of Sudden Death. J Punjab Acad Forensic Med Toxicol. 2009; 09(2):96-8.
11. AGGARWAL B, GOREA RK, PARIHAR K. Berry Aneurysm-A Case Report. J Punjab Acad Forensic Med Toxicol.2011;11(2):90-1.
12. Brennan M, Scott S, Bergin P. Sudden unexpected death in epilepsy (SUDEP) in New Zealand; a retrospective review. NZMJ [Internet]. 2020;17:1508.
13. Bharucha NE. Epidemiology of Epilepsy in India. 2003;44:9–11.
14. Annegers JF, Coan SP. SUDEP: overview of definitions and review of incidence data. Seizure. 1999 Sep 1;8(6):347-52.
15. Barranco R, Caputo F, Molinelli A, Ventura F. Review on post-mortem diagnosis in suspected SUDEP: Currently still a difficult task for Forensic Pathologists. Journal of forensic and legal medicine. 2020 Feb 1;70:101920.
16. Thomas, S.V., Jose, M., Divakaran, S. and Sankara Sarma, P. (2017), Malformation risk of antiepileptic drug exposure during pregnancy in women with epilepsy: Results from a pregnancy registry in South India. Epilepsia, 58: 274-281.
17. National Center for Chronic Disease Prevention and Health Promotion, Sudden Unexpected Death in Epilepsy.
18. So EL. What is known about the mechanisms underlying SUDEP?. Epilepsia. 2008;49 Suppl 9:93-98.

J Punjab Acad Forensic Med Toxicol 2024;24(2) ISSN : 0972-5687 DOI:10.5958/0974-083X.2024.00058.0

A Case Report

Humid Environment Pink Tooth Phenomenon in Deceased Bodies : A Case Report

1. **Roben Suhadi Pasaribu,** Division of Forensic Odontology, Department of Oral Biology, Faculty of Dentistry, University of Indonesia, Jakarta-Indonesia
2. **Asri Megaratri Pralebda,** Forensic Medicine Installation of Bhayangkara TK-I Hospital, Jakarta, Indonesia
3. **Nurtami Soedarsono***
4. **Elza Ibrahim Auerkari***

*Division of Forensic Odontology, Department of Oral Biology, Faculty of Dentistry, University of Indonesia, Jakarta-Indonesia

ABSTRACT

Introduction: Decomposition is a stage that will occur after death. The process of body decay will give a distinctive picture at each stage. One of the phenomena that appears during decay in the oral cavity is the appearance of the pink teeth phenomenon (PTP). PTP is a discoloration of the teeth that is seen due to the penetration of coloring pigments into the dentinal tubules.

Aims and Objectives: To show the appearance of PTP in a victim found in a case that was not drowned but found in humid conditions.

Case: On 2nd October, 2024, a body was found at 10.20 am in the bathroom of the house and 17th November 2024, a body was found at 3.15 pm inside his house. Both were taken to the forensic facility to get examined and were found decomposed and surrounded by maggots and peeling skin. Both victims were found in a humid environment and there was a pink tooth phenomenon.

Conclusion: PTP is a phenomenon that will be found in the process of decay. This condition cannot be used to determine the cause of death but can be used to predict the environmental conditions when the corpse was found.

Corresponding Author :
Dr. Elza Ibrahim Auerkari, Division of Forensic Odontology, Department of Oral Biology, Faculty of Dentistry, University of Indonesia, Jakarta-Indonesia
E-mail: eauerkari@yahoo.com
Contact : +

Article History:
Received: 21 November 2024
Received in revised form: 11 January 2025
Accepted on: 11 January 2025
Available online: 15 April 2025

Keywords: Pink Teeth Phenomenon; Decomposition; Moisture, Forensic.

INTRODUCTION

The body will respond to death by decomposition, putrefaction, mummification and skeletization.[1] Decomposition is a complex biological process. This chemical process involves interactions between enzymes, bacteria, fungi, and protozoa. The body's response through this decay process will provide a distinctive picture and become information that can be used in the forensic world.[1]

In forensic dentistry the pink teeth phenomenon is one form of response that occurs during decay. The Pink Teeth Phenomenon was first observed in 1829, which is considered as a change that occurs in cadavers, in deciduous and permanent teeth that become reddish in color.[1,2] The cause of the pink teeth Phenomenon is associated with the presence of asphyxia experienced by the victim before death as in the case of drowning. Some speculations state that this pink tooth phenomenon is found in cases due to asphyxia such as drowning, hanging and strangulation.[3,4] Another speculation is the presence of bacteria that produce red pigments and carbon.[3] However, some case reports suggest that pink teeth are more common in drowning cases.[5,6] The growing theory of pink teeth invalidates the theory that pink teeth will appear in deaths caused by asphyxia.+ PTP can be found in all types of deaths such as asphyxia, cranio-encephalic trauma, intoxication, hemorrahage, and posioning.[1,7,8]

However, there are factors that influence the emergence of PTP, namely humid and wet environmental conditions. In addition, the prone position of the corpse with the head

lower than the torso is one of the factors that can increase the risk of PTP.[3,9,10] The position of the head lower than the limbs will cause the amount of blood in the pulp to be greater so that the potential for discoloration will be greater, however, this theory has not been proven empirically.[9]

Minegishi et al. in 2022, made a classification of Pink Teeth based on the degree of color and discolored regions. Based on the degree of color (Score of Pink Teeth Color, SPTC), it is divided into 3 namely Faint Pink (Score 1), Pink (Score 2), and Dark Pink (Score 3). Based on the exposed region (Pink Teeth Region, SPTR), it is divided into 3 namely score 1 if the affected root is below the cervical part of the tooth, score 2 if it involves the cervical region to the lower ½ of the crown, and score 3 if it affects the upper ½ of the crown.[3]

The observation of Pink Teeth phenomenom in the forensic field is important because this condition can be related to the environmental conditions in which the victim was found such as prolonged submersion in water, exposure to moist soil, and even extreme pressure change processes.[9] The purpose of this case report is to show the occurrence of pink teeth in victims found in moist conditions but were not drowned.

Case 1

On October 2, 2024, a body was found at 10.20 am in the bathroom of his house. The body was then taken to the Forensic Installation for examination by the Forensic team. At 1:38 pm, an examination was carried out by forensic pathology and forensic odontology. The corpse was male. The body was found in a bulging condition with peeling skin, hair and eyebrows easily detached. There were no palpable fractures and no injuries found on the corpse. White maggots were found all over the body with the largest size of 1 cm.

On examination by forensic odontology, the maxilla contained removable partial dentures on teeth 11 and 21 but there were residual roots on these teeth. On examination in the lower jaw, the teeth were in complete condition but there were cavities in teeth 46, 47 and 48. In teeth 32 and 43, PTP was found. Based on the score of Pink Teeth (SPTC), teeth 32 and 42 are included in faint pink (score 1) and based on Pink Teeth Region (SPTR) score 1 (the affected area is from cervical to apical). **(Figure 1).**

Case 2

On November 17, 2024, a body was found at 3:15 pm inside

Figure 1: Pink Teeth Phenomenon in Tooth 32 and 42

Figure 2: Pink Teeth Phenomenon in Tooth 11 and 23

the house. The body was then taken to the Forensic Installation for examination by the forensic team. At 20.49 WIB, an examination was carried out by the forensic pathology and forensic odontology teams. The corpse was male. The corpse was found in an advanced state of decomposition with peeling skin on the whole body, head hair that was easily separated, the skin of the facial area looked darker. Maggots were found throughout the body with the largest size of 1.3 cm and the smallest 0.1 cm. No signs of trauma were found, namely wounds and no broken bones were found on the corpse.

On examination of the oral cavity by forensic odontology, no injuries to the soft tissues around the oral cavity were found. On examination of the teeth, a black denture using a material with a hard consistency resembling rubber was found on teeth 16, 15, 12, 22, 24, 26, and 27. On teeth 11 and 23, PTP was found **(Figure 2)**. Based on the score of Pink Teeth (SPTC), teeth 11 and 23 fall into the Pink category (score 2) and based on the Pink Teeth Region (SPTR) score 1 (the affected area is from the cervical to the apical).

DISCUSSION

Pink teeth are a multifactorial phenomenon. The analytical challenge of pink teeth is influenced by the time after

death, the complex influence of the environment, and the physioligical conditions that occur after death.[9] The occurrence of pink teeth is associated with red blood cell components penetrating into dentin.[4,11]

Dentin in teeth is composed of microstructures in the form of compartments of dentinal tubules that fundamentally have the function of hydrating the tooth, signaling the transduction of stimuli, and the need for an adhesive system.[9,12] Dentin thickness is influenced by several factors such as geographical origin, diet, environment, and age.[12]

Under normal conditions, the diameter of dentin will prevent red blood cells from entering dentin.[5] Red blood cells have a diameter of 7.5 micrometers and dentinal tubules have a diameter of 3 mm. The color components in red blood cells such as hemoglobin, porphyrins, and hemosiderin can only enter the dentin after the red blood cells are lysed.[4,11] Therefore, the factors that affect the diffusion speed of hemoglobin into the dentinal tubules are influenced by the decay process such as the length of death, humidity and the stage of decay.[1–3]

The process that occurs after death is reduction in oxygen, causing necrosis followed by autolysis and decay. Factors that influence the decomposition process are the presence of insects, the acidity, (pH) of the soil, exposure to the sun, the size of the corpse, the presence of trauma, and exposure to rain. However, the factors that will significantly affect the rate of decay are temperature and humidity.[13] The optimal temperature for enzymes to work is at 37^0 degrees C. Every 10^0 C increase in ambient temperature will increase the speed of enzymes in the body to react up to 3 times. This process shows that an increase in temperature will accelerate the decay process. Humidity is related to watery environmental conditions. Water is a very important component in the process of chemical reactions. Water will affect the acidity and temperature which will have an effect on hydrolyzing enzymes that can break the polymer bonds of biological materials, fats and proteins.[13] In both cases, the bodies were found inside the house. One of the bodies was found in the bathroom in a humid environment. This condition is one of the factors that can accelerate the rate of decomposition. This can be seen from the condition of the two victims who were already in an advanced phase of decomposition when they were found and examined. Some case reports also state the finding of corpses with pink teeth symptoms in humid places. Ademir F et al. reported that out of 61 cases with pink teeth, 51 cases (83.6%) were found in damp places. Of the 66 cases found with pink teeth, 38 cases (57.7%) were already at an advanced stage of decay and putrefying.[1] The findings of pink teeth vary widely within the oral cavity. The process of discoloration to pink is more prominent in single-rooted anterior teeth than in multiple-rooted posterior teeth. The pink color will be more prominent in the cementoenamel junction and cervical area of the tooth root.[6] In both cases, the findings of teeth that experienced pink discoloration were in the anterior teeth.

Teeth in a healthy condition have a higher risk of experiencing Pink Teeth compared to teeth with caries. This is associated with a decrease in pulp volume and the amount of blood in the pulp chamber.[2,9] In addition, this incident is more potential in children than adults because the condition of children's teeth has not undergone the process of forming a lot of secondary dentin. The formation of secondary dentin will also affect the volume of the pulp chamber and pulp so that the blood supply will decrease along with these changes.[2,9] Increasing age will affect the anatomical structure of the dentinal tubules. Dentinal tubules will be reduced in number, narrower in size, and partially closed which makes it difficult to penetrate the degradation of red blood cells into the dentinal tubules.[4–6]

Gender also has no significant effect on the formation of pink teeth because gender has no influence on dentin structure, pulp condition and pulp chamber.[1] Minegishi et al stated that out of 68 cases examined, there was no significant difference between pink teeth and gender, age and location of the corpse. Their results indicated that there was no significant relationship between cause of death and the occurrence of PTP. They stated that environmental factors and the level of decay were more influential.[3] These results are also supported by research conducted by Sumi et al in 2022 which stated that the decay process significantly increased the appearance of the pink teeth phenomena.[14]

CONCLUSION

The phenomenon of pink teeth is one of the conditions that will be found when examining a corpse, especially when it has undergone advanced decomposition and is found in a place with humid conditions. Environmental factors greatly influence the formation of pink teeth. Pink teeth cannot be used to determine the cause of death, but the pink teeth phenomenon can be used to predict the environment where the victim was found. As in this case,

both victims were found inside a house with humid environmental conditions. The cause of death of the two victims cannot be determined because no post-mortem was performed.

Conflict of Interest/Funding : Nil

REFERENCES

1. Franco A, de Oliveira MN, Gomes-Lima LK, Pereira-de-Oliveira VHF, Franco RPAV, Blumenberg C, et al. Case-specific characteristics of pink teeth in dental autopsies-A systematic review. Vol. 68, Journal of Forensic and Legal Medicine. Churchill Livingstone; 2019.
2. Franco A, Mendes SDSC, Picoli FF, Rodrigues LG, Silva RF. Forensic thanatology and the pink tooth phenomenon: From the lack of relation with the cause of death to a potential evidence of cadaveric decomposition in dental autopsies-Case series. Forensic Sci Int. 2018 Oct 1;291:e8–12.
3. Minegishi S, Saitoh H, Utsuno H, Ohta J, Namiki S, Toya M, et al. Association of Cadaveric Factors with the Degree and Region of Discoloration on Pink Teeth: An Approach to Serial Cases. Applied Sciences (Switzerland). 2022 May 1;12(9).
4. Mittal P, Mittal M, Sharma G. Pink teeth and the dead: A review with reports of two cases. Journal of Indian Academy of Forensic Medicine. 2016;38(3):366–9.
5. Alyssa Niara Brites, Ana Luísa Rezende Machado, Ademir Franco, Ricardo Henrique Alves Silva. Revisiting autopsies of death by mechanical asphyxia in the search for post-mortem pink teeth. Journal of Forensic Odonto- Stomatology. 2020 May;38(1):34–8.
6. Shamsudeen SMS. Pink Tooth in Forensic Dentistry- A Short Review. International Journal of Medical Science And Diagnosis Research. 2022 Jan 31;6(1).
7. Hartomo BT, Adrianto AWD, Auerkari EI. Pink teeth as post mortem indicator: A literature review. In: AIP Conference Proceedings. American Institute of Physics Inc.; 2019.
8. Mittal P, Karagwal P, Gupta D. Pink Teeth Phenomenon and Asphyxia: A Reassessment and Update. Journal of Forensic Research. 2021;12:2021.
9. Braga S, Caldas IM, Dinis-Oliveira RJ. Forensic significance of postmortem pink teeth: A narrative review. Vol. 169, Archives of Oral Biology. Elsevier Ltd; 2025.
10. Sakurada K. Effects on oral tissues of asphyxiation caused by cervical compression: The pink teeth phenomenon in Kato's studies (1941). Vol. 64, Legal Medicine. Elsevier B.V.; 2023.
11. Charan Gowda B, Sivapathasundharam B, Chatterji A, Chatterji B. Histological appearance of postmortem pink teeth: Report of two cases. J Forensic Dent Sci. 2015;7(2):168.
12. Arola DD, Gao S, Zhang H, Masri R. The Tooth: Its Structure and Properties. Vol. 61, Dental Clinics of North America. W.B. Saunders; 2017. p. 651–68.
13. Cockle DL, Bell LS. Human decomposition and the reliability of a "Universal" model for post mortem interval estimations. Forensic Sci Int. 2015 Aug 1;253:136.e1-136.e9.
14. Sumi N, Minegishi S, Ohta J, Utsuno H, Sakurada K. Study on the Mechanism of the Pink Tooth Phenomenon Using Bovine Teeth: A Pilot Study. Diagnostics. 2023 Aug 1;13(16).

INSTRUCTIONS TO AUTHORS

- **Unpublished, Ethical, Un-Plagiarised original manuscript written in English should be sent to: Dr. Ajay Kumar, Editor-in-Chief, Journal of Punjab Academy of Forensic Medicine and Toxicology by email at: iamdrajay@gmail.com**
- **Images (Good quality) should be sent separately in JPEG format.**
- **References should be in Vancouver Style only.**

The Publication Particulars

The JPAFMAT is the official publication of the Punjab Academy of Forensic Medicine & Toxicology, published since 2001.

The Contents of the Journal

The journal accepts a range of articles of interest, under several feature sections as follows:

Original Papers: Includes conventional observational and experimental research.

Commentary: Intended for Reviews, Case Reports, Preliminary Report and Scientific Correspondences.

Letter to the Editor

Designed to be an avenue for dialogue between the authors of the papers published in the journal and the readers restricted to the options expressing reviews, criticisms etc. It could also publish letters on behalf of the current affairs in the field of Forensic Medicine in the country.

Editorial

Intended as a platform, for the Editor-in-Chief and for others with a keen interest in forensic medicine that wished to comment on the current affairs.

Special Features

In the History of Indian Forensic Medicine, Book Review, Abstracts, Announcement etc, which appear frequently,

but not necessarily in every issue.

News and Notes

Intended for providing information of members and activities of the Academy and other such other organizations affiliated to the Academy may appear frequently and not in every issue.

General Principles

The text of observational and experimental articles is usually (but not necessarily) divided into the following sections: Introduction, Methods, Results, and Discussion. This so-called "IMRAD" structure is not an arbitrary publication format but rather a direct reflection of the process of scientific discovery. Long articles may need subheadings within some sections (especially Results and Discussion) to clarify their content. Other types of articles, such as case reports, reviews, and editorials, probably need to be formatted differently. Electronic formats have created opportunities for adding details or whole sections, layering information, cross linking or extracting portions of articles, and the like only in the electronic version. Double spacing all portions of the manuscript— including the title page, abstract, text, acknowledgments, references, individual tables, and legends—and generous margins make it possible for editors and reviewers to edit the text line by line and add comments and queries directly on the paper copy. If manuscripts are submitted electronically, the files should be double-spaced to facilitate printing for reviewing and editing. Authors should number all of the pages of the manuscript consecutively, beginning with the title page, to facilitate the editorial process.

International Uniform Requirements

Please visit http://www.icmje.org/ for detailed instructions for manuscript submission.

Life Members (PAFMAT)

No.	Name	No.	Name	No.	Name
1	Dr. R.K. Gorea	43	Dr. Mian Abdur Rashid	85	Dr Iram Khan
2	Late Dr. Sat Pal Garg	44	Dr. Shilekh Mittal	86	Dr Charanpreet K. Pawar
3	Dr. D.S. Bhullar	45	Dr. B.R. Sharma	87	Dr Mukul Chopra
4	Late Dr. A.S. Thind	46	Dr. D.Harish	88	Dr Mohit Gupta
5	Dr. Hakumat Rai	47	Dr. Krishna D. Chavali	89	Dr Rahul Chawla
6	Dr. K.K. Aggarwal	48	Dr. Ashwani Kumar	90	Dr Maneel Grover
7	Dr. Jaswinder Singh	49	Dr. Vikram Bains	91	Dr Y.S. Bansal
8	Dr. Karamjit Singh	50	Late Dr. Kirpal Singh	92	Dr C.S. Gautam
9	Dr. Harjinder Singh	51	Dr. Gurbachan Singh	93	Dr S.P. Mandal
10	Dr. Virender Pal Singh	52	Dr. Sangeet Dhillon	94	Dr Murli . G
11	Dr. Ashok Chanana	53	Dr. Sukhbir Singh Chauhan	95	Dr Anil Kumar Mittal
12	Dr. J.S. Dalal	54	Dr. Parminder Singh Bhatti	96	Dr G.A. Sunil Kumar Sharma
13	Dr. Jagdish Gargi	55	Dr. Rakesh Kumar	97	Dr Abhishek Yadav
14	Dr. R.S. Parsad	56	Dr. Jagbir Singh	98	Dr Jagdev Kullar
15	Late Dr. Ajit Singh	57	Dr. Karnveer Singh	99	Dr Gurpreet Kaur Randhawa
16	Dr. Harish Tuli	58	Dr. Rajiv K. Chowdhary	100	Dr Gursirat Singh Khokhar
17	Dr. S.K. Bal	59	Dr. Parmod Kumar Goyal	101	Dr Saginder Samara
18	Dr. S.S. Sandhu	60	Dr. Ajay Kumar	102	Dr Saginder Samaraj
19	Dr. Akashdeep Aggarwal	61	Dr RK Sharma	103	Dr Neha Sharma
20	Dr. Kuldeep Singh	62	Dr Brij M. Gupta	104	Dr Sunil Mahajan
21	Dr. Vishal Garg	63	Dr Sunil Gambhi	105	Dr Harshdeep Kashyap
22	Dr. S.S. Oberoi	64	Dr Vijal Pal Khangwal	106	Dr Kiran Kumar
23	Late Dr. Ram Lubhaya	65	Dr Rajiv Joshi	107	Dr Swati Tyagi
24	Dr. Amandeep Singh	66	Dr Manpreet Kaul	108	Dr Mini
25	Dr. Harkirat Singh	67	Dr Sheikh AnayatUllah	109	Dr Mandeep Kaur
26	Dr. I.S. Bagga	68	Dr Satinder Pal Singh	110	Dr Gurinder Singh
27	Dr. Harpreet Singh	69	Dr Preetinder Singh Chahal	111	Dr Minal
28	Dr. Parminder Singh	70	Dr Kulbhushan Garg	112	Dr Kanchan Jyoti Heera
29	Dr. Anil Garg	71	Dr Imran Sabri	113	Dr Manpinder Kaur Bhullar
30	Dr. O.P. Aggarwal	72	Dr Bindu Aggarwal	114	Dr Arashdeep Singh
31	Dr. Gaurav Sharma	73	Dr Adish Goyal	115	Dr Chamandeep Singh Bains
32	Late Dr. Madhur Tayal	74	Dr Charak Sangwan	116	Dr Maninder Singh
33	Dr. Gurmanjit Rai Mann	75	Dr Pardeep Singh	117	Dr Akhilesh Agarwal
34	Dr. Didar Singh	76	Dr Ishwer Tayal	118	Dr Guneet
35	Dr. Kuldeep Singh	77	Dr Ripan Chanana	119	Dr Hitesh Bhatia
36	Dr. Pankaj Gupta	78	Dr Gurvinder Singh Kakkar	120	Dr. Deep Rattan Mittal
37	Dr. Karam Singh	79	Dr Ravdeep Singh	121	Dr. Arun Kumar Maria
38	Dr. Baljit Singh	80	Dr Rohit Kumar Singal	122	Dr. S Valliappan
39	Dr. Puneet Khurana	81	Dr Prabhdeep Singh	123	Dr. Preet Inder Singh
40	Dr. Puneet Arora	82	Dr Jasbir Singh	124	Dr. Harvinder Singh Chhabra
41	Dr. Prabhsharan Singh	83	Dr Jatinder Pal Singh	125	Dr. Bhoj Kumar Sahu
42	Dr. Dildar Singh	84	Dr Alok Kandpal	126	Dr. Amarnath Mishra

Life Members (PAFMAT)

No.	Name
127	Dr. Shekhar Chumber
128	Dr. Navroz Goyal
129	Dr. Gurjeet Singh
130	Dr. Deepika Kanwar
131	Dr. Mohd. Amjad Bhatt
132	Dr. Nikhil Mehta
133	Dr. Charan Kamal
134	Dr. Amit Singla
135	Dr. Sukhdeep Singh
136	Dr. Munish Kumar
137	Dr. Arindam Chatterjee
138	Dr. Ranjodh Jeet Singh
139	Dr. Kanika Kohli
140	Dr. Vinka Maini
141	Dr. Ravi Tejpal
142	Dr. Preet Mohinder Singh
143	Dr. Satbir Singh
144	Dr. Kamaljit Singh
145	Dr. Mrinal Kanti Jha
146	Dr. Vijay Arora
147	Dr. Vivek Srivastava
148	Dr. Pankaj Chhikara
149	Dr. Lalit Kumar
150	Dr. Prem Chandra Srivastava
151	Dr. Niraj Kumar
152	Dr. Om Parkash Saini
153	Dr. Rajesh Kumar Verma
154	Dr. Shailender Kumar
155	Dr. B.L. Chaudhary
156	Dr. Parmod Kumar Saini
157	Dr. Rajendra Singh Kulhari
158	Dr. Nidhi Sachdeva Agarwal
159	Dr. Rajeev Varma
160	Dr. Pragnesh Bharatkumar Parmar
161	Dr. Yatiraj Singi
162	Dr. Navpreet Kaur
163	Dr. Kunal Khanna
164	Dr. Smitha Rani Shetty
165	Dr. Vivekanshu Verma
166	Dr. B.V. Naga Mohan Rao
167	Dr. Anju Gupta
168	Dr. Guriqbal Singh
169	Dr. Prashanthi Krishna Dharma
170	Dr. Amarjit Singh
171	Dr. Keshav Soni
172	Dr. Faisal Nasim Gilani
173	Dr. Ashok Sagar
174	Dr. Suresh Chand
175	Dr. Jaswinder Singh
176	Dr. Prateek Rastogi
177	Dr. Varun Garg
178	Dr. Hitesh Chawla
179	Dr. Sanjeev Buri
180	Dr. Sunil M Doshi
181	Dr. Sanjay Kumar
182	Dr. Akhilesh Pathak
183	Dr. Raghvendra Kumar Vidua
184	Dr. Jitendra Kumar Gupta
185	Dr. Manoj Kumar Pathak
186	Dr. Surendra Kumar Pandey
187	Dr. Mayank Gupta
188	Dr. Amandeep Kaur
189	Dr. Mukesh Kumar Meena
190	Dr. Jitender Kumar Jakhar
191	Dr. Kamal Singla
192	Dr. Rajender Kumar Saini
193	Dr. Chandra Pal
194	Dr. Rattan Singh
195	Dr. Jyoti Barwa
196	Dr. Chaitanya Mittal
197	Dr. Atul Shankarrao Keche
198	Dr. Niranjan Sahoo
199	Dr. Vanshikha
200	Dr. Pulkit Girdhar
201	Dr. Alwin Varghese
202	Dr. Karan Pramod
203	Dr. Balbir Kaur
204	Dr. Malvika Lal
205	Dr. Shashank Shekhar Jha
206.	Dr. Vipan Bhandari
207.	Dr. Jaspinder Pratap Singh
208.	Dr. Dipen M Dabhi
209.	Dr. Neha Chaudhary
210.	Dr. Deepak Sharma
211.	Dr. Mohit Chauhan
212.	Dr. Gurpreet Singh
213.	Dr. Chandra Prakash
214.	Dr. Arun Garg
215.	Dr. Anjalika Gill
216.	Dr. Amandeep Kaur
217.	Dr. Samuel Khokher
218.	Dr. Showket Rashid
219.	Dr. Rajesh Kumar Nayak
220.	Dr. Rajeev Kumar
221.	Dr. Ashish Mittal
222.	Dr. Girish Matwa
223.	Dr. Hussanpreet Singh
224.	Dr. Gagandeep
225.	Dr. Vikrant Mehta
226.	Dr. Sachin Kumar Bhatti
227.	Dr. Sandeep Raju
228.	Dr. Varun Modgill
229.	Dr. Merry Pal Kaur Chawla
230.	Dr. Sunny Basra
231.	Dr. Tajbir Kaur
232.	Dr. Bhavish Prakash
233.	Dr. Arpan Kumar Pan

Glimpse of Mid Year CME of Punjab Academy of Forensic Medicine & Toxicology

Held on Saturday, 25 May 2024 at B.R. Ambedkar Institute of Medical Sciences, Mohali

Editorial Board

Editor-in-Chief
Prof. (Dr) Ajay Kumar

Joint Editor
Dr Harvinder Singh Chhabra

Assistant Editor
Dr Sahil Thakral

Subscription Rates for Year 2024

Personal: Rs. 1,000/-
Institutions: Rs. 5,500/-

Postal Charges Extra

- Subscription request be sent on email to iamdrajay@gmail.com
- Payments be made in Bank Account of Journal of Punjab Academy of Forensic Medicine (A/c No. 65075504236, State Bank of India, Branch Rajindra Hospital Patiala, IFS Code SBIN0050263

Printed & Published by:
Prof. (Dr.) Ajay Kumar
Professor
Department of Forensic Medicine & Toxicology
All India Institute of Medical Sciences
Bathinda (Pb.) India M. 9646121575, 0164-2867665
E-mail: iamdrajay@gmail.com

Printed at: