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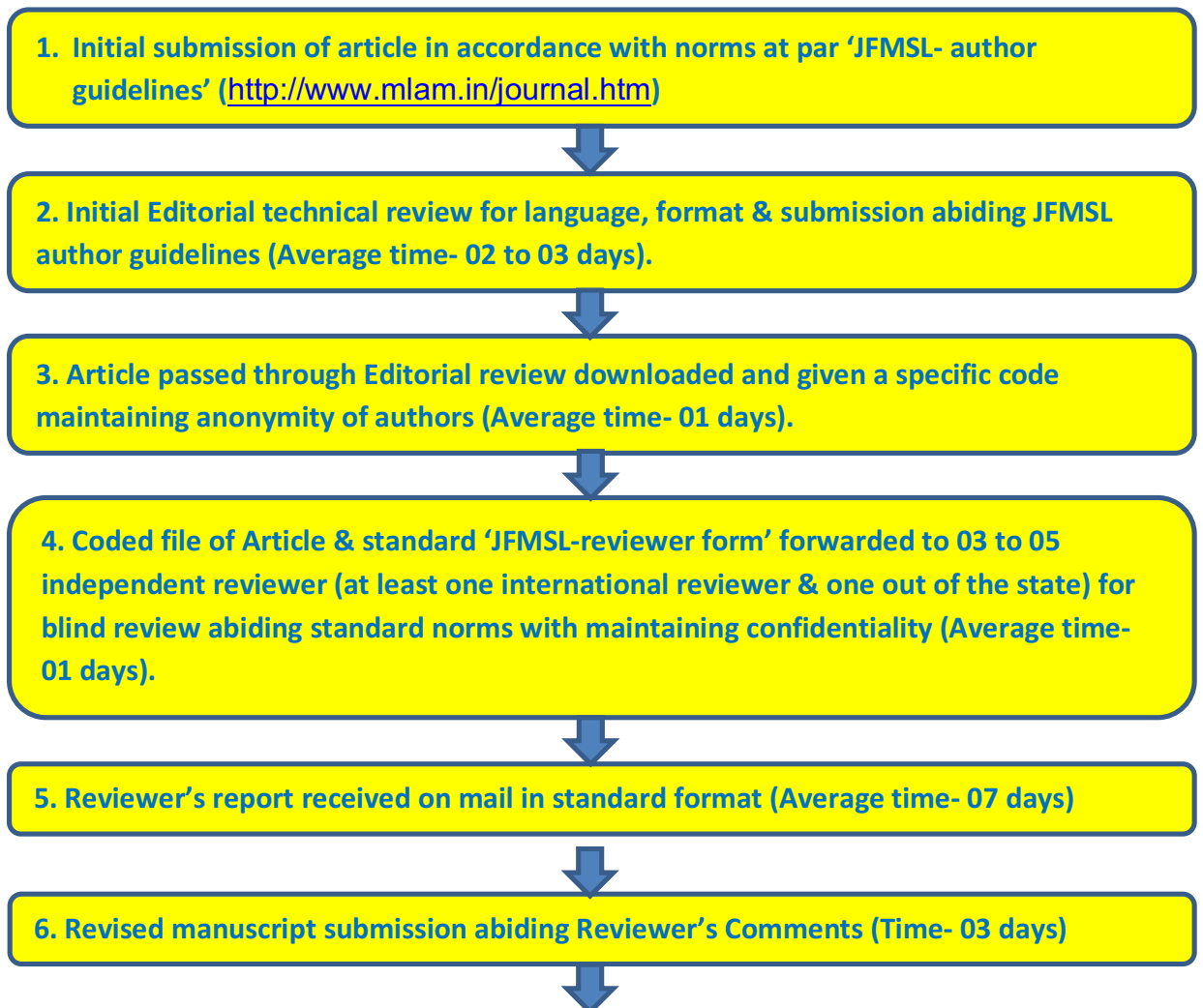
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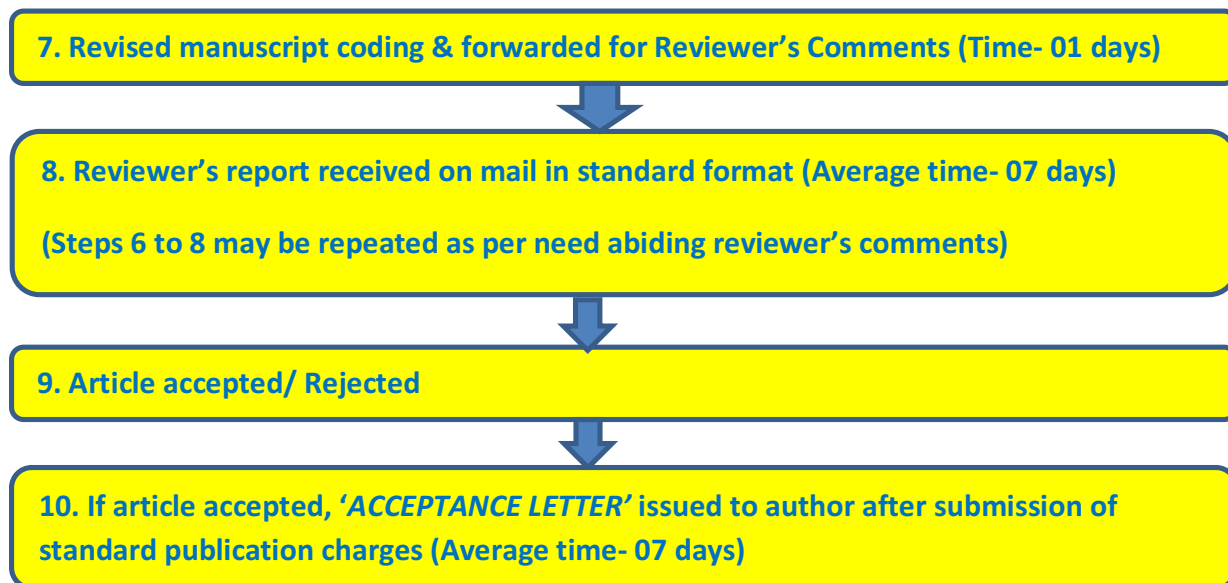
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Editorial

Artificial Intelligence in Healthcare and Biomedical Research - Ethical Aspects

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1. Introduction

Artificial intelligence (AI) is a scientific field which involves creating advanced machines/computers to learn, reason, and act in a such way which requires human intelligence. It is a system's ability to achieve specific goal or task by interpreting external data in correct sense with flexible adaption.¹

It can perform various simple to complex and repetitive to cognitive tasks using complex computer algorithms emulating human cognition. It has many applications in healthcare sector and biomedical research. The AI-based tools and techniques are expected to improve healthcare delivery system leading to improvement in affordable and accessible quality healthcare to needy. But, the integration of AI in these fields has raised many ethical concerns. Hence, AI technology development and its application should be governed by an ethically sound policy framework.

The conventional or AI-based health and biomedical research should adhere with the basic ethical principles of autonomy, beneficence, non-maleficance and distributive justice. This will ensure the protection of dignity, rights, safety and well-being of Human community. There is huge risk of mistakes in patient diagnosis using AI and there may be difficulty in establishing accountability for it.

AI-based machine learning system in healthcare may subject to algorithmic bias based on gender, race, etc.² There is need from Governmental regulatory bodies and healthcare institutions to establish a structure to monitor the key issues and provide for governance mechanism to overcome its negative implications.^{3,4}

Indian Council of Medical Research (ICMR) Artificial Intelligence Cell issued its document named 'Ethical Guidelines for Application of Artificial Intelligence in Biomedical Research and Healthcare' in 2023 to ensure ethical conduct in Biomedical research and Healthcare by addressing the key emerging ethical challenges due to application of AI. These guidelines provide needed ethical framework guiding decision-making towards AI application in development, deployment and adoption of AI-based healthcare solutions. These guidelines provide the basic ethical framework for all stakeholders involved research on Artificial intelligence in healthcare and biomedical research.⁵

These guidelines applicable to the AI-based tools involved in biomedical and healthcare research and the concerned stakeholders. AI in healthcare applied to various purposes and scientific fields such as diagnostics and screening of diseases, therapeutic, drug discovery and development purposes, clinical care, epidemiology

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and disease prevention, behavioural and mental healthcare, forensic medicine, health management system. These guidelines include various sections related to ethical principles, guiding principles for stakeholders, an ethics review process, AI use governance and informed consent.

AI-based healthcare solutions mostly dependant on the data from human subjects. It involves additional concerns of autonomy, interpretation, data handling, human personal biases, data sharing, professional competence and data privacy. An informed, collaborative and multidisciplinary approach on safe, secure, fair, transparent, ethical and responsible AI deployment will facilitate to assure equality in prediction judgements addressing the explicit and implicit biases in the system.

1. Ethical principles for AI in healthcare and Biomedical Research⁵

The AI technology development and application in health sector is being guided by the values and core principles of ethics. As it directly affects to the human lives and may result in grave consequences endangering human life, there is need of cautious, non-obstructive and ethical approach in development and deployment of AI in healthcare and Biomedical research. The ethical principles are as follows-

1.1 Autonomy

Using AI technologies may undermine human autonomy and there is possibility of independent functioning of the AI system. The decision-making powers may be fully transferred in the hands of machine. To avoid this, humans need to have complete control on AI-based healthcare solutions and healthcare decision making. At any circumstances, the AI technology should not interfere with patient's autonomy. More emphasis should be given to formulate the policies and guidelines which facilitate the strengthening of autonomy of the participants.

1.2 Safety and risk minimization

Before starting use of AI-based solutions in healthcare there is need of affirmation about system's safety, consistent performance and reliability towards protecting participants rights, dignity, well-being and safety. It

should have a robust set of control mechanism to prevent its deliberate or unintended misuse.

1.3 Data privacy

The AI-based solutions need to ensure privacy, confidentiality and personal data protection at all stages of its implementation in healthcare. Use of surplus data from participants should not be used without proper consent.

1.4 Optimization of Data Quality

As the AI is data driven technology, the outcome is based on data used in training and testing and data bias is considered as the greatest threat. Hence, training data should be free from known biases. It needs to represent the large section of target population. Sampling bias should be avoided.

1.5 Trustworthiness

For effective use of AI in healthcare, healthcare providers and researchers should provide simple, systemic and trustworthy way to test its validity and reliability. A trustworthy AI solution should provide lawful, ethical, reliable, transparent, explainable and valid, technically sound and quality results.

1.6 Accountability and liability

An individual researcher or organization obliged to account for its activities. They need to accept responsibility for their actions. They owe responsibility of disclosing the results in a transparent manner. There is mandatory need of regular internal and external audits of AI technologies for ensuring optimum functioning. The concept of 'Human in The Loop' (HITL)⁶ is going to place human beings in a supervisory role for healthcare purposes to ensure an individualized patient-centric decision making by the health professionals. In case there is a harm due to AI-technology, the legal liability and the relative role of stakeholders in damage should be identified based on appropriate mechanism ethical norms.

1.7 Accessibility, equity and inclusiveness

The digital divide is existent in almost all countries. It is more prominent in low- and middle-income countries (LMICs). The dependence on technology may affect its

wide application to such states. Stakeholders need to provide fair and equitable opportunities to access the AI based healthcare solutions to different users. The potential end user groups such as underprivileged, poor, etc. should be encouraged to access the AI technologies through Government schemes. AI developers and stakeholders should be determinant on providing the accessibility of AI technologies to economically and socially disadvantaged classes.

1.8 Non-discrimination and fairness principles

Bias-free and accurate data collection from representative population will ensure quality. AI-tool developers need to promote and protect equality of individuals ensuring individual rights, dignity equality and justice. AI solutions should be designed for universal use and free from any discrimination based on race, age, caste, religion or social status.

1.9 Collaboration

As the field is data driven, a well-curated large datasets collection is needed for development of any meaningful AI for health which can be achieved by fostering collaboration amongst various stakeholders at every level encouraging inter-disciplinary collaborations.

1.10 Validity

Before applying the AI technology in healthcare on patients/participants, it must be subjected to rigorous clinical and field validation to ensure safety and efficacy.

2. Guiding principles for stakeholders

AI-based solutions development, validation/testing and its utilization in healthcare is a multistep process involving partners and collaborators from various fields. Each step needs to follow standard practices for making AI-based solutions ethically appropriate and technically sound with application to larger part of society with fairness and equity. The stakeholders need to follow the guiding principles to make the AI-based solutions more acceptable and useful to beneficiaries.

Public engagement is essential to improve acceptability and help to build public trust. Stakeholders have important role in various processes such as conceptual framework, designing,

development, implementation, training, monitoring, feedback, ongoing education, improvements, accountability and advocacy.

3. Ethical review process in Medical AI

Ethical committee (EC) has a great role in assessing the scientific proposal with ethical considerations. It is responsible to ensure that the scientific proposal is sound and benefits population at large. EC need to check the proposals for data sources, methodology, anonymity, data safety and security, privacy and confidentiality, sound selection process, data quality, subject protection, compensation and possibility of stigmatization, etc.

4. Informed Consent

In the AI-based bio-medical research, researcher should obtain a written informed consent from study participants. Full information should be disclosed to the participants informing them risks, benefits, complications and subject have right to refuse to participate. The researcher should ensure voluntariness for participation in the research. With advancement of technology and science, there are various avenues in forensic medicine with use of AI technology.⁷⁻⁹

5. Use of AI technology in healthcare and biomedical research governance

The Indian Government is keen on streamlining the AI technologies in all sectors including healthcare. To leverage Digital health Technologies, the National Health Policy (2017) have made focused efforts to integrate digital health establishing National Digital Health Authority.¹⁰ Further, National Digital Health Blueprint (NDHB 2019) facilitates the development of a system of electronic health records based on international standards integrating principles of data anonymity and de-identification.

The Government of India Ministry of Health & Family welfare (MOHFW) proposed the Digital Information Security in Healthcare Act (DISHA) 2018 provides for electronic health data privacy, Security, safety, confidentiality and standardization, it also provide for establishment of National Data Health Authority and Health Information Exchanges.¹¹

Definition of medical device is expanded with inclusion of any software or an accessory intended

to be used for a medical purpose as per the Medical Device Rules, 2017 and its amendments in 2020.¹²

The incorporation of AI-based solutions and technology is expected to improve healthcare delivery to underprivileged and needy. It aims to make healthcare accessible and affordable to all.

It is improving the quality care of healthcare services provided to large sections of the society. Following ethical guidelines in development and deployment of AI based solutions in healthcare will facilitate appropriate implementation of AI in healthcare and biomedical research.

We can harness AI's potential to improve healthcare and biomedical research by acknowledging and addressing these ethical considerations, with ensuring responsible and beneficial innovation.

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Original Research Article

Age Estimation in Children and Adolescent in Central Indian Population: A Comparative Analysis of Demirjian's and Kronfeld's Method

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Abstract

Introduction: Radiology plays an indispensable role in human age determination. Developing teeth are used most reliably in age estimation in forensic science as they are the most indestructible part of the body. **Aim:** This cross-sectional study aims in comparing an age old Kronfeld's method and modified Demirjian's method of dental age estimation in reported MLC cases in Government Dental College. **Method:** The comparison was done among 120 individuals using digital Orthopantomogram. The subject comprised of male and female having age range of 7-22 years reported to GDC for age estimation. The analysis of 120 cases for age estimation was done by both Kronfeld's and Demirjian's method. The study was processed by paired T test. **Results:** Both the methods of age estimation show significant results in relation to actual age individually but comparison between the two method shows Kronfeld's method gave age estimates nearer to the actual age. **Conclusion:** Kronfeld's method can be used in analysis of age estimation cases.

1. Introduction

An indispensable role is played by radiology in human age determination. Developing teeth are used most reliably in age estimation in forensic science as they are the most indestructible part of the body.^{1,2} Age estimation of children and adolescents is vital for responding to plethora of legal questions, including issues of status of majority and criminal liability. The teeth are useful predictors of age in this age group, particularly because of their relative accuracy and also because of the lack of other reliable predictors.^{2,3,4} Various

methods for dental age estimation are practiced worldwide. Logan and Kronfeld developed a method depending on the calcification and development of permanent and deciduous teeth giving the age estimates in humans.³

Schour and Masseler (1941) had studied the development of deciduous as well as permanent teeth, mentioning 21 chronological steps from 4 months to 21 years of age and published the numerical development charts for them.^{3,5} The American Dental Association (ADA)

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has periodically updated these charts and published them in 1982 making it possible to directly compare the calcification stages of teeth on radiographs with the standards. They have their origin in work by Logan and Kronfeld.^{6,7,8}

Radiographically, the mineralization of deciduous incisors commences at the age of 16th week of intrauterine life. These stages of intrauterine mineralization and subsequent development, eruption and root completion were evaluated in deciduous (3-4 months intrauterine) and permanent (25 years after birth) and projected in two different charts in data provided by Kronfeld in 1935.⁵

Demirjian's developed a formula for age estimation based on OPG but this formula resulted in inferior age prediction when used in Indians (9.2% misclassification at 99% confidence interval vs. 0% misclassification in the original study); therefore, India-specific regression formulas were developed, which gave better age estimates (mean absolute error, MAE = 0.87 years) than the original formulas (MAE = 1.29 years). This suggests that Demirjian's 8-teeth method also needs adaptation before use in diverse populations.² Age estimation using Demirjian's formula resulted in an inferior age prediction of the Kanyakumari population, whereas there was very little difference between estimated dental age and chronological age calculated using an Indian-specific formula.^{2,4,5}

On the evaluation of the above-mentioned methods of age estimation, this research has been planned to compare Demirjian and Kronfeld's age estimation method using OPG.

Also, the comparative results of Demirjian's and Kronfeld's methods of age estimation are not assessed in children and adolescents. This study aims to compare the efficiency of Demirjian and Kronfeld's age estimation method using OPG.

2. Material and methods:

The present study was designed as an analytical and observational study, conducted on patients attending the outpatient department of Oral Medicine & Radiology, Government Dental College & Hospital, Nagpur, Maharashtra state, India.

Sample

A sample size was calculated using epi info and taking into consideration previous studies. Considering the 10% attrition sample size was 120 for each group.

A convenience sample was used to recruit patients, from the patients reporting to the Outpatient department. Only those patients were

included in the study who have been advised OPG from other departments and are in the age range of 7-22 years to avoid ethical issues of radiation exposure.

Patients having any pathologies like- fractures, cysts, tumors, fibrous dysplasia etc., missing teeth, congenital anomalies, systemic disease and uncooperative were excluded from the study sample.

The chronological age of the subject was noted and verified with valid official credentials (Aadhaar card, voters card etc.)

Analysis

The subjects underwent an Orthopantomogram scan (OPG) on the Sirona Orthophos XG OPG Machine. The digital OPG images obtained were saved in jpeg format keeping the exposure parameters constant for all the subjects and as per the instruction provided by the manufacturer. These OPG images were viewed in a dimly lit room on a desktop monitor. The demographic data was removed from the OPG images to blind the observers to the age and sex of the patient.

All 120 subjects were first analyzed for Kronfeld's method of age estimation. The observer used the chart provided by Kronfeld (**Figure 1 – A & B**) and the observations were recorded in Excel sheet by observer number 1 having expertise in Forensic Odontology.

These same subjects were analyzed for Demirjian's method of age estimation. The observer used the chart and scoring table provided by Acharya² for the Indian specific population which is a modified version of Demirjian's age estimation method (**Figure 2 & Table 1**) and the observations were recorded in Excel sheet by observer number 1 having expertise in Forensic Odontology.

The above procedure was carried out for observer number 2 who has expertise in oral radiology and observations were recorded in separate Excel sheets.

3. Results:

The present study was conducted on 120 subjects of which 16 (13.34%) were males and 104 (86.66%) were females. There was randomization in the sample collection. The majority of sample subjects were between 12-19 years of age.

The inter-observer bias was assessed by including two independent observers (observer number 1 with expertise in Forensic Odontology and observer number 2 with expertise in oral radiology) to assess the samples. Referring to a single measurement, i.e.

Figure 1 (A & B): Chart by Kronfeld- (A): Development of the deciduous teeth. Data from Kronfeld (1935), Y= age in years; M= age in months; MIU= months intrauterine; A= deciduous central incisor; E= deciduous second molar; (B): Development of the axillary and mandibular permanent teeth. Data from Kronfeld (1935) 1= First permanent incisor; 8= third permanent molar.

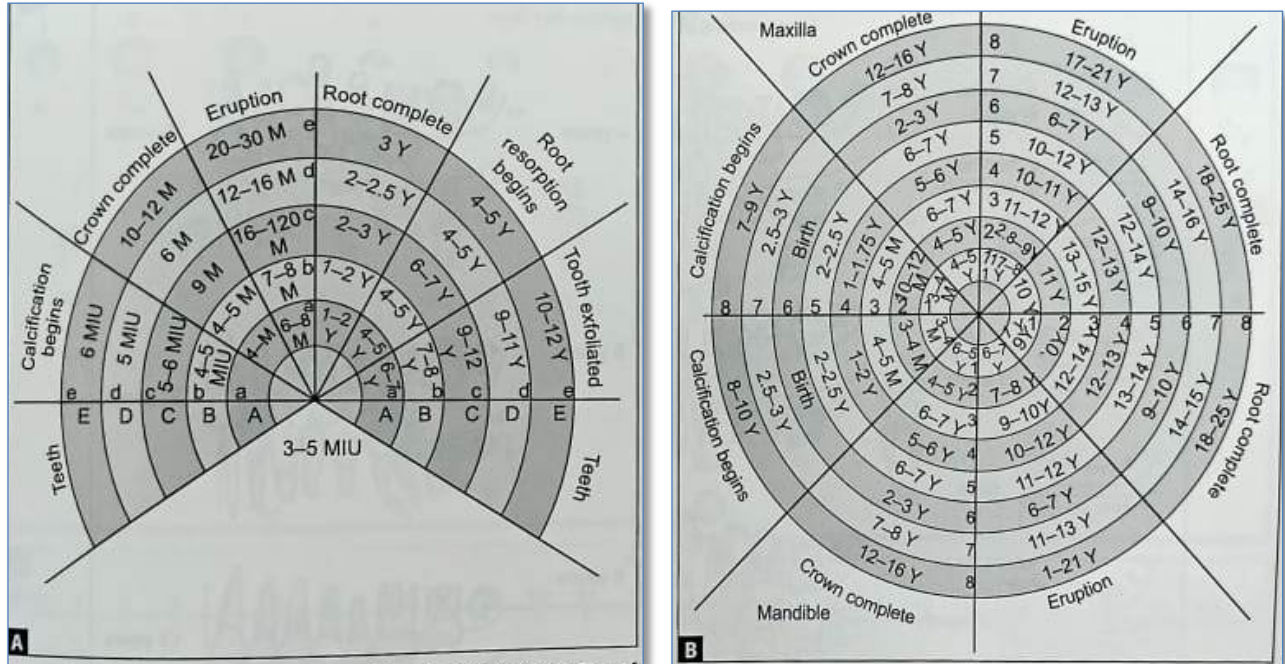


Table: 1 (A & B) Demirjian’s scoring table modified by Dr. Acharya for Indian population

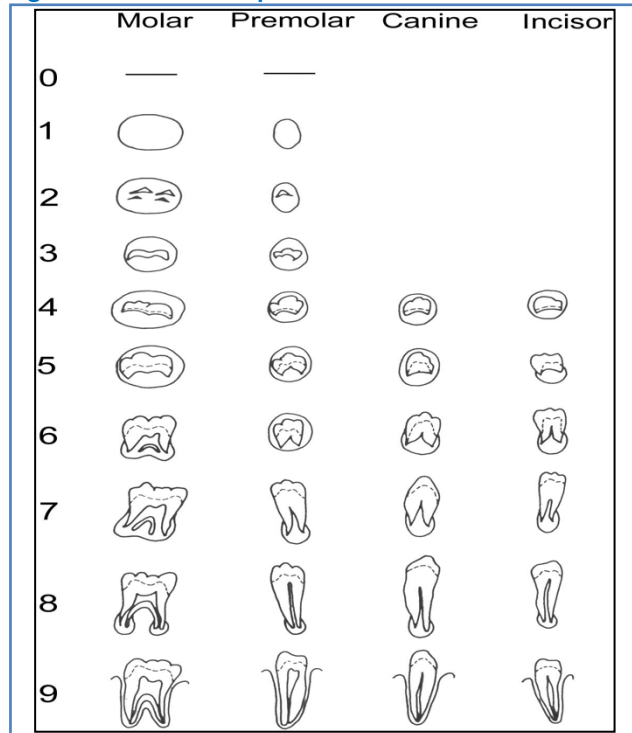
A: Maturity Scores for Females

Stage	31	32	33	34	35	36	37	38
0								6.40
1							2.57	7.74
2					2.43			8.92
3				2.56	3.43		2.65	9.31
4			2.55	3.54	3.83		4.10	10.22
5	2.58	2.65	3.15	5.09	5.75	2.58	6.51	11.04
6	3.10	4.54	5.40	6.31	6.81	3.25	8.00	12.65
7	5.02	5.40	7.19	8.09	8.70	4.25	9.13	13.77
8	6.66	7.02	9.22	9.82	10.80	6.88	11.00	14.45
9	10.61	10.89	11.99	12.29	12.79	10.94	13.84	16.65

B: Maturity Scores for Males

Stage	31	32	33	34	35	36	37	38
0							1.70	6.19
1					1.69		2.98	7.64
2				1.70	2.27		3.41	8.28
3			1.70	1.98	3.41		4.74	8.86
4			2.67	3.52	3.41		4.88	9.89
5	2.31	2.55	4.34	5.19	5.59	2.13	6.69	11.17
6	4.35	4.71	6.14	6.47	6.96	3.73	7.89	12.25
7	5.16	5.75	7.59	8.18	8.68	4.94	9.08	13.66
8	6.56	6.97	9.52	9.84	10.64	7.00	11.13	14.07
9	10.68	10.91	12.56	12.57	13.11	11.22	13.63	15.32

Figure 2: Tooth development chart



coefficient value was 0.96 {96% CI: 0.96-0.99} indicating an excellent agreement among the observers. There were two cases in which the

disagreement was observed. To assess the intra-observer bias, the same subject OPG was evaluated thrice by the first observer at a gap of one week between each evaluation.

The ICC obtained was 0.98{98% CI: 0.96-0.99}, with a p-value of < 0.0001 indicating excellent agreement between the scores obtained at three different instances. There was one case in which disagreement was observed in the time interval. For both inter and intra-observer assessment disagreement was only for one stage.

Table 2: Paired Samples Statistics (SD: Standard Deviation, Std. EM: Standard Error of Mean)

	Mean	N	SD	SEM
Pair 1 Kronfeld	16.63	120	3.234	.295
Chronological age	16.05	120	2.798	.255
Pair 2 Demirjian	16.51	120	2.929	.267
Chronological age	16.05	120	2.798	.255

Table 3: Paired Samples Correlations

	N	Correlation	Sig.
Pair 1 Kronfeld &	120	.820	.000
Chronological age			
Pair 2 Demirjian &	120	.810	.000
Chronological age			

Table 4: Paired Samples Test

		Paired Differences			
		Mean	SD	SEM	95% Confidence
		Lower			
Pair 1	Kronfeld – chronological age	.578	1.855	.169	.243
Pair 2	Demirjian – chronological age	.463	1.768	.161	.143

Table 5: Paired Samples Test

		Paired	t	df	Sig. (2-tailed)
		95% Confidence			
		Upper			
Pair 1	Kronfeld – chronological age	.914	3.416	119	.001
Pair 2	Demirjian – chronological age	.782	2.867	119	.005

The high level of agreement indicates that the scoring system and chart used for analysis are reproducible and reliable.

The recorded data was analyzed using SPSS 20 statistical software. The correlation coefficient was 0.820 for Kronfeld’s method and 0.810 for Demirjian’s method which shows high agreement between the chronologic age and dental age (Table,2,3 & 4).

Both Demirjian’s and Kronfeld’s methods are highly significant but Kronfeld’s method showed higher

significance (0.001) compared to Demirjian’s method (0.005) of age estimation (Table 5).

4. Discussion:

Absolutely, age is a critical factor in both identifying individuals and addressing various legal and medical issues.^{9,10} The evolution of forensic odontology is believed to have started in the Garden of Eden era and has revolutionized the present age of genetics.¹¹ Technological advances in dentistry and medical record-keeping have indeed increased the likelihood of using dental records for forensic

purposes.¹² Estimating age from teeth is considered a reliable method in forensic science and archaeology due to preservation of teeth for longer duration.¹³

The development and eruption of teeth are useful dental events to assess age. The tooth development process starts from the initiation of tooth bud formation from the embryonic cells and continues till complete root development.^{1,7}

Schour and Massler in 1941 introduced a chart explaining the development and eruption of human dentition.³ They studied the development of deciduous and permanent teeth in seven stages, i.e., prenatal (4.5–5 months utero), neonatal (at birth), infancy (birth to 6 months), childhood (2–6 years), early grade school (6–10 years), prepubertal period (10–12 years), and adulthood (12–21 years) using histological and radiographical method.³ They also compared the calcification stages of teeth on radiographs with the standards. The proposed numerical chart describes 21 chronological steps of teeth development ranging from 5 months in utero to 21 years of age. The American Dental Association (ADA) has periodically updated these charts and published them in 1982.¹⁴ This chart has its origin by Logan and Kronfeld but there is not much data available on the work done by Logan and Kronfeld.^{6,7,8}

In the present study, an attempt was made to utilize this simple technique to estimate the age of children and adolescents and compare it with the well-established Demirjian's modified technique of age estimation.

In 1935, Kronfeld and Logan developed the technique for age estimation in deciduous (4 MIU) till the age of 25 yrs.^{1,3,4,5} This technique is very simple and utilizes OPG and a radiologist which was appreciated in our study. There was an underestimation of age in 2 subjects (1.66%) and an overestimation in 2 subjects (1.66%).

Modified Demirjian's technique with Indian specific formula developed by Dr. Acharaya gave a low error rate in estimating age which justifies its application in the East Indian population.^{4,9} Age estimation using Demirjian's formula resulted in an inferior age prediction of the Kanyakumari population, whereas there was very little difference between estimated dental age and chronological age calculated using an Indian-specific formula as analysed by Akhil S et al which is by our study ($P=0.05$).⁴ In this study, there was an overestimation of age in 6 subjects (5%) and an underestimation in 8

subjects (6.66 %) in Demirjian's method of age estimation.

In the above age estimation methods i.e. Kronfeld and Demirjian's the common requirement was OPG- Orthopantomogram. Demirjian's method required an additional computer system for analysis using the sex-specific formula and charts provided for stage identification and score table. Comparatively, in Kronfeld's method, only a chart is required for the estimation. Besides age estimation from teeth development, there are other methods of age estimation in living and dead.¹⁵⁻²⁰

The advantage of Demirjian's method is that it can give exact age estimates but there is a practice to consider the range, also there is a separate formula and score for male and female. On the other hand, in Kronfeld's method, there is no requirement for any formula and a separate chart is provided for the maxilla and mandible, also using this method estimation of age can be done from the age of 4 months in utero till 25 years of age which proves its applicability in a wide age range.

5. Conclusion:

In conclusion, this study compares Demirjian's and Kronfeld's methods for age estimation in Central Indian population. Kronfeld's approach, utilizing panoramic radiographs, demonstrates higher significance and practicality, making it a reliable tool for age estimations in children and adolescents. The study highlights Kronfeld's method as a preferred option, emphasizing its simplicity and potential for application in forensic contexts, contributing to the advancement of forensic odontology.

Ethical Clearance: IEC approval is taken from the Institutional Ethical committee.

Contributor ship of Author: All authors equally contributed.

Conflict of interest: None to declare.

Source of funding: None to declare.

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Original Research Article

Pre-Mortem Versus Post-Mortem Findings in Trauma Fatalities - An Autopsy Based Study

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Key words

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Discrepancies.

Abstract

Background: This study evaluated the discrepancies between pre-mortem and postmortem diagnoses of trauma fatalities in autopsied deaths at a tertiary care center. **Material & Method:** The autopsy reports of forensic deaths were analyzed in comparison to the clinical records for 300 trauma fatalities over a period of one year. **Results:** Trauma deaths with at least six hours of hospitalization were included in the study; consent taken an inclusion criteria, 3139 medico-legal autopsies were conducted at the study centre during the study period, amongst which 1769 were trauma fatalities. Out of these, randomly selected 300 cases were included in the present study on the basis of inclusion and exclusion criteria and clinical records and autopsy details were analyzed. Mean age of traumatic fatalities was 37.72 + 18.29 years; Road traffic accident being the commonest cause of trauma. Cases of trauma fatalities within 24 hrs of the incident were maximum (25%) and least number of fatalities occurred after 2 weeks (5.3%). 52 cases had discrepancies between pre and post mortem findings and there was no discrepancy in diagnoses in rest 82.7% cases. Majority of cases with discrepancies were of traffic accident casualties (84.6%) followed by falls (15.4%). When clinicians focused on the treatment according to their main diagnosis, they overlooked the fatal injuries in other parts of the body. **Conclusion:** This study shows that autopsy is the most reliable method for the confirmation of the clinical diagnosis in trauma patients. Therefore, clinicians particularly surgeons should compare the results of the autopsy diagnoses to their own diagnosis to monitor and modify diagnostic and treatment protocols.

1. Introduction

An Autopsy is a vital tool for assessing the precision of clinical diagnosis, investigating and determining unsuspected diseases, and identifying causes of death.¹ Autopsy not only instructs and confirms but also serves as a pathway of study and

source of investigation.^{2,3} However, in recent years, the rates of autopsy have decreased dramatically worldwide.⁴ This decrease is due to several factors, including progress in diagnosis of diseases, particularly the development of advanced medical

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imaging methods such as computer tomography and magnetic resonance imaging.¹ However, it has been stated that advances in medical technologies do not bring a considerable reduction in the incidence of misdiagnoses.⁵ Undoubtedly, the recent technologic advancements in medical areas have allowed more sensitive and reliable methods for clinical diagnosis during life; nevertheless, significant discrepancies between clinical diagnosis and autopsy findings for patients who died in the hospital have been reported.⁶⁻¹⁰

Studies comparing the accuracy of ante-mortem diagnosis to autopsy diagnosis in different times have not documented a substantial decline of errors in diagnoses despite the new diagnostic resources available.¹¹⁻¹⁵ Severe injury is the leading cause of death among children, adolescents, and young adults, and represents the third most common cause of death for all ages in the western countries, after cardiovascular diseases and cancer.¹⁶

In cases of trauma death, review of autopsy data is also used as part of the trauma quality assurance process, and autopsy rates are queried by the American College of Surgeons Committee on Trauma in their reviews.¹⁷ Especially in death after trauma, autopsy data can provide sufficient data to assist in determining the presence of missed injuries contributory to death¹⁸, and also confirming the clinical cause of death.¹⁹ This study was undertaken to identify the discrepancies, if any, between ante-mortem diagnoses and post-mortem findings in medico-legal autopsies of traumatic fatalities at S.M.S. Hospital, Jaipur during the year 2017-2018.

2. Objectives

1. To observe discrepancies, if any, in clinical and post-mortem findings in traumatic fatalities.
2. To observe discrepancies, if any, in clinical and forensic cause of death in traumatic fatalities.

1. Material & method

This descriptive observational study was carried out at the Department of Forensic Medicine, SMS Medical College and Hospital, Jaipur over a period of one year from 1st April, 2017 to 31st March, 2018 on cases of hospitalized traumatic deaths at the institute after obtaining clearance from the Institutional Ethics Committee. Hospitalized traumatic deaths with more than six hours of admission with at least one clinical diagnosis along with clinical certification of cause of death were kept as inclusion criteria. Written informed consent for participation in the study was also an inclusion

criterion. Brought dead cases of trauma, those with insufficient records, non-autopsied releases and undiagnosed traumatic mortalities were excluded from the study. All cases were subjected to post-mortem examination and the post mortem findings recorded and forensic cause of death concluded. These were compared to the ante-mortem diagnosis and clinical cause of death. Complete details of clinical findings, ante-mortem diagnosis and clinical cause of death were noted from the treatment papers. Clinical records were scrutinized separately and independently after conducting postmortem examination to avoid observation bias during the autopsy. Period of survival was divided into eight groups viz. within 24 hours, 24 to 48 hours, 48 to 72 hours, 72-96 hours, 4 to 7 days, 1 to 2 weeks, 2-4 weeks and more than 4 weeks. Comparative results of clinical and forensic cause of deaths were categorized as completely consistent, completely inconsistent and partly inconsistent.

- **Completely consistent-** if both clinically as well as medico-legally, same injury and similar mechanisms were attributed to cause death.
- **Completely inconsistent (CI)-** if clinical and post mortem cause of deaths were completely incoherent or inconsistent; where a misdiagnosed or undiagnosed injury resulted in death which was either missing or overlooked in the clinical records.
- **Partially consistent (PI)-** if clinical and post-mortem cause of deaths were from similar injuries but not exactly the same injury; if any other injury was additionally found to contribute towards mortality or if mechanism of mortality was variable although injuries responsible were same.

Discrepancies recorded if any between pre-mortem and postmortem findings as regards to external and internal injuries were categorized in two groups-obvious and marginal discrepancies.

- **Obvious discrepancies-** those autopsy findings which remained clinically unsuspected, incorrect or interpreted differently in clinical records and contributed to fatality either alone or in conjunction with attributed clinically fatal injuries or mechanisms.
- **Marginal discrepancies-** those autopsy findings unsuspected or incorrect findings at autopsy when compared to clinical records that did not directly contribute to the patient's death but likely had an impact on the patient's mortality.

Continuous variables were summarized as mean and standard deviation whereas descriptive analysis for nominal/ categorical variables was in form of percentages and proportions. Statistical

analysis was conducted using Medcalc 7.4 version software. Chi-Square test was used for analysis of significance of nominal categorical variables, and, P value < 0.05 was considered as significant.

Figure 1: Showing Distribution of cases with and without discrepancies according to survival period

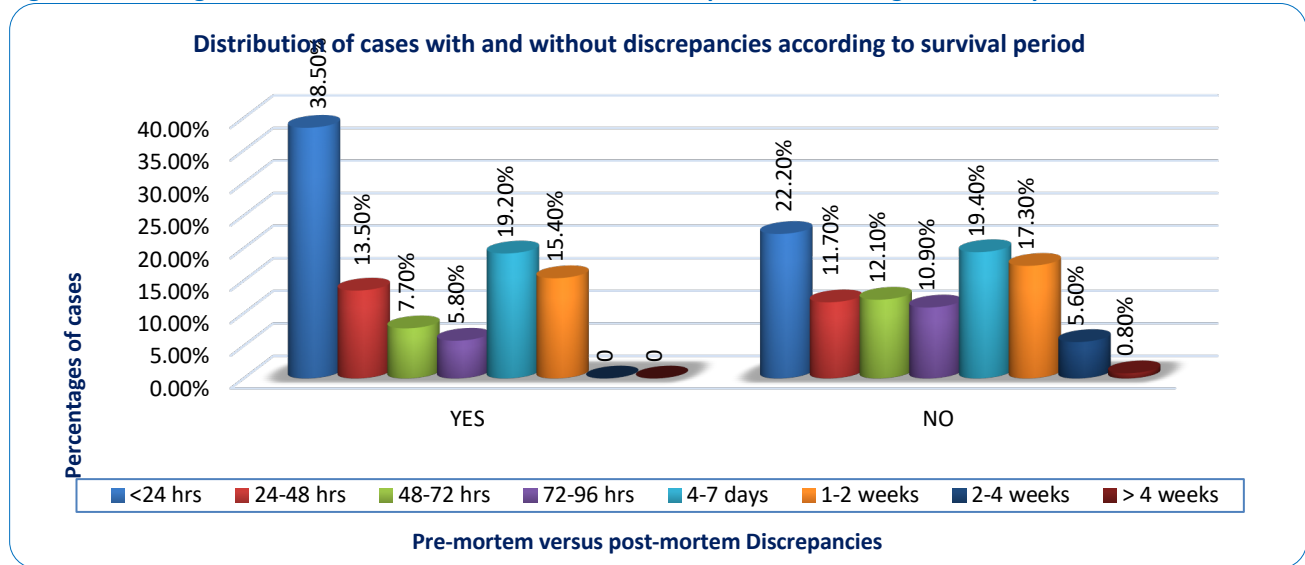


Figure 2: Proportion of missed injuries contributing to discrepancies between Clinical & Forensic cause of deaths

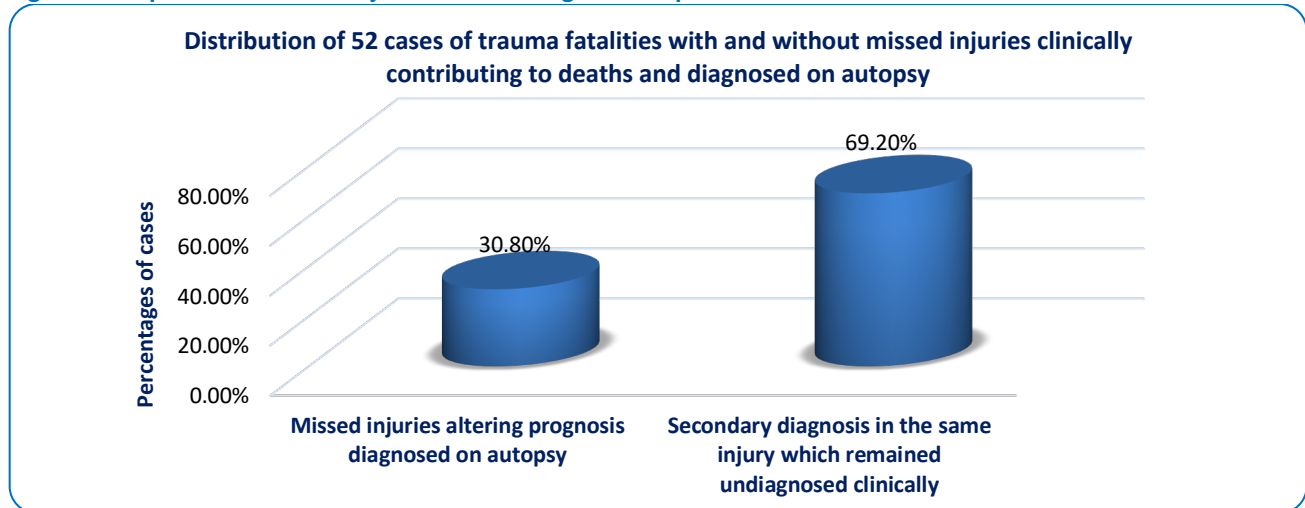


Figure 3: Showing sex wise distribution of cases with type of discrepancy in cause of death

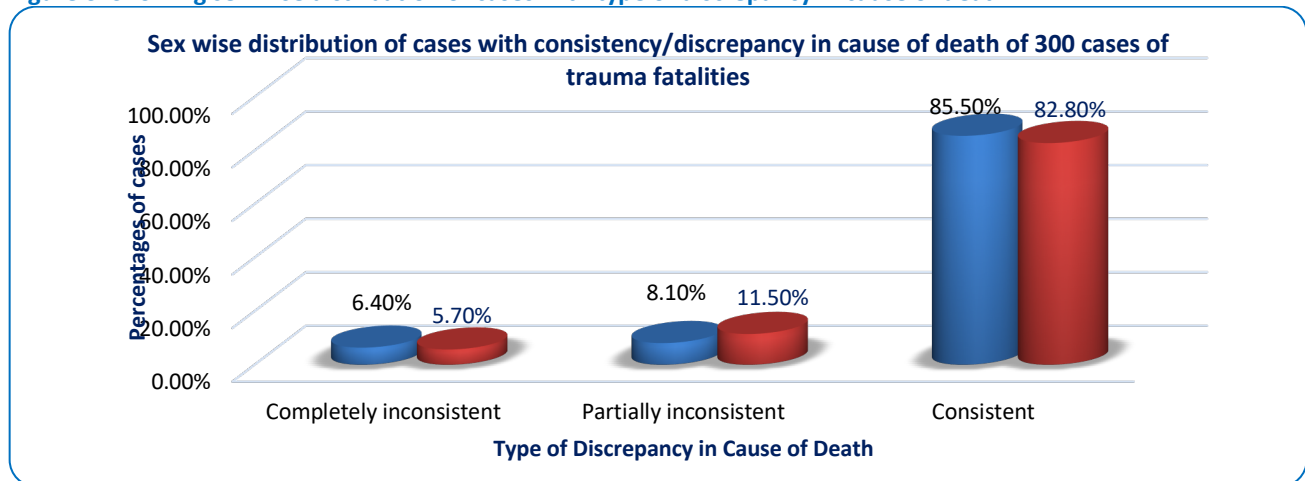
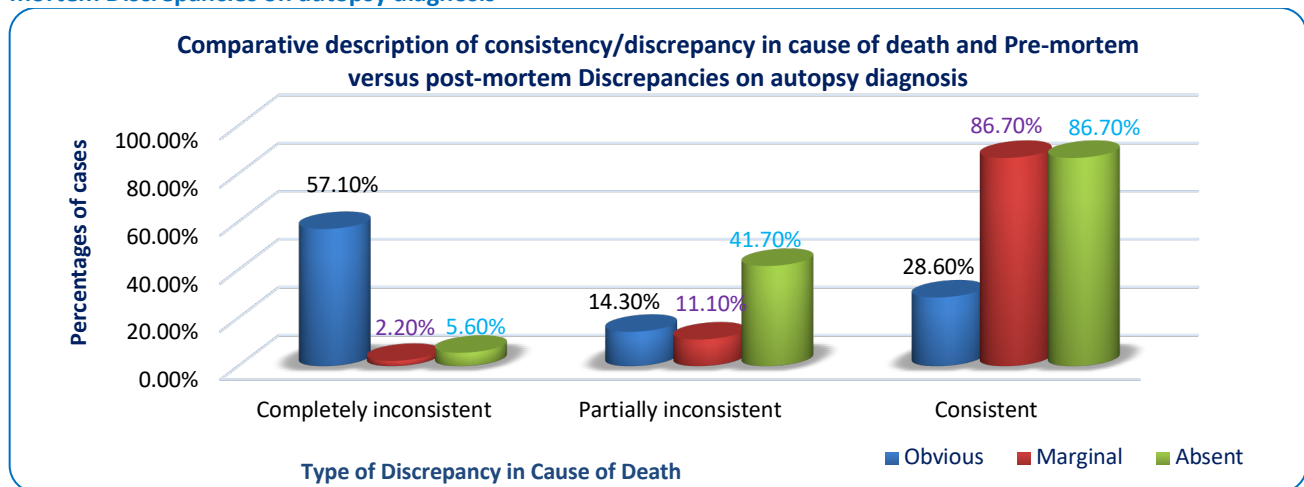


Figure 4: showing Comparative description of consistency/discrepancy in cause of death and Pre-mortem versus post-mortem Discrepancies on autopsy diagnosis



2. Results

A total of 1769 cases of traumatic fatalities were autopsied at the center between 1st April, 2017 and 31st March, 2018 out of which 300 cases satisfying the inclusion and exclusion criteria were included in the present study. The youngest traumatic fatality was 1.5 years old and oldest one was 95-year-old; mean age being 37.73±17.57 years; and mean ages of cases with and without discrepancies in the present study were respectively 38.70 and 37.52 years. Amongst 300 fatalities, discrepancies between clinical and post mortem findings were observed in 52 cases (17.3%). 86.5% of these (45 cases out of 300 i.e. 15%) had marginal discrepancies and rest seven cases 13.5% of discrepant (2.33% of all cases) had obvious discrepancies. 13.5% cases with discrepancies were females (all with marginal discrepancies) and rest 86.5% cases with discrepancies were males with all obvious discrepancies seen in males. Discrepancies in clinical versus post mortem findings were most commonly observed in the senior citizen age group (20.5%) and least commonly observed in less than 10 years age group (12.5%). 17.75% discrepant cases were road accident fatalities. Majority of the cases with discrepancy survived for less than 24 hours. Discrepancies were observed in 18.2% cases of road accidents in comparison to 15.7% cases with falls. 80.8% of these discrepant cases were misdiagnosed despite availability of investigation reports, and in rest 19.2% cases, the requisite investigation to conclude diagnosis was not advised by the clinician. In 30.8% of these cases, the discrepancy contributed to the fatality, thus altering the prognosis of the case.

Discrepancy between clinical and forensic cause of death was observed in 15% (45 cases) of the

traumatic fatalities. The clinical versus forensic cause of death was completely inconsistent in 42.2% of these (19 cases) and partially inconsistent in rest 57.8% (26 cases). The discrepant cases were proportionately more in females and were most commonly observed in 21-30 years followed by 41-50 years. 11 cases with discrepancy in clinical versus forensic cause of death, also had discrepancies between pre and post mortem findings but in rest 34 cases, there were inconsistencies in clinical versus forensic causes of deaths without any mismatch in pre & post mortem findings. Premortem and postmortem findings were completely consistent in 157 cases (52.3%) including these 34 cases. Most cases of completely inconsistent cause of death (73.7%) had no discrepancies in pre versus post mortem findings. Discrepancies in cause of deaths were observed in 12% cases of road accidents and 21.6% cases of falls. Maximum discrepancies were seen in < 24 hour (26.6%) and in 4-7 days survival following trauma.

115 cases (38.3%) out of 300 had discrepancies in radiological findings in clinical assessment as compared to the relevant findings on autopsy. 46.2% of these were senior citizens and 45.5% were teenagers and 86.9% were males. 49 cases with discrepancies in radiological findings including 13 cases of missed injuries remained undiagnosed clinically too, thus simultaneously exhibiting discrepancies between pre and post mortem findings. There were co-existing discrepancies in cause of deaths in cases with radiological discrepancies in 16.5% cases (6.9% completely inconsistent and 09.6% partially inconsistent).

3. Discussion

Trauma, including injuries from accidents, violence, and other causes, is indeed a significant public health issue, particularly in developing countries.²⁰ The present study included 300 traumatic deaths ranging from 1.5 to 95 years of age including 82.7% males and 17.3% females owing to their predisposition to trauma being active members of every society. Reported proportion of males was slightly higher in another study conducted at Turkey in 2015 due to societal variations.²¹ Mean age in the present study was 37.73 ± 17.57 years higher than reported by another author.²¹ Married males of 21-50 years were the predominant population of traumatic fatalities in the present study. Road traffic accident was the commonest cause of trauma in the present study followed by falls (17%) and hit by heavy objects (2% with a single case of train accident which are similar to the results of a study from Berlin with high velocity traffic accidents as leading cause of polytrauma followed by fall from height which had a single case each of homicidal stab injury, accident at work place and train accident adding to the similarity in the two studies.¹⁹ However, these results are much variable from another study from Turkey whose predominant fatality resulted from canister shots (56%), gunshots (26.1%), traffic accidents (6.5%), falls from a high place (8.1%) and others in 3.3%.²¹

We observed that in 70% cases, the mode of death was coma brought about as a consequence of head injury; in 10.3% cases, it was spinal shock consequent to vertebral and/ or spinal injuries; in 10% cases, deaths occurred due to septicemia consequent to secondary/ nosocomial infections following trauma during treatment and death resulted from hemorrhage and shock in 9.7% cases. 25% fatalities occurred within 24 hours and rest 75% fatalities occurred after 24 hours of the traumatic episode which is similar to 37.8% deaths in within 24 hours and rest 62.2% deaths after 24 hours²¹ but variable to 47% deaths within 24 hours, 32% deaths after a week and 21% between 4 hours to one week¹⁹ in comparison to 25% deaths within 24 hours, 22.3% deaths after a week and 52.7% deaths between 24 hours to one week in this study.

The premortem and postmortem findings were completely consistent in 157 cases (52.3%) and in rest 143 (47.7%) cases, there was one or the more type of discrepancies. The discrepancies observed in pre mortem clinical records and findings on medico-legal autopsy were- in forensic versus clinical cause of

death; clinical versus post mortem findings; and, discrepancies in radiological findings of clinical records. There were 52 cases (17.3% of all cases and 33.9% cases out of the 143 discrepant cases) with discrepancies in pre-mortem versus post-mortem findings. Out of these 52 cases, there were obvious discrepancies (majorly contributing to fatality) in seven cases (13.5% of cases with discrepancies in findings and 04.9% of 143 discrepant cases) and marginal discrepancies (partially contributing to fatality) in remaining 45 cases (86.5% of cases with discrepancies in findings and 31.5% of 143 discrepant cases). Thus, overall pre-mortem versus post-mortem findings were consistent in 52.3% cases and no discrepancy in diagnoses was seen 82.7% cases, which is nearly same as 79.5% consistent cases of premortem versus postmortem diagnoses by another author.²¹ All seven cases of obvious discrepancies were males. Majority of discrepancies in findings were observed in 21–30-year age group males from rural regions suffering traffic accident casualties (84.6%) followed by falls (15.4%) who succumbed within twenty-four hours and least number less than 10 years age group (1.9%). 38.5% discrepant cases succumbed within 24 hours in comparison to 22.2% non-discrepant cases. which is similar to two other studies.^{19,21}

Out of 52 cases with clinical vs autopsy discrepancies, investigations for diagnosing the discrepant findings were carried out in 42 cases (80.8%) and could not be done in rest 10 cases, which is again a notable finding as in spite of the advancement in technology of non-interventional diagnostic procedures and their execution, still there were discrepancies in pre mortem i.e. clinical versus post mortem findings. Amongst these 42 cases, there were cases 16 cases (30.8%) with secondary diagnoses on autopsies which were injuries that had been missed altogether, either unsuspected or complaint overlooked during clinical workup and had contributed to the fatality in all these cases. There were additional findings observed during autopsy in clinically diagnosed injuries in the rest 68.2% cases (36 cases). Amongst these 16 cases, there were 05 cases (31.2%) of obvious and rest 11 cases (68.8%) of marginal discrepancies. There were co-existing discrepancies in cause of deaths in 08 cases (05 obvious and 03 marginal discrepancies). These results show that there were missed injuries in 5.3% cases. The results of the present study are much lower to 14.6%²¹ and 50%¹⁹ reported by other authors but

quite comparable to another study where evident clinical consequences were ascertained in 4% (n = 1) and marginal clinical consequences in 24% (6/25) and in 16% (4/25), marginal differences with minor forensic consequences were revealed.²²

A total of 45 cases (15%) were incongruent in clinical versus forensic cause of deaths in the present study which is quite lower in comparison to 32%¹⁹ the reason being the advancement in technology over the years owing to the eight-year variation in the study period of both studies. Further classifications of these cases revealed that in 19 cases (42.2%) it was completely inconsistent and was partially inconsistent in rest 26 cases (57.8%). Gender based comparison of cases with and discrepancies in cause of death revealed that, discrepancies in clinical versus autopsy cause of deaths were higher in males (80%) in comparison to females (20%). Also, more prominent inconsistencies were observed more commonly in males. The mean age of study population was 37.73 years and the mean ages for cases with and without discrepancies of cause of death was 37.18 year and 37.82 year respectively considering cases with and without secondary diagnosis with maximum discrepancies observed in patients of 51-60 years age group from rural regions. Discrepancies in cause of deaths were observed in 12% cases of road accidents and 21.6% cases of falls. Thus, cases with discrepancies in cause of deaths were more commonly observed in fatalities due to falls in comparison to those due to traffic accidents.

No case of discrepancy in cause of death was observed in cases surviving for more than four weeks after the trauma and maximum discrepancies were observed in those surviving for less than 96 hours. This pattern was different for cases with and without discrepancies in cause of death as 27% cases without discrepancy died within 24 hrs in comparison to 13% cases with discrepancy. However, in 24.4% with discrepancy injuries in 4-7 days, and 18% cases without discrepancy. This proportion still increased in cases who died in 1-2 weeks period 26% with discrepancy and 15% without discrepancy and the proportion still was on the rise in cases with >2-week survival being about 3.9% cases without discrepancy and 13.3% with discrepancy. The results for the survival period of cases with and without discrepancies in cause of deaths was statistically significant (p-value= 0.039). The results of present study are in congruence to another study which reports 83% of cases (790 patients) did not have an

unexpected change and 17% of cases (162 patients) exhibited a true change in their final diagnosis of cause of death.²³ There are many autopsy based studies related to trauma fatalities²⁴, road traffic accidents with head injury²⁵, fatal trauma in road traffic accidents (RTA) involving two-wheelers²⁶, death due to traumatic injuries following fall from heights²⁷, antemortem study involving traumatic injuries in RTA²⁸.

4. Conclusion

The rates of discrepancies and missed injuries were especially higher in deaths due to road accidents which are commonest offender of human life through the globe and not just its incidence needs to be checked but also there is a grave need to monitor the quality assurance of services rendered in trauma care centers to reduce the effective mortality in these cases. Although definite opinion can't be given on the proportion of preventability of the fatalities in the present study, yet there appears a clear need to enhance radiological services to minimize faulty diagnoses as well as to reduce undiagnosed cases. The need of the hour is to start evaluation of autopsy data for surveillance of polytrauma care intended towards reduction of mortality following traumatic incidents.

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Original Research Article

Sexing of Dry Mandibles of Eastern Indian Population Using Discriminant Function Analysis

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Abstract

Introduction: At times, during an autopsy, the task becomes challenging without sufficient and robust information to properly fix the sex of the person. This study was done on archived museum sets of preserved dry mandibles of the Bengali population in the Department of Forensic Medicine of a medical college in Eastern India. **Methods:** A total of 44 mandibles were included in the study of which there were 26 males and 18 females. First, the sexing of each mandible was done based on the morphological characteristics of the bones. Then, eight (8) parameters were measured and studied in each mandible- four of them were midline data, and the rest four were bilateral data. **Results:** Standardized canonical discriminant function showed Bigonial Breadth (BGB) has the most explanatory power & the best predictor of sex. Discriminating Function equation and the sectioning point (Zo) was calculated using the Xavier formula. In the present study, the discriminant Function Analysis and equation obtained there of mandibles were correctly sexed with accuracy. **Conclusion:** Thus, it has been proved that morphometric data of mandibles can be used with precision to determine the sex of unknown samples.

1. Introduction

The largest and sturdiest lower jaw bone in the face is the mandible. It provides attachment to the mastication muscles and has lower teeth. Its body is anteriorly curled and posteriorly united by two rami. The mandibular teeth are supported by the body of the jaw within the alveolar process. The coronoid and condylar processes are located

on the rami. The temporomandibular joint is created by the articulation of each condylar process with the nearby temporal bone of the skull.^{1,2} Identification of human skeletal remains is a serious issue and crucial to anthropological and medical research.³

Age and sex can be determined by looking

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close to the skull and pelvis in human remains. The mandible's morphometric analysis and its relationship to gender play an important part in anthropological diagnosis. Due to its thick covering of compact bone and its ability to keep its shape and contour, the mandible is a sturdy component of the skull. The morphological features of the mandible aid in determining sex because they are subjective and frequently unclear. On average, female bones are weaker and smaller than male bones. Various lifestyles and chewing habits might affect how the mandible is shaped. The objective data provided by morphometric characteristics makes sex determination more precise and preferred.

The sex of skull bones can be determined using more precise methods based on osteometric measures. Discriminant function analysis can produce accurate results.⁴⁻¹¹ Several reference works of literature are devoted to mandibular morphological anatomy-based sexual polymorphism, race, and age transformations.¹²⁻¹⁹

Most of the parameters in Indian mandibles differ markedly from other ethnic groups. Such a racial variation is expected to exist because of the genetic makeup and social habits of different races. Numerous studies have demonstrated that skeletal characteristics vary by population-specific standards for sex determination. The present study was done to examine information about mandibular eight morphometric parameters in the Eastern Indian Bengali population to derive discriminant factors to determine the sex of the mandible. This study will be helpful not only for Forensic Medicine experts in medico-legal works, but also for Anatomists, Anthropologists, and Dental surgeons. The research study approval was taken from the Institutional Ethical committee. [Ref no: IEC-CNMC/2022/26].

2. Methodology:

All the preserved dry mandibles in the museum of the Department of Forensic Medicine of two medical colleges in Eastern India were used in this study. Mandibles with visible evidence of Fracture, Congenital deformity, and other damages or loss of bone tissue from any place were excluded from the study.

At first, the sexing of each mandible was done based on the morphological characteristics of the bones. Male and female sex was assigned by a set of two experts examining each bone independently. In the present study, eight (8) parameters were studied in the mandible [Figure 1].

1. **Bicondylar Breadth (BCB):** The maximum perpendicular distance between the most lateral points on the two condyles.
2. **Bimental Breadth (BMB):** The maximum axial distance between the two mental foramen.
3. **Bigonial Breadth (BGB):** The maximum perpendicular distance between the two gonias.
4. **Coronoid Breadth (CB):** The maximum perpendicular distance between the most lateral points on the two coronoid processes.
5. **Coronoid Height (CH):** (both left and right) Base or lower border of the body of the mandible to the highest point of the coronoid process perpendicularly.
6. **Maximum Ramus Breadth (MxRB):** (both left and right) Maximum antero-posterior breadth of the ramus.
7. **Minimum Ramus Breadth (MnRB):** (both left and right) Minimum antero-posterior breadth of the ramus.
8. **Maximum Ramus Height (MRH):** (both left and right) Direct distance from the highest point on the mandibular condyle to the gonion.

The first four parameters were singular including midline and the next four were measured on both sides of the mandible. A manual spreading caliper with fine adjustments was used. All measurements were done in centimeters and recorded to the nearest millimeter. After the measurements of all mandibles, the data were tabulated in MS Excel spreadsheet. Statistical analysis was conducted using Statistical Package for Social Sciences (SPSS) for Windows, version 29.0.1.0 (171).¹⁶ The level of statistical significance was set at $p < .05$. Firstly,

The descriptive statistics for the mandibular measurements were obtained. Then Levene's test was performed to find out the equality of variance between sexes followed by an independent student t-test to establish whether statistically significant differences existed ($p < .05$) between male and female counterparts. Then the demarking point for each variable was calculated. Then direct discriminant function analysis was done to find out the formula for sexual dimorphism.

3. Results

In this study, 44 dried mandibles were included. In three cases, there was confusion about sex initially. A third expert was involved in the examination to finalize the sex of the mandibles. Finally, 26 male (59%) and 18 female (41%) mandibles

were examined. The measurements were taken by two independent observers separately and the average of them were tabulated. The descriptive statistics were compiled for midline data (BCB, BMB, BGB, CB) in **Table 1** and for bilateral data (CH, MxRB, MnRB, MRH) in **Table 2**. Levene’s test for equality of

variance in two groups (male and female) was performed in each set of data. The p-value of Levene’s test must be <0.05 for unequal variance. In this study, the p-value of Levene’s test for all eight parameters was found to be >0.05 which signifies all the parameters have equal variance.

Figure 1: Eight (8) morphometric parameters of dry mandible

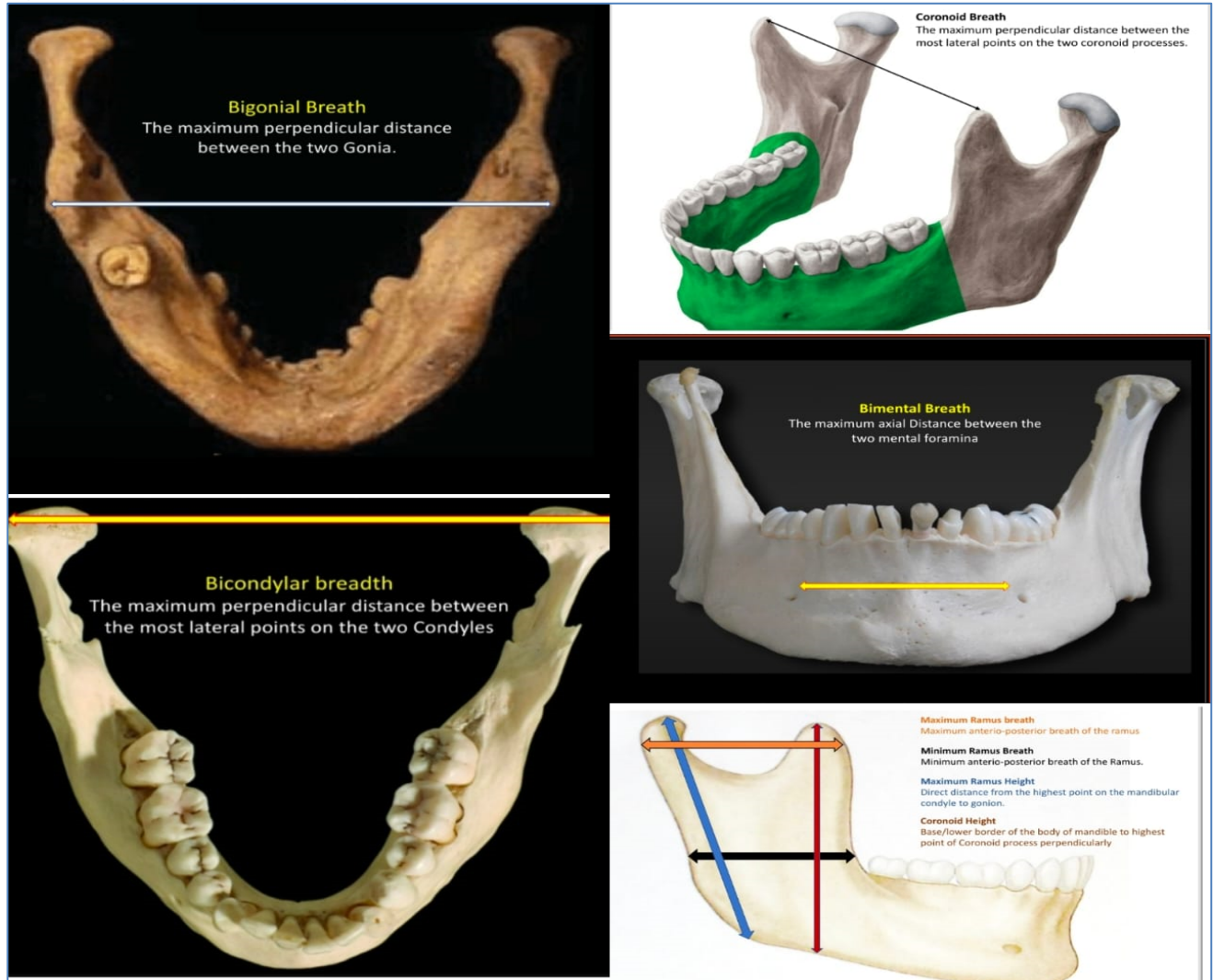


Table 1: Descriptive statistics of midline data measured in millimeters (n=44)

		Male	Female	Total
Bicondylar Breadth (BCB)	Max	127.6	118	127.6
	Mini	79	82.8	79
	Mean	110.65	101.25	106.80
	Median	112	105	107.45
	Standard Deviation	10.49	10.92	11.53
	Bimental Breadth (BMB)	Max	49.5	51.6
Mini		33.8	33.8	33.8
Mean		43.66	40.98	42.57
Median		43.3	40.7	42.6

		3.50	4.16	3.97
Bigonial Breadth (BGB)	Standard Deviation	3.50	4.16	3.97
	Max	105.6	95.8	105.6
	Mini	64.9	67.3	64.9
	Mean	91.44	82.3	87.70
	Median	93.55	82.05	87.8
Coronoid Breadth (CB)	Standard Deviation	8.28	7.49	9.10
	Max	109.6	107	109.6
	Mini	63.4	70	63.4
	Mean	94.01	84.82	90.25
	Median	95.35	85.5	89.65
	Standard Deviation	9.21	9.87	10.43

Table 2: Descriptive statistics of bilateral data measured in millimeters (n=44)

		Male		Female		Total	
		Right	Left	Right	Left	Right	Left
Coronoid Height (CH)	Max	567	70.5	63.4	65.9	567	70.5
	Mini	31	30.7	34.6	36	31	30.7
	Mean	78.05	58.63	51.28	52.37	67.1	56.07
	Median	60.05	60.45	53.1	54	56.95	57.5
	Standard Deviation	8.39	8.61	8.31	8.37	77.64	8.97
Maximum Ramus Breadth (MxRB)	Max	42.8	42.9	40.2	40.4	42.8	42.9
	Mini	26.9	26.6	22	22.4	22	22.4
	Mean	37.45	37.1	34.71	33.95	36.33	35.81
	Median	37.75	37.35	36	35.2	37.05	36.75
	Standard Deviation	3.48	3.65	4.78	4.99	4.24	4.48
Minimum Ramus Breadth (MnRB)	Max	36.6	36.8	36.4	35.8	36.6	36.8
	Mini	25.1	25.6	19.5	20.3	19.5	20.3
	Mean	31.26	31.38	29.2	28.41	30.42	30.17
	Median	32	31.85	29.55	29.15	30.85	30.5
	Standard Deviation	3.15	2.96	4.65	3.58	3.92	3.51
Maximum Ramus Height (MRH)	Max	74.9	80	69.5	67.5	74.9	80
	Mini	38.3	36.9	39.1	39.4	38.3	36.9
	Mean	60.96	60.61	55.07	55.35	58.55	58.46
	Median	63.4	63.1	54.35	56.2	60.6	58.9
	Standard Deviation	8.18	8.80	8.14	7.38	8.59	8.56

Figure 2: Explanatory power of the variables

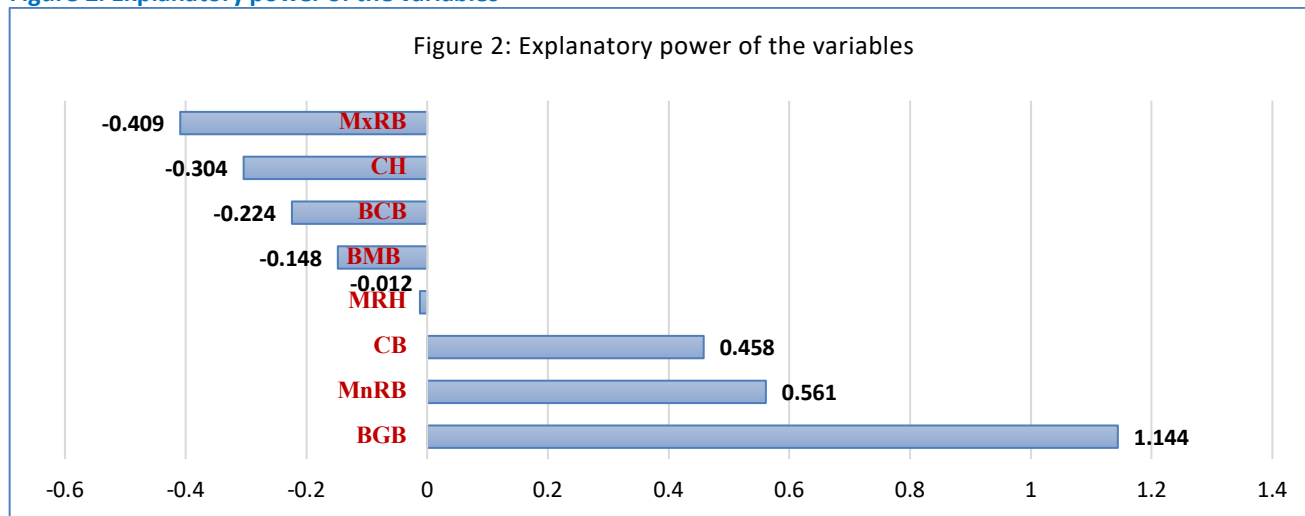
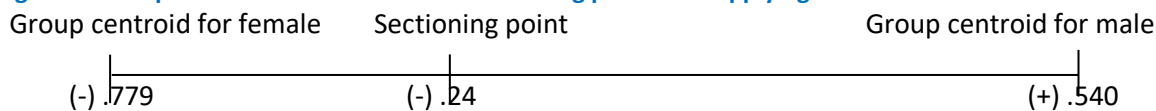


Figure-3: Group centroids for each sex and sectioning point after applying Xavier’s formula



An Independent t-test for comparing the mean values (Male and female) of each parameter was then performed. The p-value of the independent t-test for all eight parameters i.e., BCB (p=.006), BMB

($p=.026$), BGB ($p<.001$), CB ($p=.003$), CH ($p=.012$), MxRB ($p=.022$), MnRB ($p=0.20$), MRH ($p=0.31$) were found to be statistically significant. ($p<0.05$). The discriminant function analysis was done to compare sexual dimorphism and to formulate the equations for determining the sex of the mandible. For the bilateral data, the mean value of right and left-sided measurements was obtained as a single data for calculation. The value of Wilk's Lambda was determined and observed. The value of Wilk's Lambda ranges between 0 to 1. A high value of Wilk's Lambda denotes low significance i.e., less discriminating power of the proposed model. In this study, the value was found to be .694 ($df=8$) which indicates the model has good discriminating power. Standardized canonical discriminant function showed BGB has the most explanatory power with a coefficient of 1.144 and MxRB has the least explanatory power with a coefficient of (-).409 in this study. All the other six measurements have explanatory power somewhere between these two parameters [Figure -2].

Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions was done and structural matrix output shows BGB is the best predictor of sex with coefficient value (.869) followed by CB (.735), BCB (.668), CH (.609), MnRB (.562), MxRB (.552), BMB (.539), MRH with least coefficient value of .519. Unstandardized coefficients were calculated to obtain the Discriminating Function equation which is given below:

$$Y = (-12.269) + BCB*(-.021) + BMB*(-.039) + BGB*(.143) + CB*(.048) + CH*(-.036) + MxRB*(-.101) + MnRB*(.165) + MRH*(-.001)$$

[where Y= Score of the Sex (Male/Female) of the mandible, Constant= (-)12.269]

Y provides the discriminant score of any mandible whose BCB, BMB, BGB, CB, CH, MxRB, MnRB, and MRH measurement is known.

This diagram (function at group centroids) shows the unstandardized canonical discriminant functions evaluated at group means. In the present study, the value of -.779 and beyond was calculated to be for females, and .540 and above value for males [Figure- 3].

In the present study, the discriminant Function Analysis and equation obtained thereof show that 77.3% of mandibles were correctly sexed with accuracy. This is proven to be a good model. The Sectioning point (Z0) is calculated from the weighted

mean of values at the group centroids for males and females using the formula provided by Xavier (Z0):

$$\begin{aligned} Z0 &= (Zm \times Nf) + (Zf \times Nm) / (Nm + Nf) \\ &= (0.540 \times 18) + (-0.779 \times 26) / (26 + 18) \\ &= (-)0.24 \end{aligned}$$

Where Zm and Zf are the group centroids for male and female groups, Nm and Nf being the number of mandibles of males and females respectively. Any value above the sectioning point is classified as male and the values below the sectioning point are classified as female.

4. Discussion

Absolutely, the methods for determining gender, age and stature from skeletal remains can vary significantly based on the bones available and their preservation.^{20,21} The dry mandible is an important source of data in identification and has been studied in different regions of India and the world with different morphological and parametric data. Eight measurements have been taken into consideration in the present study and studies done in abroad and in India with similar parameters have been compared in the following Table 3.

Bigonial Distance (denoted as BGB in the present study) and MRH were considered in a Brazilian study done on 66 adult skulls (34 males & 32 females) yielded different results due to variations in ethnicity. The discriminant formula was created and sexing accuracy was found 76.47% for males & 78.13% for females which shows a similar result as in our study. It can be hypothesized that Latin American mandibles are similar in measurements to that of the Eastern Indian population (Bengali population).²⁹ BCB, BGB & CH were studied on 102 adult (68 males & 34 females) mandibles by Thailand researchers and all showed statistically significant differences between genders.³⁰ Two recent studies performed in Indian setup AP and East Asian setup Malaysia showed greater morphometric measurements in males in comparison to females.^{4,19} An Iranian study done in 2014 on 45 young subjects <20 years of age showed no statistically significant difference in the mandibular anthropometric values between two genders below the age of 12 years but above 12 years showed sexual dimorphism.²⁴ 67% accuracy was shown in an Egyptian study done recently on child and adult mandibles (99 males & 114 females) considering ramus measurements which were found statistically significant as in the present study.⁸ A recent study on the Greek population with (94 adult

mandibles (105 males & 89 females)) used 20 linear and 3 angular measurements to determine sex 85.7% accurately which is higher than the present study. Another Greek study done recently on 70 adult

mandibles showed a statistically significant difference between genders considering BCB, BGB & BMB, and the highest accuracy was shown 80% which is almost similar to the present study.^{5,9}

Table 3: Studies with similar study parameters done worldwide

Author	Year	Region	Sample Size	Bicondylar Breadth (BCB)	Bigonial Breadth (BGB)	Bimental Breadth (BMB)	Coronoid Breadth (CB)	Coronoid Height (CH)	Maximum Ramus Breadth (MxRB)	Minimum Ramus Breadth (MnRB)	Maximum Ramus Height (MRH)
Nutcharin Ongkana et al. ²²	2009	Thailand	102 (M=68, F=34)	✓	✓			✓	✓	✓	✓
Ivan Claudio Suazo Galdames et al. ²³	2009	Brazilian	32 (M=20, F=12)	✓	✓					✓	✓
Mihai Marinescu et al. ¹¹	2013	Romanian	200 (M=100=F)	✓	✓						
Mitra Akhlaghi et al. ²⁴	2014	Iranian	45 (M=23, F=22)		✓					✓	
Elena F. Kranioti ⁹	2014	Greek	70 (M=36, F=34)	✓	✓	✓					
Aspalilah Alias et al. ⁴	2018	Malaysia	79 (M=48, F=31)	✓	✓			✓	✓	✓	✓
Vineeta Saini et al. ⁶	2011	BHU	116 (M=92, F=24)					✓	✓	✓	✓
Vinay G. et al. ¹²	2013	Bangalore & Puducherry	250 (M=175, F=75)	✓	✓						
Pokhrel and Bhatnagar ¹⁰	2013	Pune	79 (M=53, F=26)						✓	✓	
KC Thakur et al. ²⁵	2013	Dehradun	60 (M=30=F)								✓
M. Punarjeevan Kumar et al. ²⁶	2013	Andhra Pradesh	80 (M=40, F=34, U=6)	✓	✓	✓	✓	✓	✓	✓	✓
James D. Raj et al. ¹⁸	2013	Chennai	120 (M=60=F)							✓	
Rahul Singh et al. ¹⁴	2015	Kanpur	50 (M=29, F=21)	✓	✓						
Anupam Datta et al. ¹⁷	2015	Karnataka	50 (Unknown Sex)	✓	✓	✓	✓				✓
Maneesha Sharma et al. ¹³	2016	Punjab & Chandigarh	120 (M=78, F=42)							✓	
J.Sarvesh Kumar et al. ¹⁵	2016	Chennai	38 (M=25, F=13)	✓	✓		✓				
Samatha K et al. ⁷	2016	Karnataka	120 (M=60=F)					✓	✓	✓	✓

B. N. V. S. Satish et al. ²⁷	2017	Karnataka	200 (M=100= F)	✓	✓				✓		
Najma Mobin et al. ¹⁶	2018	Karnataka	120 (Unknown Sex)	✓	✓					✓	✓
Dr Ranjana Agrawal et al. ²⁸	2018	Jhansi	52 (M=29, F=23)							✓	
Dr.Praveen Vaddadi ¹⁹	2021	Andhra Pradesh	100 (M=57, F=43)		✓			✓	✓	✓	
Present study	2023	India	22 (M=26, F=18)	✓	✓	✓	✓	✓	✓	✓	✓

Discriminant function analysis was done in a Romanian study on 200 adult mandibles with a mean age of 39 years including Bigonial Width (measured as BGB in the present study) and BCB with sexing accuracy of 84%. Most dimorphic singular measurement was found to be Bigonial Width 80.5% alone which is similar to the present study findings.¹¹ The measurements in males and females for different parameters are similar to the studies done in North India & South India recently.^{14,15} The measurements in our study (8 parameters) showed higher value in the case of males in comparison to female samples as a whole and the difference is statistically significant proven by unpaired t-test ($p < 0.05$) which is similar in studies done in different Indian set up of Chennai & Karnataka very recently.^{16,17} A recent study performed in South India (Bangalore) on 250 adult mandibles (175 males & 75 females) measured BGB & BCB showed a statistically significant gender difference which is similar to the respective measurement calculated in our study.¹² A study done in North India (Chandigarh & Punjab) on 120 mandibles (93 adults, 27 old) of both sexes measured MnRB and statistically significant difference in gender difference. The accuracy of sex determination from the mandible was calculated to be 60% with the addition of 2 more parameters namely diagonal length & horizontal length. However, in our study, the accuracy of sex determination from the mandible was measured to be higher (77.3%).¹³

MxRB, MnRB & CH were analyzed in a South Indian study with discriminant function analysis and the sexual dimorphism was noted to be statistically significant as in the present study.⁷ 6 dominating parameters were identified in another South Indian study in Chennai & Andhra Pradesh on 74 mandibles (40 males & 34 females) in which accuracy was found to be 75% which is comparable with the present

study.²⁶ Two recent research articles done in the middle part of India (Madhya Pradesh) yielded statistically significant results considering MnRB in one and the other highlights important findings in the form of a systematic review that includes 36 articles of which 16 are on radiographic studies 14 out of them are on adult mandibles showing statistically significant result involving different parameters for sexing of mandibles.^{28,30} Among MRH, BGB & BCB, these 3 parameters, MRH was proven to be most sexually dimorphic through a study on 200 adult mandibles (18-30 years) done in Karnataka recently.²⁷

A Western Indian study showed a varied range of accuracy (69.2-89.6%) of sexing mandibles if MnRB and MxRB are considered.¹⁰ A Northern Indian study measured ramus height at 49.4 millimeters on the right side and 48 millimeters on the left side which is comparatively shorter than the measurement in the present study.²⁵ Some researchers estimated sex from mandibular canine index³¹ and some estimated age from radiological evaluation of maxillary third molars³². This study is not beyond limitation. Taking more parameters, including more samples, and performing the study over a longer period may yield better results.

5. Conclusion

Mandibles can be a good source of data for identification in a given population. Not only the intact mandible with all the teeth available in the alveolar process, but a fragmented or broken mandible can also be helpful in the identification of sex sphering the midline data as considered in this study.

This study is the first of its kind performed in eastern India (Bengali population) where discriminant function analysis has been performed for mathematically determining the sex of a dried mandible. The measurements and discriminating

power are unique in this population and it is also comparable with other Indian data and that of Latin American studies. The determination of sex, thus, can be easier in the future for the identification of unknown subjects.

6. Recommendations / suggestions:

Apart from the sexing of the mandibles in forensic anthropology during investigation and postmortem examination, it is recommended to take into account the morphometric parameters in addition to the morphological attributes. India is a culturally and ethnically diverse country. A regional database can be prepared on mandible and other bones using discriminant function analysis of the morphometric parameters for future use.

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Contributor ship of Author: All authors equally contributed.

Conflict of interest: None to declare.

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Original Research Article

Exploring Cheiloscopy Patterns in Tamil Nadu: A Comprehensive Analysis of Lip Print Variations among Students

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Abstract

Introduction: India is one of the largest countries, inhabited by diverse populations comprising different tribes, castes, religious groups, and migrants. While the people of India share some common physical features, they also exhibit differences in their cultural, anthropological, and genetic traits. In this study, our objective is to analyse diverse lip print patterns in human subjects, considering both their gender and geographical background. **Materials and methods:** Our study includes five hundred randomly selected specimens, encompassing individuals of both genders and diverse regions from various districts of Tamil Nadu between 18 to 25 years. Participants with lip deformities, allergies to agents used during sample collection, and those experiencing lip inflammation were not included in our study. **Results:** The present study comprised 500 participants. The average age of the study population was 21.76 ± 1.894 . The demographic distribution showed 51% males and 49% females. In the female population residing in all the major cities Type 2 was the most common compare to all the other types but in Madurai type 1 was more common. **Conclusion:** Given the uniqueness of lip prints for each individual, Cheiloscopy emerges as a valuable method for identification in forensic odontology. Consequently, the study underscores the importance of lip print analysis, or cheiloscopy, as a valuable adjunct for identification in the field of forensic odontology.

1. Introduction

The India is one of the largest countries, inhabited by diverse populations comprising different tribes, castes, religious groups, and migrants. While the people of India share some

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common physical features, they also exhibit differences in their cultural, anthropological, and genetic traits.¹

In forensic investigations, personal identification holds utmost importance. It is typically based on the theory asserting that each individual is unique and can be identified based on distinctive features. The biological phenomenon of characteristic patterns observed on the vermilion border of lips was initially described by Fischer in 1902. However, it was Snyder in 1950 who proposed the use of lip prints as an identification tool.² A normal wrinkle and groove between the inner labial mucosa and outer skin are defined as lip prints, and the examination of these is known as cheiloscropy.³ In 1970, Suzuki and Tsuchihashi presented the term "Sulci labiorum" for the lip prints comprising these grooves, labelled "FIGURALINEARUM LABIORUMRUBRORUM" The study of these lip prints, denoted to as cheiloscropy, is said to be unique to each individual, akin to fingerprints.⁴

The techniques employed in cheiloscropy are accorded the same significance as other forms of forensic evidence commonly used for personal identification and sex determination.^{5,6} Suzuki and Tsuchihashi devised a lip print classification method in 1970, which remains the most widely used classification in literature.⁷ In this study, our objective is to analyse diverse lip print patterns in human subjects, considering both their gender and geographical background. Additionally, we aim to identify any commonalities in specific patterns among the subjects. To the best of our knowledge, this study signifies the first instance in the literature where lip print analyses have been performed, comparing both genders and populations from various districts of Tamil Nadu.

2. Materials and methods

Subjects: Our study includes five hundred randomly selected specimens, encompassing individuals of both genders and diverse regions from various districts of Tamil Nadu. The age range for participants in our study is between 18 to 25 years, with a distribution of 255 males and 245 females.

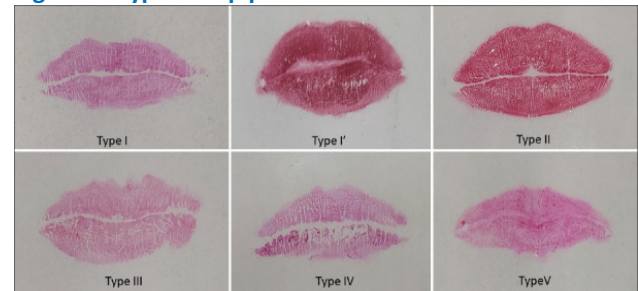
Exclusion Criteria: Participants with lip deformities, allergies to agents used during sample collection, and those experiencing lip inflammation were not included in our study.

Ethical Considerations: Prior to sample collection, informed valid consent was obtained from each participant. Additionally, the study received approval

from the ethics committee. The specimens were coded and documented in accordance with ethical guidelines.

Recording and Examination of Lip Prints: To record lip prints, we applied dark red or pink nonglossy, non-metallic lipstick with a single stroke evenly up to the vermilion border. The lipstick was applied onto cleaned and dry lips, left for 2 minutes, and then a lip impression was made on a strip of cellophane tape. This tape was then affixed to white, thin bond paper (A4 70 GSM). The impressions for different lip print patterns were observed under a 10X magnifying glass. The same method was consistently employed for obtaining impressions from all subjects. Each lip print impressions were classified into six patterns based on the classification given by K. Suzuki and Y. Tsuchihashi (figure 1). All these data were coded and analyzed using the Statistical Package for the Social Sciences (SPSS, ver. 17.0; SPSS Inc, Chicago, IL, USA). The level of statistical significance was kept at $p \leq 0.05$.

Figure 1: Types of lip prints



Type I – A clear-cut groove running vertically across the lip.

Type I' – Partial length groove of Type I.

Type II – A branched groove.

Type III – An intersected groove.

Type IV – A reticular pattern.

Type V – Morphologically not differentiated (undetermined)

3. Results

The present study comprised 500 participants. The average age of the study population was 21.76 ± 1.894 . The demographic distribution showed 51% males and 49% females (Figure 2).

Geographically, 21% of the participants were from Chennai district, 20% were from Trichy, Coimbatore, Madurai district and 19% of the participants were from Tirunelveli district (Figure 3).

In the male population residing in Chennai, Trichy and Coimbatore Type 2 was the most common compare to all the other types, in Madurai and Tirunelveli type 1 was more common compare to type

2 (Table 1). In the female population residing in all the major cities Type 2 was the most common compare to all the other types but in Madurai type 1 was more common (Table 2).

Figure 2: Gender distribution in percentage

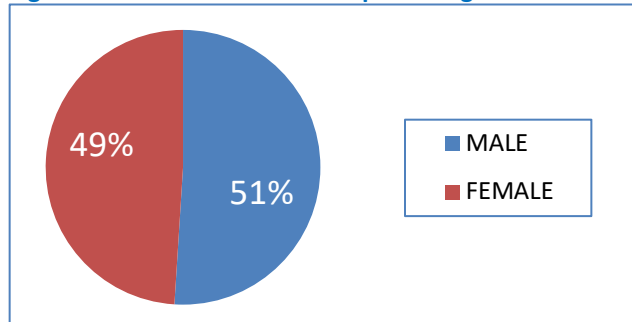


Figure 3: Geographic distribution in percentage

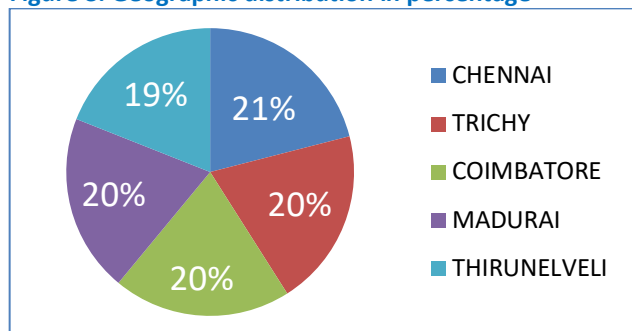


Figure 4: Total distribution of lip print types

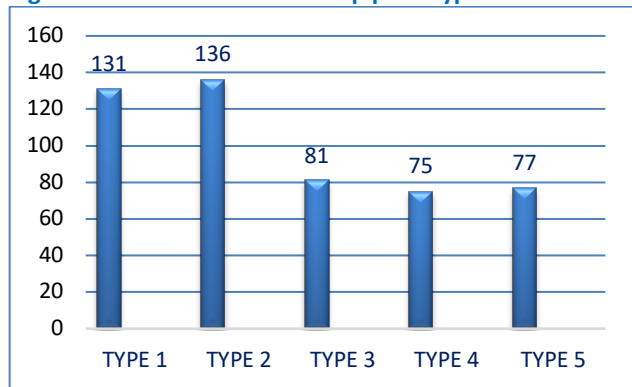


Table 1: Number of males in each zone (total - 255)

Zone	Type 1	Type 2	Type 3	Type 4	Type 5
Chennai	14	15	8	9	9
Trichy	12	14	9	8	8
Coimbatore	14	15	8	6	7
Madurai	13	12	9	8	9
Tirunelveli	14	13	6	9	6

Table 2- number of females in each zone (total- 245)

Zone	Type 1	Type 2	Type 3	Type 4	Type 5
Chennai	13	15	8	7	7
Trichy	14	15	8	8	6
Coimbatore	13	14	8	6	7
Madurai	13	12	8	7	9
Tirunelveli	11	11	9	7	9

Comparing both the genders in all the cities of Tamil Nadu type 2 was the most common (27.2%), type 1 was the second most common (26.2%) and type 4 and type 5 are seen least common compare to all the other types. (15%) (Figure 4).

4. Discussion

Determination of the identity of the person is one of the vital for conviction of the culprit.⁸ Various methods of human identification exist, with fingerprint and DNA analysis being common techniques. Lip print patterns, unlike fingerprints and DNA, are permanent and remain unchanged even after death, except in monozygotic twins. These unique lip print patterns prove valuable in personnel identification and forensic investigations. In this study, we employed the conventional lipstick method for recording lip prints.

This study is the first to compare lip print patterns in Tamil Nadu population. When comparing different districts, no statistically significant differences were observed. However, a significant difference was noted between males and females for the 1st and 2nd type, while no significant difference was found for the other types.

The predominant lip print pattern observed in our study across state was Type 2 (refer to Table 1). This finding aligns with a study by Makesh Raj et al.⁴, where Type 2 was common in the upper lip of males. Similarly, Dwivedi et al.⁹ reported Type 2 as the most common pattern. Bharathi and Thenmozhi⁵ found Type 2 to be predominant in the upper lip of males and in females, with Type 2 being most prevalent in the lower lip.

In the population of Madurai, Type 1 was the most predominant pattern, coinciding with Kapoor and Badiye's study in an Indian sample population.³ This result also aligns with Ghimire et al.'s study in Nepalese students, where Type 1 was the most common pattern in both males and females. Ranjan et al.¹⁰ found Type 1 to be the most common pattern in students from, Modinagar (Uttar Pradesh). Studies by Alzapur et al.¹¹ and Vahanwalla and Parekh¹² also found Type 1 to be the most common lip print pattern in diverse populations. Kaul et al.¹ observed Type 1 as the most prevalent pattern in various Ethno-racial Groups in India. However, the present study contrasts with findings by Sivapathasundharam et al., Sharma et al., Verghese and Mestri, who confirmed that Type 4 was the most prominent pattern,^{3,11,13,14,15} and Gondivkar et al. and Saraswathi et al.^{16,17} who showed Type 3 as the most

predominant type. Tsuchihashi's study on 1364 Japanese men and women revealed Type 3 as the most common in both genders. Loganadan et al.¹⁸ conducted a study among Deutero-Malay population in Indonesia, finding Type 1' as the most dominant lip print type. Similarly, Bindal et al.¹⁹, using samples from three races in Malaysia, observed Type 1' as the most common pattern.

5. Medicolegal implications

Forensic Identification: Lip prints, as a unique biometric marker, can enhance forensic identification practices. Our study provides evidence supporting the reliability and uniqueness of lip print patterns, potentially adding another tool for forensic odontologists and investigators.

Individualization and Uniqueness: Like fingerprints, lip prints are considered permanent and unique to each individual (except for identical twins). This characteristic strengthens their utility in cases where positive identification is crucial, such as in criminal investigations or disaster victim identification.

Gender and Geographical Variability: Our study highlights variations in lip print patterns based on gender and geographical location within Tamil Nadu. This data can assist forensic experts in narrowing down potential matches or excluding individuals based on these characteristics, enhancing the accuracy of identifications. Some researchers studied use of fingerprints for gender identification.²⁰

Validation of Lip Print Classifications: By using Suzuki and Tsuchihashi's classification method and demonstrating its applicability in a diverse population, our study contributes to the validation and standardization of lip print analysis in forensic science. This can lead to wider acceptance of lip prints as admissible evidence in legal proceedings.

Ethical and Legal Compliance: Our study emphasizes ethical considerations, such as obtaining informed consent and securing ethical approval. Adherence to ethical guidelines ensures the validity and integrity of the data collected, which is crucial for legal acceptance and compliance with regulatory requirements.²¹⁻²³

Scientific Foundation for Forensic Practice: Establishing the prevalence and distribution of lip print patterns in a specific population (Tamil Nadu) contributes to the scientific foundation of forensic odontology. This foundation supports the development of protocols and best practices for using lip prints in forensic investigations.

Education and Training: Findings from your study can inform educational curricula and training programs for forensic odontologists and investigators, enhancing their proficiency in using lip prints for identification purposes.²⁴⁻²⁷ Some researchers studied fingerprints to establish identity of individual.²⁸

Our research on lip prints has significant implications for enhancing forensic practices, improving identification accuracy, and ensuring ethical and legal compliance in forensic investigations. These implications underscore the importance of continued research and application of lip print analysis in forensic odontology and related fields.

6. Conclusion

Given the uniqueness of lip prints for each individual, Cheiloscopy emerges as a valuable method for identification in forensic odontology. Our study revealed Type 2 as the predominant pattern in the cities like Chennai, Trichy Coimbatore and Tirunelveli while Type 1 was prevalent in the Madurai population. The study concluded a statistically significant gender difference with variations in geographical locations. Consequently, the study underscores the importance of lip print analysis, or cheiloscopy, as a valuable adjunct for identification in the field of forensic odontology.

Ethical Clearance: IEC approval is taken from the Institutional Ethical committee.

Contributor ship of Author: All authors equally contributed.

Conflict of interest: None to declare.

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Original Research Article

Retrospective Analysis of 1988 Indian Airlines 113-737 Crash at Ahmedabad: Medico-legal Investigation of a Mass Disaster

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Abstract

Introduction/Background/Aim: This retrospective study of 1988 Ahmedabad airplane crash is aimed to determine the role of Forensic Medicine Expert in medico-legal investigation of a mass disaster. The larger aircraft, with capacity for more passengers, make such investigation a study in mass disaster planning, procedures and logistics. **Materials & Methods:** Medico-legal autopsy reports and accompanying police papers of victims of this airplane crash are evaluated and findings are compared with the studies having similar objectives. **Results:** Most of victims (84 %) were identified by the secondary methods of identification (Personal belongings especially metallic ornaments). 8% victims were identified by anthropological data obtained during autopsy e.g. age, sex, stature etc. Old scar and congenital deformities were useful in 4 % cases. Dental method was useful in 3 % cases and 1 case was identified by the lower limb prosthesis. Maximum number of deceased had burns (76.74 %), followed by head injury with skull fracture (54.26 %). Fractures of tibia and fibula are also seen in 42.63 % cases. Most common cause of death was burns (41.86 %), followed by multiple injuries to body (32.55 %). 15.50 % victims were died due to burns associated with multiple injuries. **Conclusions:** In airplane crash disasters, Forensic Medicine Expert has three major functions: identification of victims, documentation of their injuries and disease process, and correlation of these findings with the aircraft and crash site evidence. It is incumbent on individual expert as well as Forensic Medicine Department in their own and the public interest to have forward planning for such an eventuality.

1. Introduction

Aviation is a highly skilled task that demands a perfect coordination of man and machine to complete the mission undertaken. An in-depth analysis of all factors and aspects leading to any such catastrophe is mandatory and should

be done to pinpoint the exact cause of accident in order to prevent any future accidents.¹ On Wednesday 19th October 1988, the Indian Airlines flight IC 113 travelling from Mumbai to Ahmedabad crashed on its final approach to

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Ahmedabad airport. The crash site was 2.5 km away from the approach end of runway. The aircraft was a Boeing 737-200. In this air crash 124 passengers and 6 crew including pilot and co-pilot were found dead on the spot. Five passengers escaped with serious injuries, but 3 of them succumbed to the injuries later on in the hospital, 2 passengers survived.²

The court of inquiry arrived at the following conclusion: the cause of accident is error of judgment on the part of the Pilot-in-command as well as the Co-pilot associated with poor visibility.² In India, all aviation accidents are investigated in detail, either by the military or Director General Civil Aviation (DGCA). The medical aspects are analyzed centrally at the Institute of Aerospace Medicine (IAM) Bengaluru.¹

Main objectives of the medico-legal investigation of an air craft accident is ^{3,4,5,6,7,8}

1. Identification of victims.
2. Establishment of the cause of death.
3. Identification of cause of crash (to look for the presence of intoxicants or evidence of disease in the pilot. Evidence of explosives or firearm's injuries)
4. Reconstruction of the event by study of the pattern of injuries.
5. Assessing effectiveness of safety equipments by identifying fatal injuries and thus indicating specific needs for improved safety features.

The prime aim of such investigation is to ascertain the conditions and causes of accident in view to safeguard the lives and prevention of accidents in future.⁸ It is essential that Forensic Medicine Expert should ensure that, there is cooperative preplanning that includes adequate provision for collection, accommodation, examination and disposal of large number of dead victims. He is often the person with the most foresight and professional knowledge to acts as the stimulus and catalyst between the major agencies responsible for overall planning.⁶ This study is aimed to determine the role of Forensic Medicine Expert in the investigation, assessment and evaluation of the fatal aircraft crashes. Study of such disasters provides many lessons in the organization of a major disaster.

This retrospective study is carried out with following aims and objectives:

- To study the various methods for establishment of identification of victims of aircraft crash disaster;
- To study the pattern of injuries and different types of causes of death in the victims of aircraft crash disaster which might help the investigating agency

in reconstruction of the disaster event and in establishment of cause of disaster by finding out any human factor responsible for the disaster either causative or contributory;

- To provide information that might prevent or minimize the occurrence and effects of similar types of incident or injury in the future, from safety point of view.

2. Materials & methods

Present study was conducted in Forensic Medicine & Toxicology Department of a medical college and tertiary care hospital in Ahmedabad city during the period of one year from January 2018 to December 2018. In this study, air crash disaster of Ahmedabad in 1988 was analyzed retrospectively in detail with respect to management of dead bodies and role of Forensic Medicine Experts in such disaster. Permission of Institutional Ethics Committee was obtained before starting this research project. For the purpose of this study only fatal cases involved in this disaster were included while living cases were excluded.

The data of 129 fatal cases was taken into consideration which was then compiled and analyzed for the present treatise. Information and data were collected from police papers including inquest reports, autopsy reports, and reports of laboratory investigations i.e. chemical analysis and histopathological examinations. Research papers of various authors regarding aircraft crash disasters and role of Forensic Medicine experts in such major catastrophic event were studied in detail and their work is compared with present study.

3. Results

Out of 129 deceased victims, 103 (79.84 %) were male and 26 (20.16 %) were female. Maximum number of victims were in the age group 21-30 years (28.01%), followed by 31-40 years (27.06%) and 41-50 years (24.8%) (**Table 1**). Most of victims (84 %) were identified by the secondary methods of identification (Visual recognition, Clothes and Personal belongings). Metallic jewellery, other metallic belongings like wrist watch and keys were proved to be very useful in the identification of the victims of Ahmedabad air crash disaster, especially in burnt and charred dead bodies (**Table 2**). Along with this, clothes (including pieces of collar with labels, undergarments), documents (air tickets, I-cards, visiting cards, driving license etc. found in the pockets or in the wallets), shoes, belt with metallic buckle, 'janeu' (sacred thread) were used in the

identification. So, preservation of these belongings during autopsy and their careful photography is very essential for the future identification. 8% victims were identified by anthropological data obtained during autopsy e.g. age, sex, stature etc. Old scar and congenital deformities were useful in 4 % cases. Dental method was useful in 3 % cases and only 1 case

was identified by the lower limb prosthesis. This emphasizes the role of complete autopsy in identification of burnt and mutilated dead bodies. Maximum number of deceased had burns (seen in 76.74 % cases), followed by head injury with skull fracture (seen in 54.26 % cases). Fractures of tibia and fibula are seen in 42.63 % cases (**Table 3**).

Table 1: Age and sex wise distribution of victims

Sr. No.	Age Group (Year)	Male		Female		Total	
		No.	Percentage	No.	Percentage	No.	Percentage
1.	0 - 10	4	3.1%	4	3.1%	5	6.2%
2.	11 – 20	1	0.77%	1	0.77%	2	1.54%
3.	21 – 30	23	17.83%	13	10.18%	36	28.01%
4.	31 – 40	30	23.26%	5	3.8%	35	27.06%
5.	41 – 50	30	23.26%	2	1.54%	32	24.8%
6.	51 – 60	14	10.85%	1	0.77%	15	11.62%
7.	>60	1	0.77%	0	0	1	0.77%
Total		103	79.84%	26	20.16%	120	100%

Most common cause of death was burns (41.86 %), followed by multiple injuries to the body (32.55 %). 15.50 % victims were died due to burns associated with multiple injuries. In 9.32 % cases isolated head injury was a cause of death and isolated abdominal injury was found as a cause of death in only 1 case (**Table 4**). In Ahmedabad air crash disaster, the cause of death in both pilot and co-pilot was burns.

Table 2: Distribution of cases according to mode of identification

S. No.	Mode of Identification	No. of Cases	Percentage
1	By facial recognition & Personal belongings	107	84 %
2	By old scar or congenital deformity	5	4 %
3	By prosthesis	1	1 %
4	Dental method	3	3 %
5	Anthropological data	13	8 %
6	Total	129	100 %

Table 3: Distribution of cases according to body part injured (Multiple causes and overlap of injuries was a common finding in this study)

S. No.	Injured body part	No. of Cases	Percentage	
1	Head injury with skull fracture	70	54.26%	
2	Lower limb fracture	Tibia & Fibula	55	42.63%
		Femur	29	22.48%
		Pelvis	4	3.1%
3	Upper limb fracture	31	24.03%	
4	Chest injury	43	33.33%	
5	Abdominal injury	29	22.48%	
6	burns	99	76.74%	

Table 4: Distribution of cases according to cause of death (Multiple causes and overlap of injuries was a common finding in this study)

S. No.	Cause of death	No. of Cases	Percentage
1	Burns	54	41.86 %
2	Multiple injuries	42	32.55%
3	Injuries+Burns	20	15.50 %
4	Head injury only	12	9.32%
5	Abdominal injury	1	0.77 %
6	Total	120	100%

4. Discussion

A disaster such as an aircraft crash raises forensic problems that are both complex and unforeseeable because of the number of victims. In Ahmedabad aircraft crash disaster, serial numbers were given to each dead body at the site and brought to the mortuary of civil hospital, Ahmedabad. Complete post-mortem examinations were carried out in all the dead bodies and body parts by the team of Forensic Medicine Experts of B. J. Medical College, Ahmedabad. The identification of victims is essential from the humanitarian point of view so that families may be able to begin mourning, from legal point of view to establish the death certificate with or without a corpse and from the investigation point of view for the reconstruction process with legal and administrative investigations.³

Identification of victims of aircraft accidents is made difficult by the severe degree of injury and the accompanying conflagration. The task may be eased by the availability of an accurate passenger manifest. Identification of the pilot is a prerequisite to discovering a human cause for the accident, while an appraisal of safety factors is dependent on identification and accurate placing of the passengers within the vehicle.⁹ In the medico-legal investigation of Airbus A-320 crash (France)³, identification criteria were divided in to preliminary criteria and conclusive criteria. The first consisted in the analysis of the personal belongings, the noticing of the sex, and the height. The conclusive criteria consisted of at least two specific morphological

characteristics such as birth marks, deformities, scar, prostheses, callus formation of old fractures, osteosynthesis material or in positive odontological identification in case of relevant coincidental features between premortem and postmortem dental records or in DNA identification by reverse paternity testing when the supplementary criteria were inaccessible.³

In Airbus A-320 disaster (France)³, out of the 87 victims 85 were identified by the forensic practitioners of the multidisciplinary team. In Ahmedabad Air Crash, most of the victims (84 %) were identified by the secondary methods of identification (Visual recognition, Clothes and Personal belongings). Metallic ornaments were found to be useful in the identification as they resist heat. Old scar and congenital deformities were useful in 4 % cases. Dental method was useful in 3 % cases and only 1 case was identified by the prosthesis. In 10 cases (8 %), dead bodies were identified by anthropological data obtained during autopsy e.g. age, sex, stature etc.

Metallic ornaments and other metallic belongings like wrist watch and keys had played important role in the identification of victims of Ahmedabad air crash. Characteristics of clothes (including pieces of clothes and undergarments) and documents i.e. air tickets, I-cards, driving license, visiting cards were also used for the identification. Shoes and belts with metallic buckle were also found useful for the identification. Prosthesis was detected in both lower limbs of one victim during autopsy by which he was positively identified. In three victims old scar of previous surgery was detected and subsequently they were identified by ante-mortem information given by the relatives. In two victims peculiar characteristics of toes (congenital deformities) were observed in the autopsy by which they were identified. In three victims, dental information was found useful. One of them was having golden metallic cap over the teeth and one had extracted teeth. In one child, dental profile (eruption state of temporary teeth) was used to determine age.

In Airbus A320 disaster (France), 9 victims could be recognized by morphological criteria only (for two victims, ante mortem fingerprints were found at home), 44 by morphological and dental identification, and 15 by odontological criteria only (for 81 victims, ante-mortem dental records were available) and finally 17 victims were identified through DNA typing.³ The identification team required the association of Forensic Medicine Experts,

odontologists, radiologists and biologists. The result of their experience stresses two major points:³

1. First the necessity of performing the autopsies only after collecting the information given by the families.
2. Second the importance of DNA analyses when all conventional identification methods have failed.

In February 1998, a civilian airplane (**Airbus 300-600 R jet**) carrying 196 individuals crashed in **Taiwan** and killed another 6 people on the ground (combination of closed and open disaster). Although there were dental and medical records, fingerprints, photographic evidence and personal effects to recognize some of the victims, DNA analysis was needed for determination of identity of severely damaged remains. From the 202 people known to have perished in the plane crash, a total 685 fragments of human remains were subjected to DNA analysis. The same 16 DNA loci were utilized for testing blood samples from 201 relatives to determine parent/child and sibling relationships. With the exception of 19 victims identified by non-genetic evidence, 183 victims were successfully identified by DNA typing. In cases of severely damaged victims from a plane crash, DNA analysis proved to be the best choice to identify victims.¹⁰

The pattern of injuries sustained by the victims of aircraft accidents may give valuable clues that may aid the reconstruction of the sequence and circumstances of the accident. The 'typical' passenger carrying aircraft crash is likely to result in either a uniformity of injuries or a steady logical gradation of injuries. Study of the injury patterns may allow the investigation to compare different accidents. This is particularly important when the circumstances of an accident are unknown such as when an aircraft crashes in to the sea when there is no wreckage trail from which impact attitude may be deduced and when little or no aircraft wreckage may be available for engineering investigation.¹¹

The majority of airplane accidents occur as planes are taking off and landing. Rutherford, in reviewing 473 civilian air crashes throughout the world, found that 34.9% occurred as the planes took off; 36.9% as they descended and landed; 26.4% in mid-flight and 1.8% while parked.⁷

Head injury is very common in aviation accidents and was seen in two thirds of Cullen's cases. In most of these the head injury caused or contributed to the cause of the death. A significant finding was that, the base alone was fractured in 18.9% of fatalities.¹¹

Comparison of injuries sustained in different Air crash disaster is shown in **table 5**.

Table 5: Comparison of various studies

S. No.	Study	Type of Injury	
		Head Injury	Lower limb fractures
1	Ahmedabad Air Crash Present Study (129 victims)	53.33%	65.83%
2	Airbus A320 Crash ³ (France) (87 victims)	72%	92%
3	Cullen ¹¹ (over land) 46 victims	91.3%	98 %
4	Cullen ¹¹ (over sea) 10 victims	100%	100 %
5	Trident Air crash ¹¹ 118 victims	67.8%	82 %

Fractures of shin are seen when legs flail forward and strike fixed structures or are trapped under seat in front of victims. Mason-1970 mentioned that this accident involved a piston engine aircraft that crashed in to a built up area while attempting to land at an airfield. The speed at impact was very low and the wreckage trail was short. A period of some ten minutes elapsed before the onset of a fire during which time many of the passengers were seen to be alive and conscious within the cabin. The hull of the aircraft remained substantially intact. Despite this 70 of the 81 passengers on board died of the fatalities, 35 had died of burning. The majority of these had impact injuries to their shins resulting in fractures that inevitably would have prevented their escaping the ensuing fire. While some victims did have head injuries caused by flailing over the lap belts and striking the seat in front, the majority did that examination of passengers seats revealed that the thin bar situated at the base of the seat back was deformed. The mechanism thought to be flailing upwards against the bar at the rear of seat in front of the victims.^{8,11}

A Impact of this investigation was rectification of design of seat to avoid similar dangerous injuries in future.^{8,11} Due to the abrupt deceleration, when an aircraft crashes, pilot's body is propelled in the direction of flights. Damage may occur in hands and feet if they are on the control at the moment of impact (Kreffft 1970). The force directed between the thumb and index finger during control column injury may be transmitted to the wrist & forearm. This may cause fracture or dislocation of the wrist. Stress applied to the forearm may cause fracture of the arm.^{8,11} According to Cullen, injuries to the bones of thorax are the most common injuries seen and occur in 80 % of all accident victims.¹¹ In present study, chest injuries were seen in 33.33 % cases. In present study abdominal injuries were seen in 22.48 % cases. According to the Cullen¹¹,

damage to the gastrointestinal track is, with one exception uncommon. They are often bruised. The distribution of bruising suggests that this is caused by compression of gut between a lap belt and the spine. This mechanism may also be responsible for the fenestration of the mesentery that often accompanies the bruising of the gut serosa. This injury is helpful in accident reconstruction as it demonstrates the use of seat belts. When such seat belt injuries are seen in cabin crew it indicates that they were seated if accident occurred at a time during the flight when one would not normally expect them to be seated, one may infer that the emergency was anticipated or that there was another reason such as turbulence for them to be seated.¹¹

In the case presented by Rautji R. et al¹², all occupants of the aircraft sustained severe deceleration injuries in the vertical axis i.e. from buttock upwards causing severe perineal tear and evisceration due to impaction of aircraft with the ground with substantial vertical speed.¹² In Ahmedabad Air Crash, most common cause of death was burns (43 %), followed by multiple injuries to the body (29 %). In 17 % cases, cause of death was combination of Polytrauma and burns. In 10 % cases isolated head injury was a cause of death and isolated abdominal injury was found as a cause of death in only 1 case. In airbus A320 crash of France³, the cause of death for all 85 (100%) identified victims have been attributed to multiple injuries and mutilations. In Ahmedabad air crash, both pilot in command and co-pilot were died due to burns. Multiple causes and overlap of injuries was a common finding in this study.

In Airbus A320 crash (France), 2 persons registered on boarding list were still missing it was not possible to find biological remains that could belong to these two passengers; they assumed their bodies had been almost completely consumed by the fire.³ In addition to identifying the passengers' remains, the forensic pathologist will autopsy the flight crew in attempting to determine whether natural disease or drugs might have contributed to the accident, although, because of the size of the flight crew and the sophisticated instrumentation of commercial planes, this is highly unlikely. The forensic pathologist will search for trauma unrelated to the crash that might explain why the crash occurred. Thus, one will look for gunshot wounds and evidence of an explosion. Bodies may be X-rayed to look for bomb fragments.⁷

Mason et al (1963) reviewed 9 aircraft accidents attributed to coronary disease on the pilot; based on dual evidence of pathology and history, 4 of these accidents were considered almost certainly to have been so caused, 4 were very likely, and 1 was assessed as likely-it was considered impossible to be dogmatic. It clearly indicates importance of double crewing as a safety factor in passenger air travel.⁹

Whether in light or commercial plane crashes, the pilot (flight crew in commercial planes) should have a complete toxicology screen for the presence of alcohol, acid, basic and neutral drugs; alkaline drugs; narcotics; carbon monoxide and possibly marijuana.⁷ In the Ahmedabad air crash disaster of 1988, most of the victims were identified by the secondary methods of identification. It is evident from this study that secondary methods of identification are ordinarily adequate to identify most of the dead bodies in a mass disaster situation. But, when dead bodies are severely mutilated or burnt and no any secondary identification data is available, then DNA profiling, Odontological examination and fingerprinting (Primary Methods) are the only methods which can be used for positive identification.^{13,14,15,16,17,18} Doctor should be abreast with recent procedural norms, legal norms and medical records maintenance while dealing with disasters.

Ideally, all victims of aviation crashes should be autopsied. It is certainly necessary to autopsy the pilot and copilot for evidence of natural disease or toxicological issues that may have impaired their ability to fly the plane or even incapacitated them. It is important to autopsy aircraft passengers for three main reasons: to help with accident reconstruction, to help with the evaluation of safety equipment, and to help with the resolution of civil and criminal processes that may occur in the future.

5. Summary & Conclusions:

The role of Forensic Medicine Expert in a mass disaster event like aircraft crash can be summarized as follows.

1. At the disaster site, to locate, recognize, and recover human remains and other evidences, especially those impacted by disaster forces e.g. burned and mutilated remains.
2. Forensic Medicine Expert can play a vital role in the identification of the disaster victims. Identification of disaster victims is a complex and difficult task which requires the employment of

multidisciplinary teams that are well trained and managed.

3. It is highly recommended that in disasters like air crash or railway accidents, to rule out the human error factor (intoxication, sedation, and pathological condition), samples for chemical and histo-pathological analysis from the key victims must be taken.
4. Reconstruction of the disaster can be done by studying the pattern of injuries over the body of the victims. It is especially helpful in air crash disaster to know the position of the plane at the time of crash.
5. Establishment of the period of survival of the victims, which is deducible by studying the time since death is required in case of presumption of survivorship. Also it can be helpful to determine whether there was any lapse in the search and rescue operation, and accordingly from these findings, necessary corrective measures can be incorporated in the plan. Many victims of Ahmedabad air crash was having carbon soot particles in their respiratory tract suggestive of smoke inhalation. This finding suggest some period of survival after crash but due to fractures of bones of lower limbs and other injuries they could not have escaped.
6. Evaluation and analysis of the data during the course of medico-legal investigation of the disaster can be utilized as a tool for development and improvement of safety measures e.g. seat belts, air bags, head rests, helmets, leg guards, laminated windshields etc. They all were developed and improved over the years by studying such data and most of these safety measures have been made mandatory in many countries.

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Original Research Article

Designing Blueprints for Theoretical Assessments of the undergraduate Medical Students in Forensic Medicine and Toxicology.

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Summative assessment.

Abstract

Introduction: Assessment is the one of the crucial aspects of medical education. The system for collecting and analysing assessments is the essential component of a curriculum. The most of the medical colleges and institutions adhere to the conventional tools for theory assessment. A blueprint is a systemically developed test plan or table of specifications to ensure proper weightage and content representativeness to a learning outcome in the assessment. **Material and methods:** The study was conducted the Blueprint taskforce team of three subject experts (One chairperson and two members) appointed from MUHS for creating a blueprint for Forensic Medicine and Toxicology subject assessment. Feedback on prevalidated questionnaire abiding five-point Likert scale was taken from twenty-one subject experts and statistical analysis was performed. **Result:** 90.5% positively reflected that the blueprints align competencies with their assessment objectives. 81 % faculty given feedback that blueprints will bring uniformity amongst the different paper setters in question paper setting using standard blueprints. **Conclusion:** Blueprints provides a proper base for assessment. It facilitates the actual execution of the CBME Curriculum for subject of Forensic Medicine and Toxicology by assigning specific weightage to various content areas and helps for uniform and valid assessment of students.

1. Introduction

Assessing the quantity and quality of knowledge that medical students have acquired is one of the most significant responsibilities of a medical teacher. Because of this, assessment is a crucial aspect of medical education, and as such, the system for collecting and analysing assessments

is an essential component of a course's curriculum.¹ The majority of medical colleges and institutes adhere to the conventional theory assessment tool pattern, which may not align with assessment principles. Many problems with the traditional or conventional pattern of theoretical

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assessment instrument in medical education exist, including the subjectivity of the paper setter, lack of uniformity, absence of peer reviewer pre-validation, and omission of the Specific learning objectives (SLOs). Following any theoretical examination, students' qualitative feedback frequently indicates that the question paper was excessively long and that not enough time was allotted to write the answers. It also frequently claims that the question paper was improperly designed, that it did not cover the entire syllabus, and that it omitted certain key topics.² This occurs because, under the conventional assessment approach used in the majority of Indian medical colleges, a single teacher or examiner sets the question paper, and another teacher administers the practical exam. There is typically no coordination between the two teachers and the exams are not usually connected with the objectives.³

It is frequently up to the examiners to decide what should be assessed. Additionally, the examiner/teacher assigns material based on what "she/he thinks is appropriate or important". Because, they are not expressed properly, the desired learning outcomes are disregarded. The assessment must be credible. Each assessment must be valid, which indicates that participants who meet the minimal performance standard have reached the level of proficiency specified in the learning objectives. Content validity is the validity that is related to academic achievement metrics. Assessment content is considered genuine when it aligns with the learning experiences and objectives. Blueprinting in assessment can help ensure congruence between these essential components of education.^{4,5} A competency based medical education curriculum is being implemented by National Medical Commission (NMC) in all medical colleges in India starting from first year undergraduates' batch since August 2019.⁶ Universities need to prepare proper assessment plan for a complete, valid and reliable assessment of all students.

A blueprint can provide a detailed plan or outline as a guide for examination strategy and specification test in education for a specific subject. It specifies the elements of performance being assessed and how items will be selected based on their core importance. At present, there are no guidelines available about the fair distribution of marks to each topic from the authority. At Maharashtra University of Health Sciences (MUHS), no blueprint was available for the assessment of the subject of Forensic

Medicine. So, this is the first blueprint of the CBME Curriculum for the subject of Forensic Medicine.

Context and Setting

The various levels of cognitive domains of medical students is assessed by the written assessment. The suitable design of the evaluation tool is vital towards quality assessment and its validity. The course content of particular subject and the appropriate modality of assessment for various competencies can be matched with help of blueprinting. Blueprinting helps to ensure aligning questions to the objectives and ascertains its content validity. It makes assessment fair and transparent and gives appropriate emphasis on levels of domains.

Why the idea was necessary?

Question paper setting is one of the major duty teachers has to do. Framing a question paper that covers the whole syllabus with proportionate weightage to various content areas according to their importance is a big challenge for the paper setter. There are no guidelines available about the fair distribution of marks to each topic from the authority. At Maharashtra University of Health Sciences (MUHS), no blueprint was existing for the evaluation of the subject of Forensic Medicine. So, this is the first blueprint of the CBME Curriculum for the subject of Forensic Medicine.

2. Materials and Methods:

The study was conducted at Maharashtra University of Health Sciences (MUHS). Before commencement of the study, Institutional Ethics Committee approval was taken. The Blueprint taskforce team of three subject experts (One chairperson and two members) were appointed from MUHS for creating a blueprint for each speciality subject in medical curriculum. A sensitization workshop was conducted for all taskforce teams at MUHS. The rating and weightage in blueprint for various topics in each speciality subjects were validated through the subject experts including various professors and associate professors in zoom meeting. Accordingly, corrections were made abiding the suggestions by various experts. The feedback on specific questionnaire was obtained from forensic experts including professors and associate professors working in various medical institutions affiliated to MUHS. The various major steps undertaken are as follows-

- a. Institutional Ethics Committee approval taken.**
- b. Sensitization workshop for the taskforce team Faculty about Blueprinting was done.** The

workshop on Preparation of blueprint had been conducted at MUHS, Nashik for sensitization of the task force members of Forensic Medicine and Toxicology (FMT) about blueprinting as an assessment tool. The expert resource persons had been invited to take a training session on Blueprinting.

c. Preparation for the weightage calculation (Activity by Sensitized Faculty)

- i. Listing of all content areas in the syllabus of FMT was done according to the allotted teaching hours, as per MUHS guidelines.
- ii. The skeleton of the assessment tool was prepared. Abiding MUHS & NMC norms, total allotted mark to FMT Theory is 100 Marks.
- iii. The weightage of each content area was decided using below table 1.

Table 1: Weightage of subject content area

Clinical Application of the topic	Weightage
No or Less Clinical Application	1
Moderate Clinical Application	2
High Clinical Application	3

- iv. Validation of the Weightage for Each Content Area was done from subject experts. The weightage of each content area was calculated and presented to all FMT professors and associate professors in a ZOOM meeting. The weightage was validated by obtaining consensus after incorporating modifications suggested by the attendees.
- v. A Blueprint was designed for the FMT examination paper based on validated weightage. The theory examination blueprints were prepared for summative assessment in FMT depending on the validated weightage. The blueprints were also validated in the same zoom meeting.
- vi. The validated weightage and the theory exam blueprints were made available to the faculty in the subject of FMT.
- vii. The feedback on specific questionnaire was obtained from 21 (twenty-one) forensic experts including professors and associate professors working in various medical institutions affiliated to MUHS.
- viii. Statistical analysis was done. Data entered using Microsoft Excel 2010 Software. All the response tabulated and Graphical representation made wherever necessary. Data analysed by using Statistical Package for the Social Sciences (SPSS) Software version

16.0. Statistical tool used as percentage and non-parametric test.

3. Results:

Weightage of various course content was calculated and the blueprint of theory assessment in FMT was actualized. Google form for feedback for obtaining perception of the participants regarding blueprinting process was created, and pre-validated by experts in medical education. Their quantitative and qualitative responses to the closed-ended and open-ended items in the feedback form were statistically analysed. Graphical representation of 21 responses on various questionnaire shown in Figure 1 to 6.

Fig. no. 1: Graphical representation of responses on questionnaire 1- Blueprint helps in aligning competencies with their assessment.

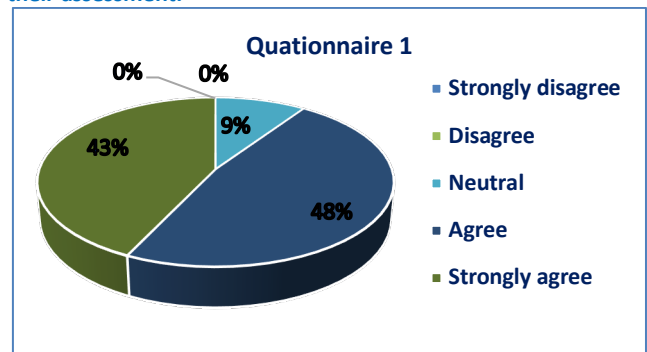


Fig. no. 2: Questionnaire 2 responses- Blueprint helps in having an appropriate weightage to recall, comprehension and application levels of cognitive domain.

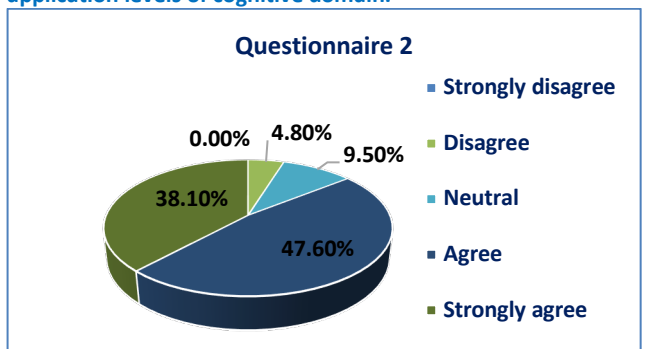


Fig. no. 3: Graphical representation of responses on questionnaire 3- Question paper setting becomes easy once the weightage and blueprints are ready.

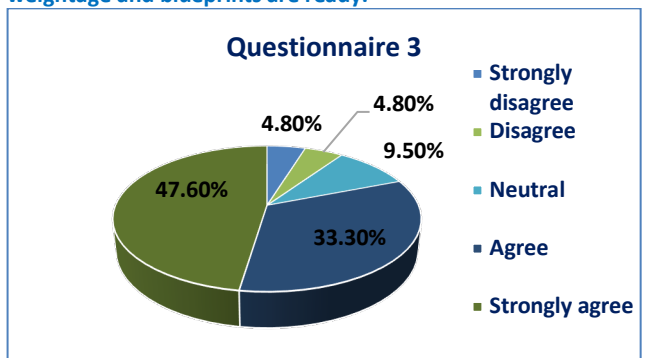


Fig. no. 4: Graphical representation of responses on questionnaire 4- Blueprint helps in focusing appropriately on core competencies while setting the question paper.

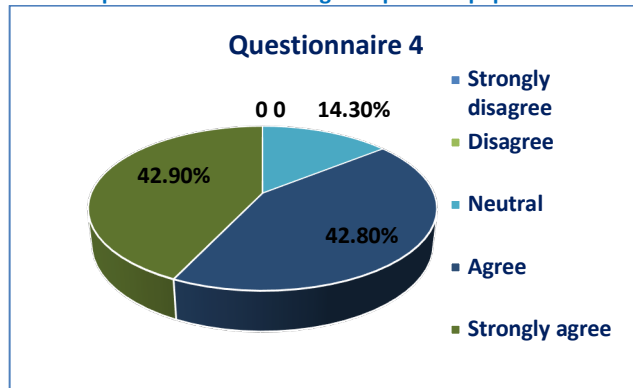


Fig. no. 5: Graphical representation of responses on questionnaire 5- Question paper setting using blueprint brings uniformity in the question paper setting.

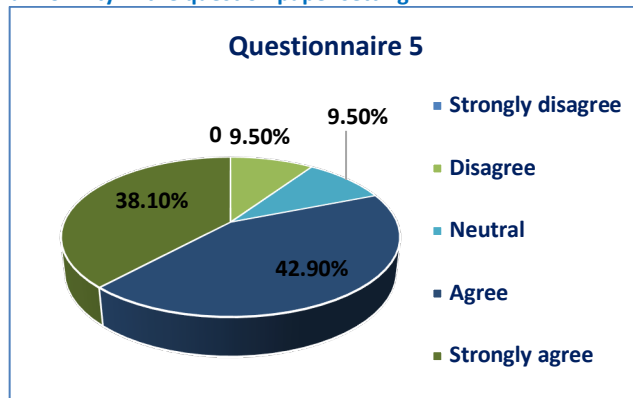
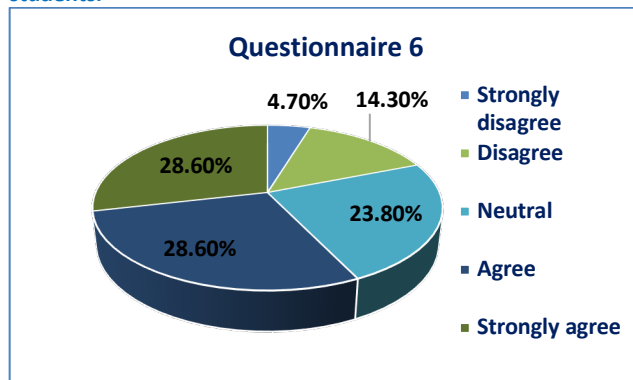


Fig. no. 6: Graphical representation of responses on questionnaire 6- Weightage and blueprint should be shared with students.



Out of all participants, 90.5% positively reflected that the blueprints align competencies with their assessment objectives (Fig. no. 1). Moreover, a majority of 86.1% opined that the blueprinting process helps in defining proper weightage of various content areas as per the levels of cognitive domain (Fig. no. 2). Also, almost 80% of the participants positively agreed that the blueprinting not only makes the paper setting easier, but also makes introduces uniformity in consequent assessments (Fig. no. 3). Appropriate focus on core competencies

using test blueprints was agreed upon by 85.8% of the participants (Fig. no. 4). 81% faculty given feedback that blueprints will bring uniformity amongst the different paper setters in question paper setting using standard blueprints (Fig. no. 5). When it came to whether the participating professors wanted to share the weightage and blueprints with the students, the response was mixed, with 57.2% of them willing to do so (Fig. no. 6). The negative feedback was perhaps due to the idea that sharing the blueprint will put a limit to the content that the students may read for the assessment. However, several authors are of the opinion that sharing the blueprint with the students will provide them a better idea of what is expected of them in the assessment, allow for organised study of content, as well as reduce stress of preparing for the exams.^{7,8}

These positive affirmations regarding the process were crucial feedbacks from participants who would potentially practice and propagate the concept to their colleagues and future professors.

4. Discussion:

According to Miller's pyramid of learning, a student demonstrates 4 levels of learning: Knows, knows how, shows how, and does.⁹ For instance, determining time since death in deceased, a student may first know factors to determine time since death, then learn how the factors vary, then make a general estimate in a fictional scenario given to them, and finally make calculated opinions during autopsies.

Each level requires a different format of testing, be it multiple choice questions, detailed answers, scenario-based questions, or practical sessions. Blooms taxonomy of assessment classifies learning behaviours into three main categories, namely cognitive, affective, and psychomotor.¹⁰ In the above instance, cognitive assessment can include rightly identifying signs of decomposition, raising suspicion regarding manner of death, and correctly dissecting the organs to expose pathology.

The cognitive domain is further divided into six levels, namely, knowledge, comprehension, application, analysis, synthesis, and evaluation. This domain is most commonly focused upon in teaching and assessment. The tasks in assessment involves testing these cognitive behaviours. However, a comprehensive set of all type of test formats is required to encompass all the six levels of the cognitive domain.

There are 4 stages of an effective test blueprint:¹¹

- 1. Identifying the major knowledge and skill domains:** It involves breaking down the subject into its important subunits. (For example, toxicology, forensic psychiatry, entomology, thanatology, etc)
- 2. Describing the objective:** The objective can be varied, from learning behaviours, to case-specific knowledge, and is documentation of what is to be expected from a student. (For example, students should be able to take informed consent for medicolegal examination of an accused; or students should be able to diagnose the poison from toxidromes)
- 3. Choosing the correct test format:** Test format should be appropriately chosen from Multiple choice questions (MCQs), theory questions, scenario-based questions, and practical assessments. (For example, a student may mark a correct MCQ regarding bi-spinous distance, but should also be practically assessed on correctly measuring the bi-spinous distance)
- 4. Specifying weightage:** Each category of assessment must be allotted marks as per their learning duration, frequency of encountering the subject in practice, importance in future learning, etc.

Validity and reliability is crucial of a good test blueprint. Validity is how good is the assessment to test the particular skill, and reliability is how trustworthy the scores in the particular test are, when it comes to judging the students. The assessment must be credible. Each assessment must be valid, which indicates that participants who meet the minimal performance standard have reached the level of proficiency specified in the learning objectives. Content validity is the validity that is related to academic achievement metrics. Assessment content is considered genuine when it aligns with the learning experiences and objectives. Blueprinting in assessment can help ensure congruence between these essential components of education.⁴ It is evident that test blueprinting not only makes the process of paper setting easier, it also allows the faculty to test the students in a holistic way. It will help the educator to evaluate student's competency on particular field appropriately.¹²

Abiding the responses from FMT experts, most of the experts given positive affirmation for the need of blueprints for uniformity in question paper setting which facilitates the proper aligning of most of the subject competencies with proper distribution of

questions abiding the weightage. These positive affirmations regarding the process were crucial feedbacks from participants who would potentially practice and propagate the concept to their colleagues and future professors.

Impact of the blueprint work:

The principal investigator and first author were initially working on this project at college level and applied for FAIMER Fellowship. Later, he was selected as Controller of Examinations at Maharashtra University of Health Sciences (MUHS), Nashik, Maharashtra, India and the chairman for FMT Blueprint taskforce. With administrative support and encouragement from Honorable Vice Chancellor, MUHS, Nashik blueprints of all 15 undergraduate medical subjects of MBBS CBME Curriculum had been prepared. Also, a book on blueprints on assessment of CBME curriculum had been released and made available to not only all colleges of Maharashtra but also to the governing council of National Medical Council (NMC). The Blueprint book is well appreciated by NMC authorities.

5. Conclusion:

Blueprints of various medical subjects including FMT abiding CBME Curriculum will improve validity, reliability and acceptability of both formative and summative assessments. There is positive feedback from sensitised faculty regarding the benefits of test blueprinting. All these results of the project conclude that blueprinting makes assessment clear, explicit and transparent to all the stakeholders. Blueprints will complement in actual implementation of the CBME Curriculum for subject of Forensic Medicine and Toxicology. Assessment is one of the key elements of competency-based medical education. A subject blueprint for assessment is must for the complete, proper, valid and reliable assessment.

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Contributor ship of Author: All authors equally contributed.

Conflict of interest: None to declare.

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Original Research Article

Awareness Regarding LGBTQ Persons Medical Problems, their Rights and Related Laws among Medical Fraternity

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Key words

LGBTQ,
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Abstract

Introduction: The LGBTQ community is a heterogenous group, with varied demographics, sexual orientations, gender identities and behaviours. Therefore, subgroups within the LGBT community are unlikely to have the same health needs. Educating healthcare professionals (HCPs) about LGBT-related healthcare issues is considered the most effective way to improve LGBT patients' management in healthcare. **Material and methods:** A total of 862 participants answered the questionnaire to check awareness in UG and PG medical students and medical professionals regarding rights and legal aspects of LGBTQ community based on MCQ type questionnaire. **Observation & results:** In this study, for 15 MCQs, 10 questions have more than 50% correct reply; and, for 5 questions with true/false or yes/no reply, 4 got more than 50% correct responses. It signifies need to increase legal literacy regarding rights of LGBTQ persons and their special medical needs among medical fraternity. **Conclusion & recommendations:** According to this survey awareness among medical students and practitioners is above 50% regarding general knowledge and legal rights but below 50% regarding healthcare needs and their treatment. To increase this awareness medical education should incorporate LGBTQ health issues in UG & PG curriculum.

1. Introduction

Lesbian, gay, bisexual, transgender, and queer (LGBTQ) people in India have experienced a long history of discrimination, including criminalization and classifications as mentally ill, attempts to forcibly change LGBTQ people's sexual orientation and/or gender identity, hate crimes and violence, and exclusion from employment, housing, public spaces, and social institutions.¹ Most health services research to date has focused on differences between non-LGBTQ and LGBTQ individuals, unable

to ascertain the variability within this population. Yet, evidence suggests that healthcare access, use, and experiences differ systematically among LGBTQ subgroups also.²

The LGBT community is a diverse group, with variation in the demographics, sexual orientations, gender identities and behaviors. Therefore, subgroups within the LGBT community are unlikely to have the same health needs. However, LGBT (plus queer (Q) and intersex (I))

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groups were primarily representing a large group of people who have been neglected by the society.³ The surge of medical conditions in the LGBT population strengthens the requirement of availability of proper healthcare. Systemic barriers include insensitive or lack of screening invitations, a lack of specialized services such as gender identity clinics, or deliberate withholding of treatment.³

The most operative way of enhancing the healthcare to LGBT patients is by making the doctors oriented about health issues faced by LGBT patients. Psychiatric doctors are more better positioned to handle issues related to LGBT patients orientation problems or gender identity. Many health professionals who do not feel comfortable in their ability to provide quality care for LGBT patients do not elicit complete sexual histories routinely and/or harbor bias towards these patients or their sexual practices. This situation underscores the continued need for further education on this topic.⁴ Criminal law, matrimonial relations, commercial and corporate law and the law of contractual relations all have ambiguity regarding LGBT rights. Traditionally, the law has not served as a barometer of social change-if anything, it has acted in response to a need to regulate a situation which has already developed. Although transsexualism as a concept has been known for centuries, it is only within the last decade or two that our legal system has begun to recognize it.⁵ The Government has recently formulated educational, social security and health schemes and welfare schemes and programmes in a manner to be transgender sensitive, non-stigmatizing and non-discriminatory to transgender persons.

As there is need to assess awareness among medical fraternity regarding rights and legal aspects of LGBTQ community and to have cognizance of their medical problems. This study is an attempt to focus on same.

2. Material and methods:

It is an observational cross-sectional study done on medical professionals i.e., UG & PG medical students, doctors and faculties from Medical College in Pune region who consented to participate in the study. A total of 862 participants answered the questionnaire to check awareness in UG and PG medical students regarding rights and legal aspects of LGBTQ community based on MCQ type questionnaire. A google form link of a questionnaire of 20 questions (15 MCQs and 5 binary answer questions) was sent to willing participants. From June

2023 to August 2023, Google form links via emails and social media were distributed. The email provided information about the survey to participants i.e., UG & PG medical students, doctors and faculties from Medical College who completed a questionnaire with 20 questions. After completion of the survey, an answer sheet was provided to participants to increase awareness. Mandatory permission from the Institutional Ethics Sub- Committee was obtained vide ref. no. I.E.S.C./IESC/46/2023 dated 19/08/2023.

3. Observation & results

A total of 862 participants responded to the questionnaire; 417 (48.7%) of them were male, 424 (49.5%) female and 13 (1.5%) didn't share gender information [Chart 1].

Chart 1: Sex distribution (856 responses)

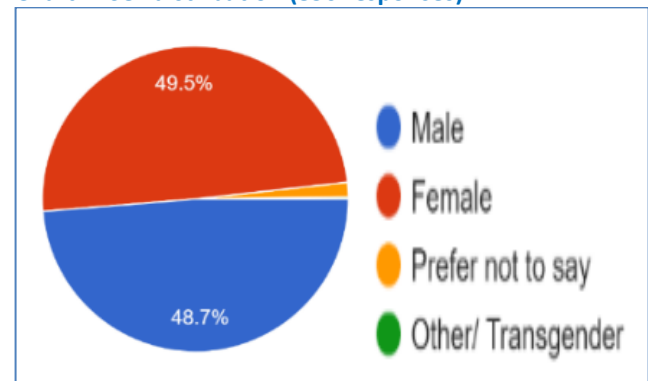


Chart 2: Age distribution (Years) (862 responses)

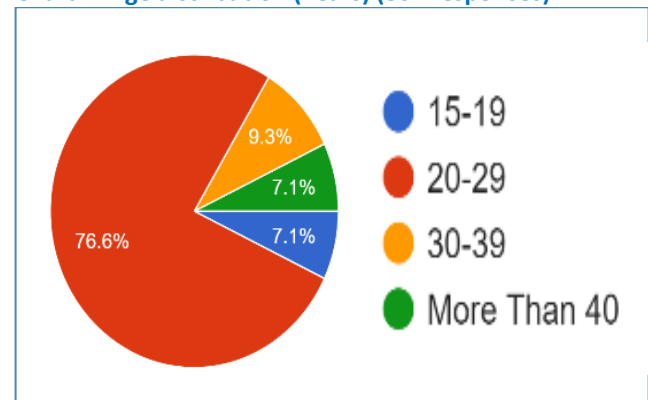
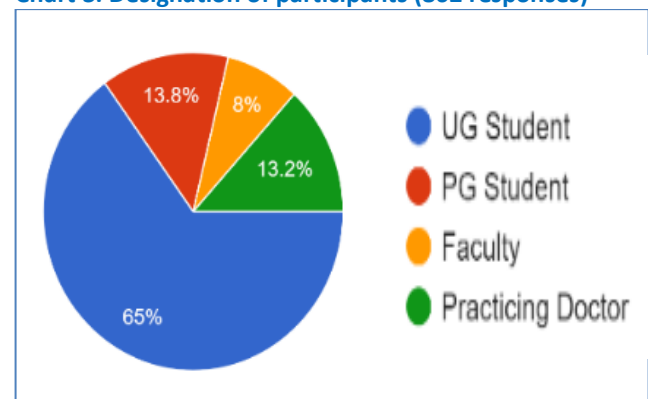


Chart 3: Designation of participants (862 responses)

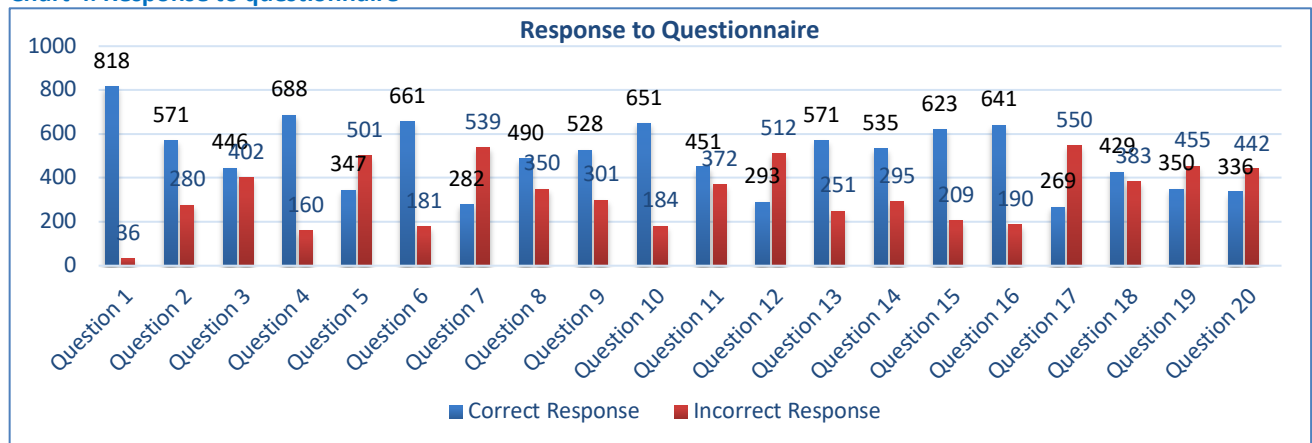


Most common age group of participants was 20 to 29 years with 660 participants (76.6%) followed by 30 to 39 year (9.3%), and less than 20 years & more than 40 years each accounted for 61 participants (7.1%) [Chart 2].

Table 1: Response to questionnaire

Sr. No.	Question & Correct Answer/Response	Total response	Correct response	Incorrect response
1	Have you Heard of LGBTQ word any time before?.....1. Yes	818	854 (95.8%)	36 (4.2%)
2	LGBTQ Persons have same civil rights as any other citizen.....1. True	851	571 (67.1%)	280 (32.9%)
3	'Gender' has same meaning that of 'Sex' of individual.....2. False	848	446 (52.6%)	402 (47.4%)
4	Being LGBTQ person is an anti-social behaviour?.....2. False	848	688 (81.1%)	160 (18.9%)
5	Indian law protects gay and transgender individuals from all forms of discrimination.....1. True	848	347 (40.9%)	501 (59.1%)
6	What is the full form of LGBTQ?..... Lesbian Gay Bisexual Transgender Queer	842	661 (78.5%)	181 (21.5%)
7	THE TRANSGENDER PERSONS (PROTECTION OF RIGHTS) ACT, 2019, "transgender person" includes all except..... Lesbians	821	282 (34.3%)	539 (65.5%)
8	What is gender identity?..... How you experience your gender internally	840	490 (58.3%)	350 (41.7%)
9	Which of the following organisations may be able to discriminate against LGBT people in certain limited circumstances?..... Religious organisations	829	528 (63.7%)	301 (36.3%)
10	How can you respect gender variance in the workplace?..... All..... Use the name and pronouns that trans people want, Avoid assumptions, Refrain from imposing theories about someone's transgender identity	835	651 (78%)	184 (22%)
11	What's the number-one most important thing we need to do to legally protect LGBT people from discrimination?.....Update antidiscrimination laws to include LGBT people.	823	451 (54.8%)	372 (45.2%)
12	Punishment for discriminating against a person of LGBTQ community for using public space is:6 months to 2-year imprisonment	805	293 (36.4%)	512 (63.6%)
13	An umbrella term for people whose gender identity and or expression don't match assigned sex at birth is..... Transgender	822	571 (69.5%)	251 (30.5%)
14	LGBTQ+ people are ____ likely to become disabled, higher risk of suicide attempts, and psychiatric disorders & LGBTQ+ people are ____ likely to be sexually or physically assaulted..... More---More	830	535 (64.5%)	295 (35.5%)
15	As a medical fraternity, if you see or hear someone who is displaying oppressive behaviour toward an LGBTQ+ patient, what should you do best?..... Stop that person	832	623 (74.9%)	209 (25.1%)
16	Which of the following is a predictor of suicide among transgender individuals?..... All..... Parental rejection, Past psychiatric hospitalizations, Previous suicide attempts or near attempts	831	641 (77.1%)	190 (22.9%)
17	The goal of voice therapy for MTF (Male to Female) individuals is-..... raising or "feminizing" the resonance of the voice	819	269 (32.8%)	550 (67.2%)
18	In the FTM (Female to Male) individual, testosterone-..... increases muscle mass.	812	429 (52.8%)	383 (47.2%)
19	Which of the following, is not common complication of breast augmentation surgery?..... capsular expansion.	805	350 (43.5%)	455 (56.5%)
20	About Phalloplasty; Not True:has fewer complications than metoidioplasty (Micro-penis).	778	336 (43.2%)	442 (56.8%)

Chart 4: Response to questionnaire



Around 560 (65%) participants are UG students, 119 (13.8%) PG students, 69 [8%] Faculties and 114 are practicing doctors [Chart 3]. In this study, for 15 MCQs, 10 questions have more than 50% correct reply; and, for 5 questions with true/false or yes/no reply, 4 got more than 50% correct responses [Table 1 and Chart 4].

4. Discussion

The LGBT community is a heterogeneous group, with varied demographics, sexual orientations, gender identities and behaviors. Therefore, subgroups within the LGBT community have varied health problems and unlikely to have the same healthcare needs.³ Absolutely, the lack of legal recognition can be a significant barrier for LGBTQ+ individuals, impacting many aspects of their lives. LGBT patients face many barriers to healthcare. Systemic barriers include insensitive or lack of screening invitations, a lack of specialized services such as gender identity clinics, or deliberate withholding of treatment.^{3,7,8}

A total of 862 participants responded to the questionnaire; 417 (48.7%) of them were male, 424 (49.5%) female and 13 (1.5%) didn't share gender information [Chart 1]. Most common age group of participants was 20 to 29 years with 660 participants (76.6%) followed by 30 to 39 year (9.3%), and less than 20 years & more than 40 years age group each accounted for 61 (7.1%) [Chart 2]. Around 560 (65%) participants are UG students, 119 (13.8%) PG students, 69 [8%] Faculties and 114 are practicing doctors [Chart 3]. In this study, for 15 MCQs, 10 questions have more than 50% correct reply; and, for 5 questions with true/false or yes/no reply, 4 got more than 50% correct responses [Table 1 and Chart 4]. Understanding the difference between sex and gender is important for knowing transsexuality. Word 'Sex' differentiates based on physical features like anatomy of genitalia, the presence or absence of gonads as male or female, while 'Gender' denotes the psychological recognition of self, its sexual inclination towards desired gender. In short, sex is external appearance as male/ female and gender being the identity is what one feels.[6] In response to question whether sex and gender are same 52.6% participants responded correctly as false statement. Most participants (95.8%) were aware of the term LGBTQ and 67.1% were aware of their rights to be treated equally.

Sex reassignment surgeries (SRS) with collaboration of behavioural, endocrinological, and

surgical specialists working as a team can solve issue of transsexuality or gender identity. The usual protocol for the management of a transsexual condition includes hormone therapy, facial hair electrolysis and reassignment surgeries. Various studies indicated that many transsexuals have benefited from such reassignment surgeries, in properly selected and carefully managed cases.⁹ To the questions 17th to 20th based on treatment needs of transsexuals; got 32.8%, 52.8%, 43.5% and 43.2% correct response respectively suggesting less awareness in medical fraternity regarding treatment needs of LGBTQ community. Not only India but even developed countries like USA lack LGBTQ-competent healthcare providers like sufficient physicians and facilities that provide high-quality LGBTQ care. There is need to address these issues through a program for medical students with the goal of increasing the number of LGBTQ-competent physicians both regionally and nationally.¹⁰ Medical institutions are failed to include LGBT health care topics in an already burdened curriculum, and study respondents reported an overall displeasure with the reporting of LGBT topics at their institutions. Tollemache N et al in their study provided suggestions for undergraduate curriculum development leads about how to improve the level and range of LGBT-associated content in their courses.¹¹ Some researchers studied awareness of medical ethics and micolegal practices amongst the medical doctors.^{12,13, 14}

In most national or state surveys lack of suitable questions relating to gender and sexual identity makes it problematic to evaluate the number of LGBT individuals and their health care needs. LGBT youth are scared to come forward and discrimination because of their sexual orientation or gender identity. This can result in increased risk of depression, posttraumatic stress disorder, substance use, and self-destructive behaviors. They are also particularly vulnerable to suicidal behaviors.¹⁵

They are also at an increased risk of physical or sexual abuse, STDs, and mental health issues. In this study more than 50% participant responded correctly to questions based on discrimination and psychosocial issues arising out of it, except for punishment prescribed in Indian law to discriminating person (6 months to 2-year imprisonment) only 36.4% responded correctly. It signifies need to increase legal literacy regarding rights of LGBTQ persons and their special medical needs among medical fraternity.

5. Conclusion & recommendations

Medical professionals should be aware about LGBTQ person's medical problems, healthcare needs, their rights and various legal issues. According to this survey awareness among medical students and practitioners is above 50% regarding general knowledge and legal rights but below 50% regarding healthcare needs and their treatment. To increase this awareness medical education should incorporate LGBTQ health issues in undergraduate curriculum. Special emphasis is needed to train and sensitize post-graduate medical students in Sex reassignment surgeries (SRS), behavioral, endocrinological therapies, that are primary needs of transsexuals. Regulatory bodies should strive to make these treatments cost-effective. CME's, seminars and workshops should be organized regularly on this topic. With these measures LGBTQ persons will get all their healthcare needs addressed as any other patient.

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Original Research Article

Cross Sectional Study to Estimate Proportion of Soundness and Completeness of Medical Certificate of Cause of Death

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Key words

MCCD,
Immediate Cause of
Death,
Manner of Death,
Mortality Data.

Abstract

Background: The medical certificate of cause of death (MCCD) is an important document of medicolegal significance that a doctor certifies following the death of his or her patient. The quality of death certificates is influenced by number of factors including medical education, physician knowledge and hospital resources. Therefore, writing the cause of death statements without errors is essential to build accurate mortality data that is important to measure the effectiveness of various mortality reduction programs. **Methodology:** The present study is Cross sectional hospital-based study where MCCD certificates from January 2021 to December 2021 from medical record department is collected for analysis of completeness and correctness. **Results:** A total of 456 MCCD forms were reviewed and analyzed in the present study. Out of which 291 (63.81%) were males and 165(36.18%) were females. Department wise data analysis revealed that intensive care units contributed majority of deaths (30.70%) followed by medicine department (27.27%). On analyzing the correctness of administrative data interval between condition and death was mentioned in 88.81% correctly. Analysis of correctness of cause of death showed correct entry of immediate cause of death as 98.63%, antecedent cause of death 89.69% and other significant condition 89.03%. Manner of death was correctly mentioned in 86.18% cases only. **Conclusion:** The MCCD scheme is a vital step in regularizing and maintaining uniformity of issuing cause of death certificate by medical practitioners. In the present study we found that incompleteness and inaccurate entries in MCCD are less than 15 %. The knowledge and skill of the staff engaged in issuing MCCD was found to be adequate.

1. Introduction

The medical certificate of cause of death is an important document of medicolegal significance that a doctor certifies following the death of his or

her patient. These documents serve as the perpetual record of the death of a person comprising important information relating to the

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demographics of the deceased and the cause of death statements.^{1,2} Mortality statistics is essential for the welfare of the community, health planning, management of health programs and to build up scientific data base for medical research. It also helps to know the impact of health services, to evaluate health indicators like infant mortality rate, maternal mortality rate and to find out magnitude of emerging and reemerging diseases.³ The standard cause of death certificate in India follows the recommendations of world health organization and the causes of death are classified according to international classification of diseases. The medical certificate of cause of death (Form 4 for institutional deaths and Form 4A for non-institutional deaths-Registration of birth and death act) is as per ICD 11. There is mandatory provision for every doctor to issue a cause of death certificate after death of his patient. Incomplete or inaccurate entry in these certificates poses difficulty in obtaining reliable information pertaining to causes of mortality.⁴

It is reported that resident physicians or junior physicians, in particular, are often known to make errors in completing the death certificate and a significant proportion of them are known not to have received prior formal training in drafting death certificates.⁵ Therefore, it is important for medical students, the future doctors, to be trained in completing the medical certificate of cause-of-death as this document primarily serves various important purposes for the legal heirs of the deceased and secondly is a vital source for mortality statistics.⁶ Writing an erroneous underlying cause of death substantially impacts the cause of death statistics.⁷ Therefore writing the cause of death statements without errors is essential to build accurate mortality data that is important to measure the effectiveness of various mortality reduction programs.⁸ The quality of death certificates is influenced by number of factors including medical education, physician knowledge and hospital resources.⁹ Objectives of this study were to determine the common errors in MCCD at institutional level as per Form 4 of WHO format, to ascertain the gaps if any and to encourage physicians to improve issuing of certificates in adequacy and completeness.

2. Material and methods

Study design- Cross sectional hospital based.

Study area- Tertiary care hospital in North Maharashtra. **Study duration-** 3 months: October to December 2023.

Study sample- All death records from medical records department of SMBT IMSRC from January 2021 to December 2021.

Study sample size- 456 issued MCCD certificates.

Statistical Tools-Data was entered in Microsoft excel spreadsheet, tabulated and described as percentages.

3. Results

A total of 456 MCCD forms were reviewed and analyzed in the present study. Out of which 291 (63.81%) were males and 165(36.18%) were females. Department wise data analysis revealed that intensive care units contributed majority of deaths (30.70%) followed by medicine department (27.27%). Age group of 51-60 years contributed to majority deaths. Name, age, sex variable was filled up in all the cases. Date of death was filled in 450 (98.68%) cases. Immediate cause of death was filled up in 443(97.14%) cases. Interval between immediate cause and death was mentioned in 405(88.81%) cases only. The antecedent cause of death includes any disease or injury which initiated the chain of events giving rise to immediate cause of death.

It was mentioned in 434(95.17%) cases. Death associated with Pregnancy or not was mentioned in 454(99.56%) cases. The doctor certifying death is required to put his signature, Full name and designation along with date and preferably should use his or her seal bearing registration number at the bottom of certificate.

Table 1: Department wise data distribution (n=456)

S. No.	Department	No. (%)
1	Surgery	103(22.58)
2	Orthopedic	42(9.21)
3	Obstetrics and Gynecology	13(2.85)
4	Medicine	129(28.28)
5	Pediatric	16(3.50)
6	ENT	7(1.53)
7	Intensive care unit	140(30.70)
8	Any other	6(1.31)

Table 2 Age wise data distribution

Age at death (Years)	Male		Female		Total	
	No.	%	No.	%	No.	%
<1	7	1.53%	5	1.09%	12	2.63%
1-10	0	0%	2	0.4%	2	0.43%
11-20	3	0.65%	3	0.6%	6	1.31%
21-30	16	3.50%	10	2.19%	26	5.70%
31-40	43	9.42%	9	1.97%	52	11.40%
41-50	43	9.42%	26	5.70%	69	15.13%
51-60	69	15.1%	36	7.89%	105	23.02%
61-70	52	11.4%	32	7.01%	84	18.42%
70+	58	12.7%	42	9.21%	100	21.92%

Doctor's signature was found in 452 (99.12%) cases but designation was mentioned in 88.81 % and registration number in 86.18% cases only. On analyzing the correctness of administrative data

interval between condition and death was mentioned in 88.81% correctly. Analysis of correctness of cause of death showed correct entry of immediate cause of death as 98.63%, antecedent cause of death 89.69% and other significant condition 89.03%. Manner of death was correctly mentioned in 86.18% cases only.

Table 3: Accuracy of each variable in the Filled MCCD forms

Sr. No.	Variable	Filled forms			
		Yes		No	
		No.	%	No.	%
1	Name	456	100	0	0
2	Age	456	100	0	0
3	Sex	456	100	0	0
4	Date of death	450	98.68	6	1.31
5	Immediate cause of death	443	97.14	13	2.85
6	Interval between immediate cause and death	405	88.81	51	11.18
7	Antecedent cause of death	434	95.17	22	4.82
8	Interval between antecedent cause and death	423	92.76	33	7.23
9	Other associated condition	413	90.57	43	9.42
10	Interval between other condition and death	402	88.15	54	11.84
11	Death associated with pregnancy or not	454	99.56	2	0.43
12	Doctor's sign	452	99.12	4	0.86
13	Designation	405	88.81	51	11.18
14	Date of verification	413	90.57	43	9.42
15	Registration number	393	86.18	63	13.81
16	Address of deceased	448	98.24	8	1.75

Table 4: Data distribution according to correctness of administrative details

Sr. no.	Component of death certificate	Correct entry	%	Incorrect entry	%
1	Name of deceased	456	100	0	100
2	Age of deceased	456	100	0	100
3	Sex of deceased	456	100	0	100
4	Intervals	405	88.81	51	11.18
5	Death associated with pregnancy or not	454	99.56	2	0.43
6	Signature of doctor	452	99.12	4	0.86
7	Name of doctor	423	92.76	33	7.23
8	Designation of doctor	405	88.81	51	11.18

Table 5: Data distribution according to correctness of cause of death

Sr no.	Component of death certificate	Correct entry	%	Incorrect entry	%
1	Immediate cause of death	427	93.64	29	6.35
2	Antecedent cause of death	402	89.69	54	11.84
3	Other significant condition	406	89.03	50	10.96
4	Manner of death	393	86.18	63	13.81

4. Discussion:

Completeness and correctness of medical certification of cause of death is essential to collect mortality statistics. To fulfill this need doctors are trained to fill up the certificate during their under

graduation by department of forensic medicine and toxicology as per CBME curriculum the interns were also trained for various medicolegal documentation and communication with various public authorities including police during their compulsory internship rotation program. However, despite multiple trainings the clinicians commit errors while filling the correct causes of death in MCCD.¹⁰

Therefore proper training of the RMP is of great importance for filling the cause of death certificate without any errors.¹¹ MCCD enables us to describe disease pattern within specified population but the absence of reliable data on cause of death hinders the structuring of health-related policies and decisions regarding healthcare.¹² Maximum mortality was in intensive care unit followed by medicine department. The mortality in these departments may be due to more admissions in these departments. This is consistent with study by Meenal Kulkarni and Jaydev Nayse.¹³ In the present study 40.34 % of deceased were found in more than 60 years of age group which is in accordance to Patel et al from a teaching hospital Vadodara.¹⁴ Researchers studied the awareness on medical practices and medicolegal issues amongst the medical doctors.^{15,16,17}

Completeness of variables such as immediate cause, antecedent cause and other significant condition were 97.14%,95.17%,90.57% respectively. The study conducted by Pallavi Uplap et al have found the results as 99.75%,98.29% and 88.04% respectively. The findings of the present study are consistent with findings of study of Pallavi Uplap et al¹⁸ and Ganswa A S et al.¹² In the present study completeness of column death associated with pregnancy was 99.56% which is consistent with Amit Patil Et al (91.37%).¹⁹ Information of pregnancy and delivery are needed in case death of women occurs during child bearing age (15-49). Even though there might not be any relationship between pregnancy and death. In present study findings related to correctness of immediate, antecedent cause of death and other significant condition are comparable with other studies conducted elsewhere in India.^{10,20,21}

5. Conclusion:

The MCCD scheme is a vital step in regularizing and maintaining uniformity of issuing cause of death certificate by medical practitioners. In the present study we found that incompleteness and inaccurate entries in MCCD are less than 15 %. The knowledge and skill of the staff engaged in issuing MCCD was found to be adequate.

Recommendations:

- Medical institution should regularly audit the MCCD certificates issued for accuracy and completeness.
- Hospital administration shall conduct training and workshops to orient physicians for correct certification of death.
- To minimize the errors, we recommend digitalization of all medico legal documents including MCCD and Hospital administration to ensure issuance of MCCD only after review by senior trained faculty.
- We recommend to evaluate the impact of training, orientation programs on Quality of MCCD issued in future.

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Original Research Article

Exogenous Lipoid Pneumonia Diagnosed on Paediatric Autopsy Examination – A Case Series

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Lipid Pneumonia,
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Abstract

Background: Lipoid pneumonia is caused due to deposition of foreign body of lipid nature within the lung parenchyma which may enter directly through upper respiratory tract or it may be secreted distal to the obstruction in terminal bronchioles. In this case series, we aim to shed light over this rare and underdiagnosed cause of pneumonia which is often missed on clinical examination as well as on autopsy. **Methods:** The information provided through Inquest report was analyzed. During autopsy tissues for histopathology were preserved. Histopathological examination of lung parenchyma was carried out to examine the features consistent with lipoid pneumonia. **Results:** Cytological demonstration of lipid-laden macrophages and histopathological examination showing bacterial colonies and lipid molecules in lung parenchyma is consistent with diagnosis of exogenous Lipoid pneumonia in the studied cases. **Conclusion:** A vast majority of Lipoid Pneumonia cases remain undiagnosed as Histopathological analysis is not done. We would like to comment that there are certain events which leads to the deposition of lipids in lung parenchyma thereby leading to the development of 'lipoid pneumonia' highlighting the importance of histopathological examination in cases with such histories.

1. Introduction

Lipid pneumonia is caused due to deposition of foreign body of lipid nature within the lung parenchyma which may enter directly through upper respiratory tract or it may be secreted distal to the obstruction in terminal bronchioles. Lipoid pneumonia is a specific form of lung inflammation (pneumonia) that develops when lipids enter the bronchial tree. The disorder is sometimes called cholesterol pneumonia in cases where that lipid is a factor.¹ Lipid pneumonia has been known to occur in underwater divers after breathing poorly filtered

air supplied by a surface compressor lubricated by mineral oil.² One of the earliest articles published on this condition was based on autopsy findings in Canadian children who developed pneumonia following nasopharyngeal injections of oil in hospital.³

The use of various folk treatments including the administration of these oils orally or by nose in children, as well as associated cultural behaviours, have also been described in the literature on exogenous lipoid pneumonia, which is linked to the

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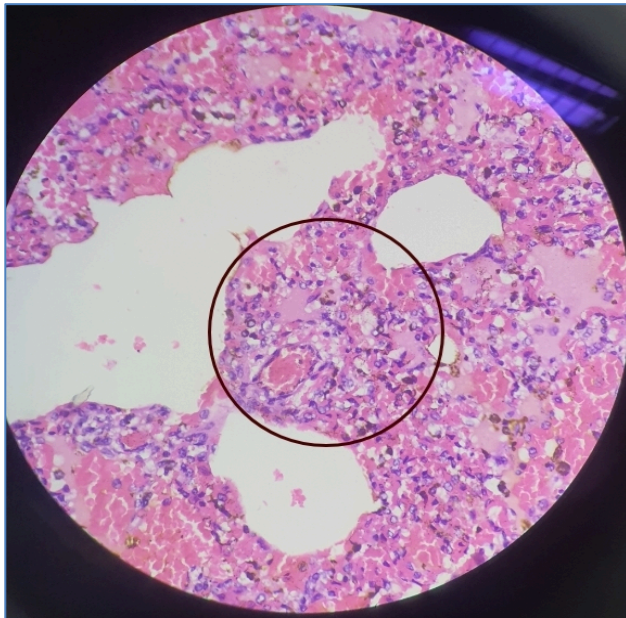
medical use of oil-based products in children.^{4,5,6} The cases of Exogenous Lipid pneumonia can be further complicated by Mycobacterium infection with expected high mortality.

2. Case presentation

2.1 Case 1:

History- The deceased, 42 days old male child, was sleeping besides his mother at home at 11.30 pm. At 2.00 am, the mother woke up to breastfeed her child but found the child unconscious with blood oozing out of his nose. The parents brought him to the hospital, where he was declared 'brought dead'.

Figure 1: RBCs In Interstitium Suggestive Of Haemorrhages



Histopathology- Thickened pleura with focal haemorrhages. Alveoli and bronchioles show haemorrhages and oily proteinaceous fluid with macrophages scattering of inflammation seen [Figure 1].

2.2 Case 2:

History- 15 days male with history of breastfeeding at 4:00 AM and at 7:00 AM, he was found in an unconscious state with blood oozing out of nose.

Histopathology- The pleura shows areas of haemorrhages. Diffuse intra-pulmonary haemorrhages seen. Patchy areas of alveoli show oedema. Interstitium is oedematous with congested and dilated blood vessels. Bronchioles are unremarkable. Blood vessels are thick walled and congested [Figure 2, Figure 3].

2.3 Case 3:

History- The said deceased 7 days female was found in unresponsive condition in the morning. She was

brought to the Hospital Casualty where she was declared 'brought dead' on the same day.

Histopathology- Diffuse Alveolar deposits of translucent, irregular shaped, acellular, strips to flat plates of unknown aspirated foreign material, septal and alveolar tissue present. No evidence of inflammatory exudate [Figure 4].

Figure 2: Fat Globules

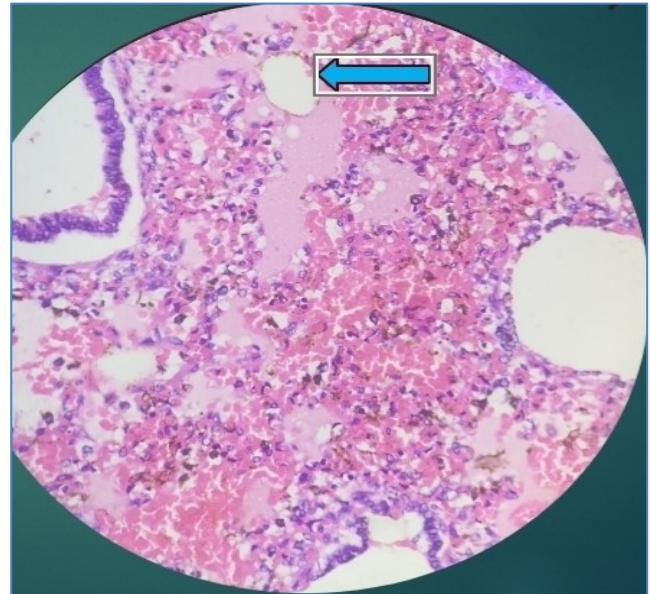
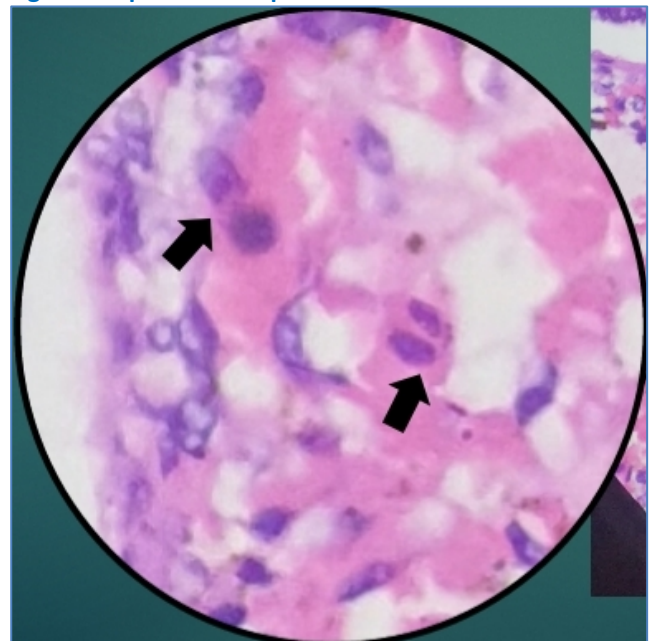


Figure 3: Lipid In Eosinophils



2.4 Case 4:

History- The said deceased, 2 years old male, while playing at his home, drank some petroleum oil thinking it was drinking water. He was declared 'Brought Dead' when presented to casualty.

Histopathology- Bronchioles and alveoli show oil droplets with eosinophilic material in air

spaces with mild to moderate inflammatory infiltrate in alveoli and interstitium. Focally the air spaces are lined by eosinophilic hyaline membranous material [Figure 5, Figure 6].

Figure 4: Acellular Eosinophilic Material

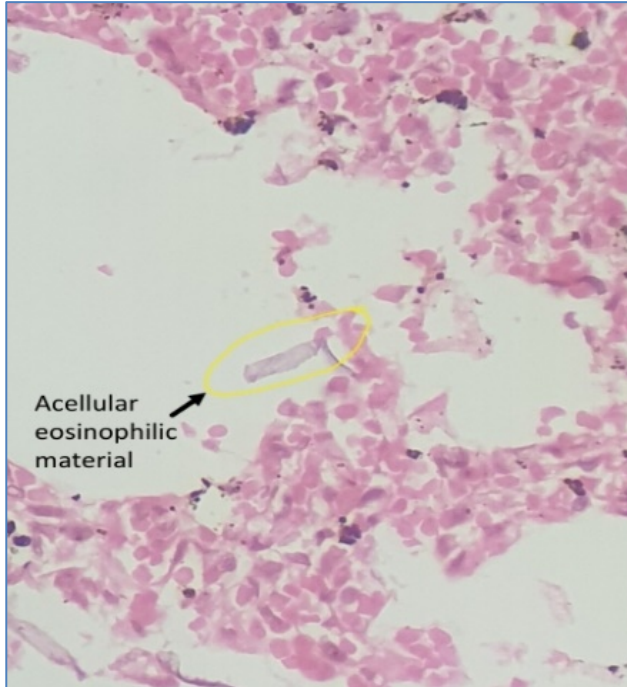
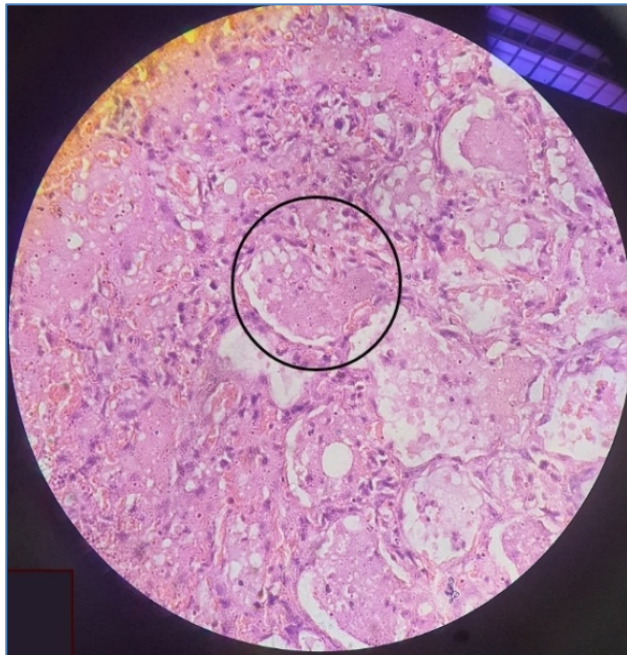


Figure 5: Eosinophilic Infiltration



Case 5

History-The said deceased, was a 13 days/ female child, was breastfed by her mother at 7:00 AM. At 9.00 AM, when father of the deceased arrived at home, found the child not moving. He hence brought him to the casualty, where on examination, was declared brought dead at 10:00 AM.

Figure 6: Hyaline Membrane

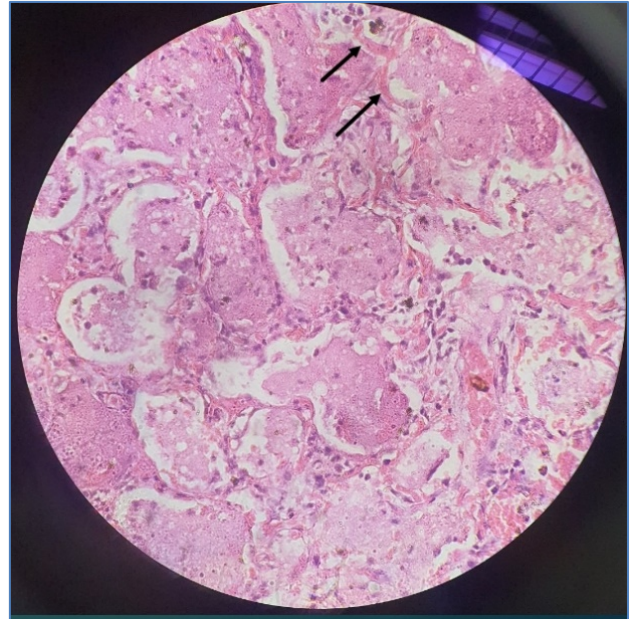


Figure 7: Neutrophilic abscess in bronchiole

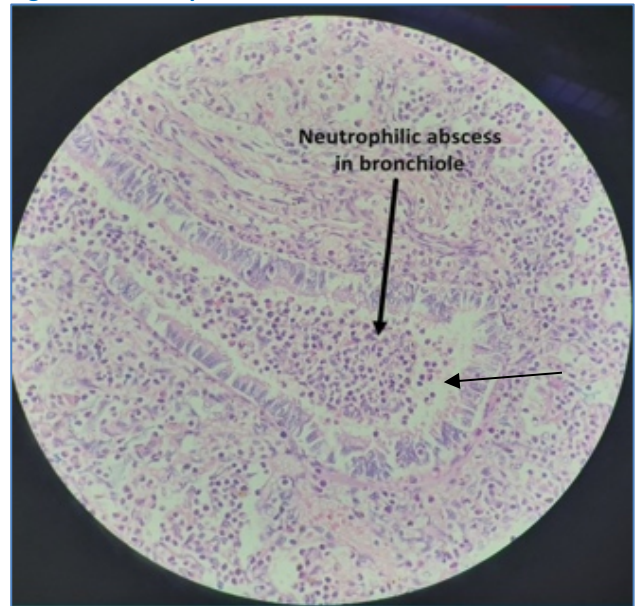
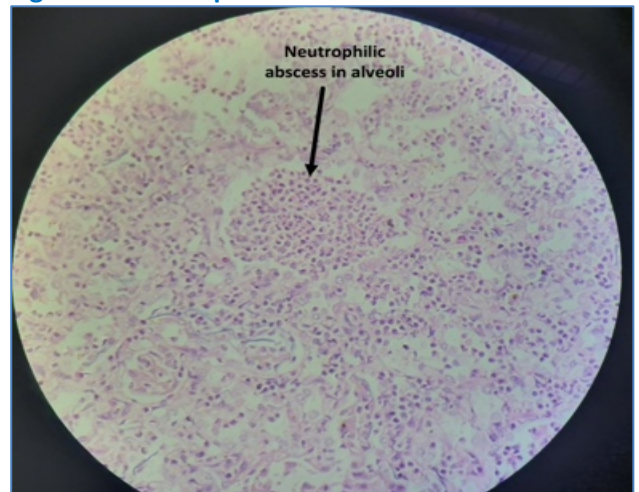


Figure 8: Neutrophilic Abscess In alveoli



Histopathology -Pleura unremarkable. Alveoli show dense mixed inflammatory infiltrate comprising of neutrophils with few lymphocytes suggestive of bronchopneumonia. Also seen are bacterial colonies within the bronchioles and foreign material within the alveoli, suggestive of aspiration. Focal intra-alveolar haemorrhage present, blood vessels congested [Figure 7, Figure 8].

3. Discussion

All the subjects were in age group ranging from 7 days to 2 years. Four of them had a history of being breast fed and 1 case included accidental ingestion of petroleum product. The conclusive results of the above cases were based on the observations of autopsy and histopathological examinations. On gross examination lungs were firm to rubbery in consistency and cut-section showed red hepatization. Histopathology study showed Fatty substance (fat globules)/ Foreign Particles, Eosinophilic infiltration, Eosinophils with lipid molecules, Hyalinization (thickening) of basement membrane and Bacterial Colonization noted. The above-mentioned observations were consistent with the diagnosis of exogenous lipid pneumonia in the above-mentioned cases. The condition of exogenous lipid pneumonia is complicated due to its non-specific and unclear ante mortem course, presentation and imaging pattern. In ante-mortem cases bronchoalveolar lavage is the most common mode of cytology sampling, and a biopsy or another modality is pursued for confirmation.⁷

While lipid pneumonias can be exogenous, they can present as endogenous when a pneumonia is developed beyond an obstruction or accumulation of lipid-containing macrophages distal to an area of obstruction, infection, or lipid storage disease. While most reported cases of exogenous lipid pneumonias are acute, there have been cases of chronic lipid pneumonias in ante-mortem cases. Complications of lipid pneumonia include the development of fibrotic component in chronic cases. Other possible complications include superinfection by non-tuberculous mycobacteria, respiratory insufficiency, cor pulmonale and hypercalcemia. The diagnosis of exogenous lipid pneumonia is based on a history of exposure to oil with radiological findings in consistent with the disease and the presence of lipid-laden macrophages on sputum. It should be considered, however, that none of these findings alone is diagnostic of lipid pneumonia.^{8,9,10}

Histopathologically, chronic exogenous lipid

pneumonia is characterized by the presence of lipid-laden macrophages that fill and distend the alveoli and interstitium, where they may be associated with accumulation of lipid material, inflammatory cellular infiltration, and variable amount of fibrosis. Alveolar hemorrhage and inflammatory exudate may be present.^{8,9,10,11} Local custom of giving oil baths to infants and of cleansing the mouth, throat, and nose with oil is a common practice in many communities. (Caffey,1967). Adams (1967) warned that substances such as cod liver-oil, castor oil, and mineral oil are easily aspirated even when carefully administered. In all such cases, aspirational pneumonia is one of the commonest causes of death.¹² Most Lipid Pneumonia cases remain undiagnosed as HP analysis is not done and COD is directly given as "Pneumonia" due to similar gross macroscopic findings.^{8,9,10} Multiple studies suggest a link between exposure to lipid-based particles and development of Pneumonia at a later stage in life which can be acute or chronic.^{8,9,10,12} Eosinophilic infiltration with lipid laden eosinophils¹³ can be found in histopathological studies in cases of sudden death due to pneumonia following lipid ingestion. In a study of Karim et al, on 107 children with pulmonary aspiration, the most frequent causes of pulmonary aspiration were caused by milk (31.8%) and oral secretions (19.6%).¹⁴

4. Conclusion

To distinguish between pneumonia and lipid pneumonia, babies and kids who die suddenly after breastfeeding or consuming oil-based materials should have their bodies checked for the presence of fat globules, lipid-laden eosinophils, or eosinophilic infiltration. A history of oil exposure, distinctive radiological abnormalities, and the presence of lipid-laden macrophages on sputum or BAL analysis are the main factors used to diagnose exogenous lipid pneumonia. Only a small percentage of individuals with chronic ELP get well even after the causing exposure has been identified and stopped, and the disease's progression may be linked to recurrent aspiration or regurgitation. Aggressive risk-factor management, which includes lifestyle adjustments (such as raising the head of the bed and avoiding late-night meals), may therefore be beneficial for these individuals.

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Review Article

From Discord to Harmony: Resolving Healthcare Conflicts through Alternative Dispute Resolution (ADR) in USA and India: Prospects and Challenges

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Abstract

Conflicts in healthcare are becoming more common and complex, involving issues like medical malpractice, insurance claims, and ethical dilemmas. This article explores how Alternative Dispute Resolution (ADR) methods, such as mediation and arbitration, can address these conflicts. Focusing on the Indian and American healthcare dispute resolution system, it discusses its unique challenges, including resource limitations and cultural factors. The article argues that ADR offers a collaborative, timely, and cost-effective way to resolve disputes, benefiting providers and patients. This approach could significantly improve conflict resolution in healthcare, offering a more effective alternative to traditional methods.

1. Introduction

With its intricate web of stakeholders and complex dynamics, the healthcare industry is not immune to conflicts. These conflicts can strain relationships between healthcare providers and patients, highlighting the need for effective resolution methods. Traditional litigation is often slow, costly, and adversarial, making it ill-suited for the unique challenges of healthcare conflicts.¹

This article explores the potential of ADR methods, such as mediation, arbitration, and hybrid approaches, as more effective means of resolving healthcare disputes. ADR offers a collaborative and flexible approach, allowing parties to engage in constructive dialogue, seek mutually agreeable solutions, and maintain confidentiality. It has gained traction as a preferred method in the healthcare sector, mainly due to its ability to reduce the

burden on courts and provide timely justice. Examining the healthcare dispute resolution systems in India and the United States, the article delves into the obstacles both face, including cultural variables and limited resources. Integrating ADR in this context requires a tailored approach considering these unique factors. By promoting ADR, India can enhance the efficiency and fairness of dispute resolution in healthcare, ultimately improving the quality of care and maintaining the integrity of the healthcare system. This shift towards ADR reflects a broader recognition of its value in effectively handling complex, sensitive healthcare disputes.

2. Conflicts in Health Care Industry: An Overview

Conflicts in the healthcare industry arise from various sources, including disputes over

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payments, contracts, and patient safety. Common issues include medical necessity, insurance coverage, and billing errors between patients, insurers, and providers. Conflicts also occur in managed care, often involving reimbursement policies, contract terms, and employment contracts, particularly over non-compete clauses.² Mergers, acquisitions, and intellectual property transactions can lead to disputes, as can class action lawsuits, usually centred on coverage and payment issues. Additional conflicts include provider networks, billing practices, product distribution, patient safety, and substandard care allegations. Intra-group conflicts and risk management concerns, such as liability and fraud claims, further complicate the landscape.³

3. Models of ADR in the Healthcare Sector in USA

The growing number of medical negligence cases and the need for transparency have led healthcare institutions to turn to the ADR mechanism. ADR, including arbitration, mediation, and conciliation, provides a quicker, cost-effective alternative to litigation. Mediators help resolve disputes by facilitating dialogue, while arbitrators make decisions based on the evidence, offering an efficient solution to the growing number of court cases.⁴

3.1 Rush Model

The Rush Model of co-mediation, introduced by Chicago's Rush Medical Centre in 1995, was created to reduce high legal costs and unpredictable jury awards in malpractice cases. The process begins with a mediation agreement and an early exchange of relevant documents, followed by an initial mediation conference where both parties present their positions. The model includes private caucuses for open dialogue and exploring resolutions. Both parties share costs equally, and the process is confidential and binding. The unique aspect of the model is that the plaintiff selects the mediators, typically experienced lawyers for both sides, which encourages active participation.⁵ This approach led to slightly fewer lawsuits, demonstrating its effectiveness in resolving healthcare malpractice disputes. The Rush Model provides a quicker, cost-effective alternative to traditional litigation, emphasizing information exchange, balanced perspectives from mediators, and confidentiality. Its success in creating win-win outcomes and saving time and money underscores its value in ADR.⁶

3.2 The VA Model

In 1987, the Department of Veterans Affairs (VA) launched a unique ADR program at the

Lexington, Kentucky, VA Medical Centre to address rising lawsuits and significant awards. This program focused on complete transparency, disclosing all errors and adverse events to patients, even if they were unaware. The goal was to provide a clear account of incidents, including any preventive measures taken, and to offer an apology from the chief of staff, demonstrating full responsibility.⁷

Unlike traditional dispute resolution methods that often use external mediators, the VA program utilized internal staff to negotiate directly with patients, their families, and attorneys until a fair settlement was reached. Compensation could include corrective medical actions, increased disability ratings, and financial reparations. The program emphasized building trust and maintaining a positive relationship with patients by prioritizing openness, apologies, and corrective actions. This approach aimed to resolve disputes more compassionately and effectively, improving communication and trust.⁸

3.3 The University of Michigan Model

In 2001, the University of Michigan Health System introduced a new policy to manage medical malpractice claims, aiming to decrease the frequency and size of such claims. There are three core principles associated with this policy which are as follows:

- **Prompt and Fair Compensation:** The policy aimed to deliver quick and just compensation to patients injured by unreasonable medical care, ensuring timely restitution for harm caused.
- **Defending Staff and the Medical Centre:** It emphasised defending the medical centre and its staff against unjust claims when care was reasonable, and the injury was not their fault.
- **Learning from Mistakes:** The policy focused on learning from errors and patient experiences to improve care and prevent future incidents.
- **Continuous Improvement:** By analysing adverse events, the policy sought to use these insights for growth and enhanced patient safety.⁹

The University of Michigan Health System's policy on medical malpractice claims encourages open and honest communication between staff and patients about errors. Discussions begin promptly, with staff expressing a commitment to helping patients heal and resolving claims outside of court. Patients are encouraged to involve their attorneys for legal advice. This approach promotes transparency, accountability, and trust while resolving claims quickly and fairly, saving time and resources. The

focus is on learning from mistakes to improve patient safety.¹⁰

3.4 The Pew Mediation and ADR Model

The Pew Demonstration, Mediation, and ADR project, implemented in four Pennsylvania hospitals in 2002, aims to manage adverse events through improved communication, addressing patient concerns, learning from incidents, and achieving fair, cost-effective claim resolutions.

The model recommends several key elements:

- **Communication Skills Training:** Healthcare professionals are trained to engage in open, honest discussions with patients and families after medical errors.
- **Involvement of Process Experts:** Experts guide the planning and execution of disclosure conversations, ensuring sensitivity.
- **Adequate Time for Disclosure:** Sufficient time is allocated for meaningful discussions, preventing rushed interactions.
- **Apology from All Parties:** Apologies from involved parties show empathy and a commitment to improvement.
- **Debriefing and Support:** Support is provided to healthcare professionals to cope with the emotional impact of errors.
- **Mediation for Claim Settlement:** Mediation is used to facilitate fair, collaborative resolutions, avoiding litigation.

The Pew Demonstration, Mediation, and ADR project uses mediation to improve communication and accountability in healthcare. Facilitating open dialogue helps parties understand each other's views after adverse events, promoting healing and learning. Mediators guide discussions to clarify issues, offering solutions like compensation and policy changes. This approach addresses patients' needs and encourages proactive safety improvements, providing a constructive resolution to disputes.¹¹

3.5 Internal Neutral Mediator Model

The Internal Neutral Mediator Model, used at the National Naval Medical Centre (NNMC) in Bethesda, Maryland, features an ombudsman who addresses healthcare issues by investigating incidents and developing preventive protocols. This impartial role focuses on understanding root causes and advocating for patients, providers, and the organization. The program offers a confidential space for discussing concerns, mediating disputes, and ensuring fair resolutions, reflecting NNMC's commitment to patient-centred care and continuous

improvement.¹² NNMC's program has set a precedent for similar initiatives in healthcare, emphasizing the value of the ombudsman in enhancing patient experiences and communication. The model promotes accountability and learning, highlighting the importance of dedicated advocates in resolving conflicts and improving healthcare outcomes.¹³

4. ADR in Healthcare System: Indian context

4.1 Arbitrability of Healthcare Disputes

In India, the Arbitration and Conciliation Act of 1996 governs arbitration, a process where a neutral arbitrator resolves disputes. The Supreme Court in *Booz-Allen and Hamilton Inc v. SBI Finance* (2011) 5 SCC 532, clarified that arbitration is suitable for disputes involving personal rights (rights in personam), not public or property rights (rights in rem). In healthcare, arbitration can address issues like treatment decisions, patient consent, and internal disputes, focusing on matters affecting specific individuals or parties.¹⁴

Contractual disputes, including those related to insurance and employment in healthcare, can also be resolved through arbitration. However, arbitration is only appropriate for minor fraud allegations in medical malpractice cases. In contrast, severe cases, as noted in the *Ayyasamy* case (2016) 10 SCC 386, should be handled by the courts due to their public importance. Arbitration's advantages, such as flexibility and faster resolution, make it an appealing option, but the nature of the dispute must guide the choice of forum.¹⁵

4.2 Mediation in Healthcare Sector

Mediation is increasingly preferred in the healthcare sector for resolving disputes, as it promotes open communication and cooperation. Unlike litigation, mediation allows parties to maintain control over the process and fosters a more constructive environment. Justice R V Raveendran highlighted the drawbacks of court proceedings, such as delays, high costs, and a hostile atmosphere, which can strain patient-doctor relationships and increase stress for healthcare providers. Mediation addresses these issues by offering a confidential setting for honest discussions, often resulting in quicker resolutions, typically within 60 days.¹⁶ Mediation is especially beneficial in preserving relationships, which is crucial in healthcare disputes involving employee indemnity insurance. It avoids the animosity of legal battles and encourages cooperative, mutually satisfactory solutions. The process also emphasizes understanding and

communication, as seen in cases like *Dr. Laxman Balkrishna Joshi vs. Dr. Trimbak Babu Godbole* (1969) 1 SCR 206, where mediation can lead to additional training and improved patient care. Mediation's focus on efficient, amicable settlements makes it an effective tool for resolving healthcare disputes.¹⁷

4.3 Lok Adalat for the medical disputes

The Indian judicial system uses Permanent Lok Adalats to relieve court congestion and resolve disputes. According to Section 22A(b) of The Legal Services Authorities Act, 1987, Lok Adalats can handle medical-related disputes, as hospitals and dispensaries are classified as Public Utility Services. This forum allows for settling disputes such as medical negligence and Medi-claims insurance outside the traditional court system, promoting timely and amicable resolutions. Lok Adalats offer a cost-effective and flexible alternative to litigation, helping to address medical disputes and reduce the burden on courts efficiently.¹⁸

4.4 Significance of ADR in Healthcare Dispute

ADR in healthcare has several implications that can positively impact the healthcare system, patients, and healthcare providers and resolve disputes. Here are some critical implications:

- **Enhanced Communication:** ADR processes like mediation and arbitration foster open, honest communication, improving understanding and empathy among parties and enhancing patient-provider interactions.
- **Faster Resolution:** ADR offers a quicker alternative to litigation, leading to faster dispute resolution and allowing patients and healthcare providers to move forward more swiftly.
- **Cost-Effective:** ADR reduces the costs associated with litigation, such as legal fees and lengthy trials, saving resources that can be redirected toward patient care and system improvements.
- **Patient-Centred Approach:** ADR prioritizes patient involvement, allowing them to express concerns and participate in decision-making, which enhances satisfaction and trust.
- **Relationship Preservation:** ADR promotes dialogue and understanding, helping maintain positive relationships between patients and healthcare providers, which is crucial for ongoing care.
- **Continuous Improvement:** ADR encourages learning from adverse events, leading to changes that improve patient safety and the overall quality of care.¹⁹

5. Manacle associated with the application of ADR in the Healthcare Industry

ADR faces two main obstacles compared to litigation. We can categorize these obstacles as perspective-related and legal obstacles.

5.1 Perspective-related obstacles

Obstacles to ADR in healthcare include physicians' fears about legal exposure and confidentiality breaches. Hospitals often see ADR as a way to avoid litigation rather than resolving minor issues. Patients may not recognise the value of ADR and prefer court if they have access to funds. Some believe ADR cannot provide satisfactory, legally binding outcomes and suspect hospitals and doctors collude to protect their interests. Lawyers may also push for litigation for financial gain.²⁰

5.2 Legal Obstacles

On a legal level, some obstacles to ADR in healthcare include concerns over access to justice. Critics argue that ADR may not adequately protect parties' rights, particularly in compulsory arbitration, which can limit court access. It undermines the value of consent, as patients might need to fully understand or agree to such terms when signing pre-treatment arbitration agreements.

ADR methods are intended to complement the court system, yet there are operational and legislative challenges. These include practical and logistical issues and existing laws that may hinder ADR's broader adoption in healthcare. Ensuring access to justice is fundamental in bridging inequalities and ensuring fair treatment in legal processes, which ADR must also support.²¹

5.3 The operational Premise:

In the operational Premise, ADR is most effective when parties voluntarily choose it, as they are more likely to understand and work towards resolving their disputes. However, issues can arise when ADR is institutionally enforced, leading to consistency in methods, application, and outcomes. Several reasons contribute to these discrepancies:

- **Healthcare Institutions Approach:** Some healthcare institutions use ADR to deter litigation, which may prioritize institutional interests over fair dispute resolution.
- **Handling Complaints and Claims:** The success of ADR depends on fair and transparent handling of complaints and claims. A lack of confidence in the process can arise if these issues are not adequately addressed.

- **Pre-treatment Clauses:** Pre-treatment arbitration or mediation clauses often favour institutions and may limit the weaker party's understanding or agreement, creating an imbalance in power and potentially undermining ADR's effectiveness.

5.4 The legislative Premise:

On the legislative Premise, there are several obstacles related to ADR that stem from legal frameworks. These obstacles include:

- **Public Order Limitations:** Some legal systems, like India's, consider health a public policy issue, often referring medical disputes to courts rather than ADR.
- **Caps on Compensation:** Countries like India may limit economic and non-economic compensation in malpractice claims, potentially reducing ADR's fairness and effectiveness.
- **Pre-screening for Merit:** Pre-screening cases in institutionalized ADR can cause delays and create barriers, affecting the process's efficiency.
- **Unified Legal Framework:** In quasi-federal countries, the need for unified laws can hinder consistent and harmonized ADR practices, posing challenges in implementation.

6. Drawbacks of ADR in Healthcare Dispute

While ADR methods like mediation and arbitration can save time and costs in healthcare disputes, they have drawbacks. The potential drawbacks of ADR in healthcare are as follows:

- **Lack of Formal Procedures:** ADR may need more formal legal procedures and standards of traditional litigation, raising concerns about fairness and predictability. It is useful to expedite the cases in pandemics.²²
- **Limited Legal Protections:** ADR participants may need more discovery access, appeal rights, and fewer opportunities to present their cases fully.
- **Power Imbalances:** In healthcare disputes, power imbalances can affect negotiation dynamics, often disadvantaging patients.
- **Confidentiality Concerns:** While ADR emphasizes confidentiality, public disclosure may be necessary for patient safety and accountability.
- **Limited Precedential Value:** ADR decisions typically do not create binding legal precedents, complicating the establishment of consistent legal principles.
- **Lack of Expertise:** ADR practitioners may need more expertise in complex healthcare issues, potentially affecting case evaluations.

- **Enforcement Challenges:** Enforcing arbitral award/ mediation settlement agreement can be more challenging than enforcing court judgments, complicating compliance.

ADR effectiveness in healthcare varies with the situation, parties' good faith, and the process's quality. Each case should be assessed individually to choose the best dispute resolution method.²³

7. Conclusion

U.S. President Jimmy Carter's quote underscores the need for mutually beneficial outcomes in dispute resolution, emphasizing that both parties must "win" for agreements to last. This principle is relevant to ADR in healthcare, where arbitration/mediation protect the interests of all parties. The Indian Supreme Court has endorsed ADR, as seen in *Food Corporation of India v. Joginder Mohindarpal Case 1989 SCC (2) 347*, and *Afcons Infrastructure v. Cherian Varkey Construction 2010 (8) SCC 24*, recognizing it as a viable alternative to litigation, especially for commercial disputes.

Implementing ADR in India's healthcare sector faces challenges due to cultural diversity, power imbalances, and varied stakeholder interests. A successful transition requires addressing these issues to ensure fair and effective ADR practices. Developing an Indian-specific ADR model that aligns with societal values can foster open communication, timely resolutions, and transparency. ADR can make dispute resolution faster and more cost-effective and improve patient safety by encouraging hospitals to adopt ADR agreements with patients.

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Review Article

Medicolegal Aspects of Examination of Accused of Sexual Offences

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Judgement.

Abstract

With the implementation of Protection of Children from Sexual Offences (POCSO) Act in 2012 the scope of legal definitions and requirements related to sexual offences has been widened. The legal framework necessitates that medical examinations follow to stringent procedures to confirm that evidence is collected in such a way that of chain of custody is properly maintained along with proper documentation. The timing of medical examinations is vital for collecting evidence that can establish the connection between an accused with the alleged crime. Deferrals in conducting these examinations can adversely affect the value of evidence collected. In India, the examination of accused individuals in sexual offenses is governed by a complex framework involving statutes, procedural rules, and judicial guidelines. This framework ensures that the process is fair, thorough, and respects the rights of all parties involved. These legal provisions ensure that the examination of accused individuals in sexual offenses is conducted in a manner that respects their rights while also gathering necessary evidence for the investigation and trial. The integration of statutory law, procedural rules, and judicial precedents helps balance the need for evidence with the protection of individual rights.

1. Introduction

With the implementation of Protection of Children from Sexual Offences (POCSO) Act in 2012 the scope of legal definitions and requirements related to sexual offences has been widened. Under the POCSO Act, the term "person" is considered as gender-neutral which indicates that accused can be either male or female. Therefore, it is of utmost importance to be prepared for medical examination of male as well as female accused. Sensitivity and secrecy should be key components of medical examination of the accused. The legal framework

necessitates that medical examinations follow to stringent procedures to confirm that evidence is collected in such a way that of chain of custody is properly maintained along with proper documentation.

The timing of medical examinations is vital for collecting evidence that can establish the connection between an accused with the alleged crime. Deferrals in conducting these examinations can adversely affect the value of evidence collected. Various biological evidence such as semen, blood,

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or other bodily fluids can get spoil over period of time. Deferrals in examination can lead to the damage or variation of this evidence, causing it tougher to associate the accused to the crime. In India, the accused need be officially arrested by the police prior to subjecting the accused for examination. This usually results in delay if arrest is not done earlier. Doctors play a pivotal role in the cases of sexual violence by providing medical care, gathering evidence, and recording findings. Their work ropes the legal process by providing indispensable medical comprehensions which can be used by investigating authority and the judiciary.^{1,2,3}

Corroboration in cases sexual offences is not the mandatory legal requirement but rather a matter of judicial discretion. In the context of criminal law, corroboration denotes to additional evidence that backs the testimony of the prosecutrix (victim) in a case of sexual violence. It is preordained to reinforce the integrity of the prosecutrix's account.⁴

In India, the examination of accused individuals in sexual offenses is governed by a complex framework involving statutes, procedural rules, and judicial guidelines. This framework ensures that the process is fair, thorough, and respects the rights of all parties involved.

2. Medical Examination Protocols

2.1 Consent: The collection of evidence from the accused should be done with their informed consent. This ensures that the process respects the legal rights of the accused while allowing for the collection of necessary forensic evidence. The examination has to be performed with the extreme respect for the accused's dignity and confidentiality. Medical professionals should be trained to handle such cases sensitively and professionally. There are legal provisions which state that the examination of accused can be done with reasonable force.

In cases of sexual offenses, Section 53 of the Criminal Procedure Code allows for the medical examination of the accused, including the use of reasonable force if necessary. This provision ensures that forensic evidence can be collected even if the accused resists the examination.⁵

2.2 Section 53 A: It deals specifically with medical examination of accused of sexual offences. This section mentions the particulars the doctor to note down in the report.

- S 53 A 2(i) CrPC- Name of the accused, address of accused & person who brought.
- S 53 A 2(ii)- Age of accused.

- S 53 A 2(iii)- Injuries present over the body.
- S 53 A 2(iv): Samples to be collected for DNA profiling.
- S 53 A 2 (v) – Other information in detail.
- S 53 A (3) – Specific reasons to be mentioned for conclusion.
- S 53 A (4)- Exact time of commencement & end of examination to be mentioned.
- S 53 A (5)- Handing report immediately.⁶

2.3 Section 54 Cr PC: It provides the accused with the right to have a medical examination conducted at their request, especially if they believe it will help their defence. Medical examinations should be conducted with respect for the accused's privacy and confidentiality. Records and findings must be protected and only disclosed as required by law.⁷

3. POCSO Act

Although primarily focused on offenses against children, the POCSO Act has provisions relevant to the examination of accused persons. It emphasizes child protection and mandates specific procedures for handling cases involving minors. It also requires careful handling of medical examinations to avoid further trauma to victims.^{8,9}

4. Supreme Court and High Court Rulings

Indian courts have issued various rulings on the rights of the accused and the procedures for conducting medical examinations. These rulings often provide guidance on ensuring fair treatment and proper procedure. For instance, the Supreme Court has emphasized the need for respect for the accused's dignity and the importance of adhering to proper medical and legal standards.

4.1 State of Bombay vs Kathi Kalu Oghad (1961):

Landmark Judgment on Right of an Accused Person against Self-Incrimination as Imbided in Article-20(3) of the Constitution of India. Foremost question was that whether collecting of evidences like finger prints, handwriting samples, DNA samples and other evidences establish lawful modes of collecting the evidences in regard of protection guaranteed under 'Article- 20(3)' under the Constitution of India. The Oghad's case did not render protection to material evidence like thumb prints, foot prints, finger prints, handwriting samples, signatures, showing body parts etc. and considered keeping it outside the ambit of 'Art. 20(3)'. Hence, these evidences do not violate the "right against self-incrimination" and the accused needs to be subjected to obligation on the basis of these evidences following due process of law.^{10,11}

4.2 Selvi v. State of Karnataka (2010):

The Supreme Court in this case considered the constitutionality of various evidence gathering techniques including narcoanalysis, BEAP (Brain Electrical Activation Profile) or 'brain mapping', and polygraph tests. The court found that neuroscientific investigative techniques could potentially violate fundamental constitutional rights, particularly the right not to be forced to incriminate oneself under Article 20(3) and the right to personal liberty under Article 21 of the Constitution. This decision underscores the importance of ensuring that investigative methods respect constitutional protections and individual rights.^{12,13}

The Court, after tracing the jurisprudence of the right to privacy in India discussed the importance of mental privacy and the choice to speak or stay silent, as well as their intersection with personal autonomy as aspects of the right to privacy. The Court observed that the right to privacy under Article 21 should account for interaction with Article 20(3), the right against self-incrimination. The Court further held that drug induced revelations and measurement of physiological responses would amount to an intrusion into the mental privacy of the subject and that forcible extraction of testimonial responses was not provided for under any statute and could not be a reasonable exercise of policing functions. The Court therefore ordered that these tests could not be administered without the valid consent of the accused.^{12,13,14}

4.3 Prakash v. State of Karnataka (2014) and Shreemad Jagadguru Shankaracharya v State of Karnataka, 2014 SCC Online Kar 5639, dated 03.12.2014:

Section 53-A CrPC allows for the medical examination of an accused person in cases of rape. It was challenged on the grounds that it might be misused by the police, particularly with regard to informing the accused about the nature of the medical examination.⁶

The court ruled that while the possibility of misuse by police officers exists, it does not necessarily invalidate the section itself. The mere potential for abuse does not reflect on the constitutional validity (*vires*) of the provision. This means that the section can still be considered constitutionally valid even if there are concerns about how it might be used. The court upheld the constitutionality of the provision, noting that not informing the accused about the specific nature of the medical examination was

important. This approach helps prevent the accused from being alerted and potentially obstructing or tampering with the evidence. In other words, the court found that maintaining the confidentiality of the examination process was necessary to ensure that evidence could be collected effectively and that the investigation was not compromised.^{15,16}

4.4 Dharam Deo Yadav v. State of Uttar Pradesh (2014):

Supreme court in the judgement emphasized need of medico legal examination and sample collection. Proper protocol to be followed during the procedure.¹⁷

4.5 State of Karnataka v. Manjanna (2000):

The Supreme Court of India highlighted the critical importance of conducting medical examinations promptly in cases involving allegations of sexual offenses. The Supreme Court emphasized that conducting medical examinations without delay is crucial. The rationale is that prompt medical examinations help preserve vital evidence that might otherwise be lost or degraded over time.¹⁸

4.6 Krishan Kumar Malik v. State of Haryana (2011) & Rajendra Prahladrao Wasnik v. State of Maharashtra (2018)

In these cases, the Supreme Court of India addressed the role of DNA evidence in sexual offense cases and its relationship with certain procedural provisions. In *Krishan Kumar Malik v. State of Haryana* (2011), the Supreme Court held that, following the insertion of Section 53A of the CrPC, it is necessary for the prosecution to conduct a DNA test to substantiate its case against the accused. This reflects the court's view that DNA evidence is a crucial component of proving allegations of rape.¹⁹

Reference in *Rajendra Prahladrao Wasnik v. State of Maharashtra* (2018): The Supreme Court reiterated the importance of DNA evidence in cases of sexual offenses, especially considering Sections 53A and 164A of the CrPC. These sections pertain to medical examinations and evidence collection in rape cases. Absence of DNA Evidence: The Court observed that while the duty is on investigators to conduct DNA profiling, the absence of DNA evidence alone does not automatically negate the prosecution's case.

The Court noted that the definition of rape under Section 375 of the Indian Penal Code (IPC) has been broadened to include acts beyond penile-vaginal intercourse. As a result, the absence of male DNA in vaginal samples (such as semen or sperm) is not sufficient by itself to conclude that rape did not

occur. The definition now covers a range of non-consensual sexual acts, making the presence of DNA evidence less determinative in isolation. While the court emphasized the importance of DNA evidence, it also acknowledged that the lack of DNA evidence would result in adverse consequences for the prosecution, highlighting that the prosecution must still prove its case beyond reasonable doubt using all available evidence.²⁰

4.7 Ram Singh v. Sonia (2012):

Supreme court stated that there is need for proper documentation and chain of custody to ensure its admissibility.²¹

4.8 State of Karnataka vs Raju (2007):

The Karnataka High Court has ruled that even in the absence of medical evidence, an accused can be convicted if the other evidence is sufficient to establish the guilt of the accused beyond a reasonable doubt. This means that while medical evidence is important, it is not always essential for securing a conviction in a rape case.

The court has emphasized that corroboration with medical reports is not a mandatory requirement in every case. The testimony of the victim, if credible and consistent, can be sufficient to support a conviction, even if medical evidence is lacking or incomplete.²²

4.9. Neeraj Sharma vs state of UP (1993):

Sample collection or any investigation needs to be done even though some discomfort occurs. Section 53 of the CrPC allows for the use of reasonable force to collect evidence from an accused, and this provision has been interpreted to be consistent with constitutional rights, provided that the force used is proportionate and the procedure respects the accused's dignity and rights.²³

4.10 Sheela Barshe vs State of Maharashtra:

In Sheela Barse vs. state of Maharashtra AIR 1983 SC 378, the Supreme Court observed: Section 54 undoubtedly provides for examination of an arrested person by a medical practitioner at the request of the arrested person and it is a right conferred on the arrested person.^{7,24}

Often, individuals in police custody may not be fully aware of their legal rights, including the right against self-incrimination and protection from torture or maltreatment. This lack of awareness can result in individuals not asserting their rights or seeking redress if they are subjected to ill-treatment.²⁴

5. Legal Safeguards through Constitution of India:

The Indian Constitution and legal framework provide several safeguards to protect individuals in custody:

- **Article 22:** This article guarantees protection against arbitrary arrest and detention and mandates that a person must be informed of the grounds of arrest and be allowed to consult a lawyer.²⁵
- **Section 50 Cr PC:** This section requires that a person arrested must be informed of the grounds of their arrest and the right to bail.²⁶
- **Section 54 Cr PC:** This section provides that an arrested person can request a medical examination to document any injuries or maltreatment.⁷
- **Protection Against Torture:** Torture and ill-treatment of individuals in custody are explicitly prohibited by law. The Constitution of India, under **Article 21**, guarantees the right to life and personal liberty, which includes protection against torture and cruel, inhuman, or degrading treatment. There is obligation on the magistrate to inform the arrested person about right to get examined by the doctor referring to section 54 CrPC to ascertain whether he was subjected to torture or not.²⁴

6. Other Legal aspects

6.1 Medical age estimation on the Accused of a Sexual violence

Though section 53(A) CrPC insists for a medical age estimation in all cases of accused of Rape; the section 94 of Juvenile Justice Act, 2015 states that only if documentary proof (school records or birth certificates issued by revenue authorities) are not there then only medical age estimation should be done that too using latest methods. The model rules under the JJ Act, 2015 insists that the medical age estimation be done by a board consisting of Radiologist, Dentist and a Physician – who should submit their report within 15 days of referral. Even the Supreme Court judgment reiterates the same in Ashwani Kumar Saxena case 2 that only in cases where those age documents or age certificates are found to be fabricated or manipulated, the special court, the Juvenile Justice Board or the Child welfare Committee need to go for medical report for age determination. But the latest judgement by Supreme Court rules the contrary that –Bone test is not enough to fix the age.^{27,28,29}

6.2 Relevancy to document the Potency of the Accused

Definition of rape and sexual violence has evolved significantly to include a broader range of acts beyond traditional penile-vaginal penetration. This expansion reflects a more comprehensive understanding of sexual violence and aims to provide greater protection for survivors. Section 53 A CrPC which specifically deals with medical examination of accused of rape does not mention anything about potency examination. Section 375 IPC defines rape as the penetration of the penis to any extent into a woman's genitals without her consent. The definition does not require that the penis be erect or that penetration be complete. This broader definition ensures that various forms of sexual violence are covered, even if the penetration is minimal.³⁰

6.3 Implications for Medical Examination

Given the legal definition, the focus is on the presence of penetration rather than the physical state of the penis or the extent of penetration. Assessment of Potency: Medically, assessing whether a person is potent (i.e., capable of achieving an erection) involves examining physical and psychological factors.³¹ However, a physical examination alone cannot definitively rule out psychological impotence. On physical examination there can be multiple causes of impotency including webbed penis.³² Even if a person is physically capable of erection, psychological factors might affect their performance, and vice versa. This makes it difficult to conclusively determine potency based solely on a physical examination.

6.4 Relevance in Legal Context

Irrelevance of Potency for Rape: Given that the legal definition of rape does not require full penetration or an erect penis, the medical examination of potency is not directly relevant to proving or disproving the occurrence of rape. **Focus on Evidence of Penetration:** The primary concern in legal proceedings is whether there was any degree of penetration, not whether the accused was capable of achieving an erection. Hence, potency examinations are not typically relevant in determining whether rape has occurred under the legal definition.

6.5 Legal and Medical Practice:

Purpose of Medical Examination: In cases of alleged rape, medical examinations are generally conducted to gather evidence of physical injuries, signs of trauma, or the presence of seminal fluid, rather than to assess the accused's potency.

Limitations: Courts generally recognize the limitations of medical examinations in determining

psychological aspects of potency, and thus, such examinations are not given undue weight in determining guilt or innocence in rape cases.¹

7. Conclusion

These legal provisions ensure that the examination of accused individuals in sexual offenses is conducted in a manner that respects their rights while also gathering necessary evidence for the investigation and trial. The integration of statutory law, procedural rules, and judicial precedents helps balance the need for evidence with the protection of individual rights.

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Short Communication

Application of Cone Beam Computed Tomography (CBCT) Tool in the Estimation of Age from Pulp Volume Ratio in Forensic Dentistry: A Short Review

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Abstract

Establishing the biological identity of dental remains or parts is quite challenging in medico-legal cases. In Forensic dentistry professionals, establishing the biological identity by dental regions is one of the most important tasks. Estimation of age is an important aspect of establishing biological identity. Physical examinations, radiographic analysis of ossification of bones, and dental exams are all currently available for predicting the age of departed or living individuals. All these methods have their advantages and limitations. Often comparing these methods provides variation in degrees of accuracy between them. Radiographic tooth growth is a more reliable age assessment as it is mostly genetically determined and thus less susceptible to nutritional and environmental variables. Various scientific research showed that the pulp-to-tooth ratio is as good as a predictor of age and has received more attention. Cone-beam computed tomography systems (CBCT) CBCT in the age estimation attracts forensic personals and researchers compared to micro – C.T. A single scan of a cone-beam C.T. in all three dental axes gives much 3D data on dentition in living individuals in the required area. The present review assessed the role of CBCT in age estimation by pulp volume methods with its merits, demerits, and advantages in the forensic context.

1. Introduction

With age, our body left a distinct signature on our bones. It is quite challenging in medicolegal investigations when the body is in a fragmentary state.¹ When the bones are in an extremely fragmented stage the age assessment from dental parts/remains bears a significant standpoint. Genetics, day-to-day nutrition, and

certain hormonal variables affect the bones and other structures of human beings. Compared to other skeleton components, teeth are less prone to be influenced by external causes. Consequently, chronological age (C.A.) through morphologically and radiologically assessing dentition is becoming increasingly essential in

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human anthropology and bioarchaeology. Dental age determination is dependent on developmental, morphological, and biochemical changes in the teeth.²

2. Importance of age estimation:

Various components of a man's body are employed for estimating age. Despite this, many body parts lose their original form in catastrophic accidents, burns, or charred remains and cannot be utilised for age estimation.³ Human teeth last for years after death and can be used to estimate human age.⁴ Furthermore, teeth are the least damaged or impacted by their surroundings activities.⁵ Estimating the age of teeth in children is pretty straightforward and depends on the teeth's developmental stage.

On the other hand, estimating adult age is a difficult task in forensic medicine. The enamel and dentin make up the tooth, the most rigid portion of the human framework. To evaluate morphological changes, tooth sections are required, which are not feasible in living persons. As a result, most age assessment approaches rely on radiographic imaging.⁶ Kvaal et al.⁷ developed a technique for estimating age based on secondary dentin deposition and pulp diameters in 1995. The authors concluded that pulp width is highly linked to aging.⁷

3. Methods of age estimation:

Calculating age in forensic odontology can be done through Physical examinations, radiography of the left hand, and dental examination. These are all currently available procedures for predicting the age of expired or living people, each with differing degrees of precision. Radiographic tooth growth has been demonstrated to be a more reliable way of age assessment since it is mostly genetically determined and thus less susceptible to nutritional and environmental variables.⁸ The radiological age is determined by evaluating the following characteristics as⁹

- Prenatal evaluation of jaw bones - Ultrasound examination can be used to diagnose prenatal jaw bones, which can then be validated by molecular testing using invasive methods, as well as post-delivery radiography and post-mortem, which includes the histomorphological study of cartilage and bone.
- Tooth germs' appearance - Tooth development is the best method for determining age because it has less variability than other development markers. Tooth eruption is one of the most easily observable alterations among the many dynamic

events, from tooth development to tooth shedding. In addition, teeth erupt at reasonably consistent times, which can be used to calculate the mean age of erupting teeth.

- Mineralisation's first visible trace or the start of mineralisation - Mantle dentine is the first mineralised layer of dentin, while circumpulpal dentine is the remaining mass. The odontoblastic cells recede in the area of the dental papilla as the deposition progresses, generating an S-shaped curve identified on a radiograph.
- During the gestation period- mineralisation of several deciduous teeth begins –
- With the crown erupting into the oral cavity - a visual technique can be used to assess age based on the tooth eruption sequence.
- Degree of root completion
- Degree of deciduous tooth resorption - Although root resorption of primary dentition is a vital aspect of dental development, the accuracy of using root resorption to determine age has received little attention.
- Open apices in tooth measurement - The examination of the morphological features of teeth, such as open apices on dental radiographs of older people, is better dependable than the majority of other techniques for estimating age, and we can say that it is the most popular method to determine age in humans.
- Formation of physiological secondary dentine/volume of the pulp chamber and root canals
- Tooth pulp ratio - Dentin and tooth pulp sometimes go through pathological and physiological changes as they are continuously used in the oral cavity and if infected by bacteria. Because breaking teeth to measure these morphological changes is impossible in vivo, age estimation approaches rely on X-ray imaging of the tooth.
- Third molar development and topography - Up until age 16, tooth development and eruption are reasonable measures of age. Only third molar growth can be examined between the ages of 16 and 24. However, there is much heterogeneity, the precision is debatable, and third molars are not generally present.

4. Cone Beam computed tomography (CBCT) and its use in age estimation: Two methods are frequently used to identify age: the "Atlas technique," which

compares dental development radiographically (mineralisation) to published guidelines, and the "Scoring technique," which divides the result of the tooth into several phases and assigns grades that are then assessed via data analysis.

Schuller used radiographic techniques for dental examination in 1921.¹⁰ These techniques have also been used to estimate age for over half a century. Kvaal et al.⁷ were among the first to recommend utilising radiography to estimate dental age among the adult population. The authors put forth several teeth and pulp length and breadth measurements. Cameriere et al.¹¹ gave a more or less similar technique for age calculation, but they modified it and assessed the tooth in two areas—the tooth and pulp area. The approach investigated the maxillary canine at first. Still, it expanded to include the second molar and mandibular canine.^{12,13} Babshet et al.¹⁴ conducted a similar investigation on mandibular canines in an Indian population.¹⁴ Conversely, radiographs render 3 - dimensional (3D) pulp as a two-dimensional (2D) image. Biological age assessment methods using microfocus computed tomography and 3-D data and ratios of the pulp cavity to all teeth in several single-rooted teeth have been studied.

A newer method for obtaining 3D images of human teeth among living people has been developed using cone beam C.T. (CBCT). It was first introduced in 2000 and allows for 3D imaging of mineralised tissues in small jaw volumes. CBCT depends on cone beam technology and acquires several successive projection images (basis images) in a single scan across the area of interest using a divergent source of ionising radiation and a 2D area detector positioned on a revolving gantry. Because cone beam reconstruction algorithms allow a complete volumetric region to be reconstructed, this area can be refurbished to reveal anatomical details in any plane.

4.1 Examining the volume of teeth

The ages of the adults can be calculated using a radiological measurement and measuring the decrease in pulp cavity size that occurs due to secondary dentine deposition, which is proportionate to their age. Kvaal et al method:⁷ Tooth and pulp ratios for the upper and lower six teeth use the maxillary central and lateral incisors, maxillary second premolars, mandibular lateral incisor; mandibular canine; and the first premolar, and will calculate the age using this method. Age is calculated by plugging

the pulp-to-tooth ratios of Kvaal et al.'s age calculation algorithm.

$$\text{Age} = 129.8 - (316.4 \times M) (6.8 \times (W - L))$$

R is pulp-to-root length, P is pulp-to-tooth length, T is tooth-to-root size, A is pulp-to-root width at cemento-enamel junction, C is pulp-to-root width at mid-root level, B is pulp-to-root width at midway between groups C and A were studied for all six teeth with the use of intraoral periapical X rays. In the formula, the average values of proportions except for T (M), the mean value of width ratio B and C (W), and the mean measurement of length ratio P and R (L) were changed.

4.2 Merits of CBCT Tool:

Cone beam computed tomography has opened new paths for getting 3D tooth views, resulting in acceptable image quality at a much less radiation dose (skin dose 1.19 mSv, total dose 20 mSv per examination). Controlled magnification, lack of overlaying, lack of deformations, and multiplanar and 3D presentations that are accessible are all advantages of CBCT over standard radiography treatments, allowing for higher structure transparency and diagnostic performance.¹⁴

4.3 The drawback of CBCT Tool:

Larger dosages than two-dimensional imaging, difficulty in precisely displaying the interior structure of soft tissues and soft-tissue pathologies, and inability to accurately portray the inner structure of soft tissues and soft-tissue aberrations are some of the disadvantages of CBCT.

4.4 Cone beam computed tomography for assessing age by calculating pulp volume of teeth:

Teeth' growth, biochemical, and morphological changes are used to estimate dental age. Because the mineralisation of dental tissues is a continual activity that may be examined radiographically in adults, morphological changes are preferred. Many techniques dependent on biochemical alterations in teeth, including aspartic acid withdrawal, are time taking, complicated, and invasive, and so are very rarely used. All adult teeth, except for the third molar, have their root formation completed around 16 years of age when their apices close. As a result, age estimation in adults using root development indicators like Demirjian's and Willem's is impossible.

Secondary dentin deposition occurs on both walls of the dental pulp throughout the developmental process of teeth after maturation, which minimises the size of the pulp cavity over time.

As a result, the degree of pulp cavity size reduction can be used as an excellent morphological criterion for determining age in adults. Tooth extraction and incision, as well as imaging techniques, can be used to determine secondary dentin deposition. Deposition of Secondary dentine can be seen and assessed using oral panoramic and intra-oral periapical radiography. On the other hand, these radiographic modalities have the drawback of being two-dimensional and presenting a distorted image. In 2-D images, there is overlapping of anatomical structures, and the problem with radiographical geometry and amplification can also be seen, so they fail to offer reliable measurements.¹⁵ Studies have used three-dimensional modalities to overcome the constraints of two-dimensional imaging for age estimates. For example, CBCT (cone beam computed tomography) provides 3-D images, an accurate and appropriate method for calculating dental pulp volume.

4.5 Interpretation of the image procured by CBCT:

Planmeca Romexis is a software of Helsinki, Finland, used to analyse the CBCT pictures. With the help of software, the crown volume (CV) is estimated by tracing a line from the cementum-enamel junction to the incisal edges of the tooth in all three planes, which can be axial, sagittal, or coronal. The grayscale criteria for all three structures, enamel, dentin, and pulp, allows the tooth crown to be segmented automatically. The tooth crown pulp volume (CPV) is calculated in the same way but with three planar axes marking the area from the CEJ to the pulp chamber roof and a grayscale threshold that divide the coronal pulp. With the help of 3D pictures, the software estimates the crown (CV) and pulp chamber (CPV) volumes. And with the use of software, each tooth's pulp chamber/crown volume ratio is measured.¹⁶

4.6 Efficacy of CBCT tool in age estimation:

Pinchi et al.¹⁷ said that their existing method, based on the geometric estimation of the various portions of the tooth, showed that it has the best accuracy in age assessment for age groups between 30 and 59 years. It was seen that age estimation error was more or less comparable to what was reported by other dental methods for different age cohorts. The Volume measurements of the pulp chamber/crown ratio (up to cemento-enamel junction) are helpful in any gender for age assessment. It is quicker and equally reliable than pulp cavity/tooth ratio investigation, as per Asif et al.¹⁸ Gulsahi et al.¹⁹ say that the pulp volume to tooth volume does not depend on gender and found out

that calculating it on anterior maxillary teeth is more reliable than calculating it on other teeth. Teeth with decay, fillings or crown fillings, periapical illnesses, or unidentifiable pulps were excluded from these studies since they obstruct the physiological events in healthy teeth. The use of cone beam computed tomography (CBCT) in today's time to calculate the pulp/tooth volume ratio is suggested for two reasons: (1) The measurement of Volumes of the pulp chamber and tooth has more weightage than area ratio calculations, even secondary dentine deposition is not identical across all pulp surfaces, and thus measurements of projected areas may give an erroneous impression of the degree of this procedure; (2) CBCT is an accurate technique for investigating the anatomical structure of the pulp chamber and root canal space, offering three-dimensional volumetric data of the tooth.²⁰ Some researchers estimated age from radiological evaluation of root developmental stages of molars.²¹

In the Indian context, it is necessary to add CBCT guidelines to the dentistry education syllabus for the best use of CBCT. Recently, NMC implemented a competency-based education system for medical graduates that can help them in developing their skills in applied aspects also.²² With technological advancement, training and skill development in CBCT techniques could be an additional option for medical graduates.²³ It is also the need of the hour that all prescribing forensic dentists, clinicians, and future researchers keep themselves trained in the latest CBCT procedure and its interpretation for maximum benefits in the medicolegal and clinical context in India.²⁴

5. Conclusion

Evaluating the pulp space opens up new possibilities for determining dental age. The calculation of secondary dentine deposition is commonly used and acts as an effective procedure. This apposition is a constant, age-related process that changes the pulp chamber's size and is altered in pathological situations (for example, caries). The size of the pulp chamber has been studied using a variety of approaches involving tooth cross-sections and radiography. The pulp-tooth area ratio of upper canines has been calculated using oral ortho-panoramic and intraoral periapical radiography. Radiographs have the disadvantage of being 2-D projections which go through significant amplification and deformational errors. As there are specific errors in 2D images, it is suggested that teeth' mesiodistal

and buccolingual measures should be calculated together. The best and most accurate approach for estimating the pulp-tooth volume ratio is Cone Beam computed tomography (CBCT)

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Case Report

Crime Scene visit and Meticulous Autopsy in Decomposed Body Yields Fruitful Results

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Abstract

Decomposition makes post-mortem examination more complicated due to distortion and changed tissue morphology. Decomposition of dead body refers to multiple degradation processes occurred in organism after death. It is the combined effect of tissue self-digestion causing autolysis and the bacterial overgrowth leading to tissue putrefaction. Hence, it is not easy to find out a definite cause of death at the end of postmortem examination in such decomposed bodies. But sometimes meticulous autopsy, crime scene visit and appropriate guidance to investigation authorities helps to solve the case and yield fruitful results even in cases advanced decomposition changes.

1. Introduction

Hanging is one of the most common methods of suicide worldwide with an estimated fatality rate of over 90%.¹ In hanging cases, the cause of death is mainly due to asphyxia due to Neck structures compression and most commonly are suicidal in nature.^{1,2,3} Hanging has been defined as a form of violent asphyxial death in which the pressure on the neck is applied by a constricting band which is tightened by the gravitational force acting on weight of deceased body.⁴ Depending on suspension and force acting for neck compression, hanging is classified as complete or incomplete. In incomplete hanging the suspension usually at low level leading to the touching victim's body, feet or legs to the floor. The most common place chosen by the suicidal victim is inside house when no one is present or all asleep or isolated and secluded areas like forest where body remained unnoticed for long time and not found till abnormal smell perceived by

someone or decomposition changes got evident distantly. Though the cases of suicide by hanging are in huge number but no much literature is available about advanced decomposition on suspended dead bodies.⁵

2. Case history:

A 31 years old, working female, who has lost her job during covid-19 pandemic found hanged at her flat with ligature around neck and with decomposition changes [Fig. 1].

3. Postmortem findings:

On external examination, the body evident with decomposition changes. No any significant injuries seen on body except ligature mark around neck. Yellowish fluid was oozing from nose and mouth with evidence of pupae. No any fracture evident on palpation, but a significant words were visible on anteromedial aspect of right thigh written with blue-black marker ink pen, i.e "..... You are

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chosen, You are blessed, You are forgiven". [Fig. 2].

Figure 1: Deceased found in hanging state at her residence



Figure 2: Suicide note written by deceased



An oblique ligature mark of total length of 30cm with 03cm width was present around neck which is running backwards and upwards. Total neck circumference was 38cm. Inverted 'V' mark evident against left mastoid. Further internal examination shows: Head was open firstly, where greenish, soft

pultaceous mass present. All internal organs were soft and decomposition grossly evident. Heart becomes soft, flabby brownish mass, lungs were collapsed, soft greenish mass, stomach was empty with mucosa blackish discoloured. Uterus was intact and empty. Subcutaneous tissues over whole body shows blackish discoloration. On neck dissection no any hemorrhages seen. Hyoid bone and thyroid cartilage were intact. Remarkably tissue adjacent to ligature mark shows more evident decomposition changes compared to structures under ligature mark. **Cause of death:** Evidence of obliquely placed ligature mark over neck. Viscera preserved for chemical analysis, and tissues for histopathological examination.

4. Discussion

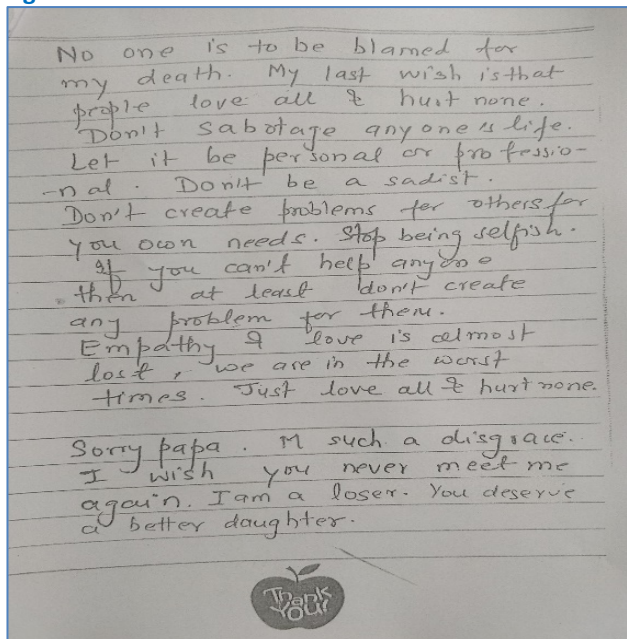
Decomposition is a sequential process. It is influenced by a various complex interaction of biotic factors (i.e. bacteria and insects) and abiotic factors (i.e. weather conditions) among which temperature and moisture. The postmortem changes can be still divided into two main groups: destructive phenomena (i.e. putrefaction) and other is conservative phenomena, which depend mainly on the external environmental conditions (i.e. maceration seen in immersed bodies, mummification seen in hot dry environment).

Decomposition is a quite complex interaction between intrinsic and extrinsic factors producing individual pattern of decomposition and insect colonization. The immediate post-mortem changes happen as a competitive result of putrefaction and desiccation. In this regard the presented case was studied and significant difference in decomposition changes observed in tissues under the ligature mark and tissues surrounding the ligature mark. This is mainly due to compression over neck causes the dissipation of tissue fluid and blood in surrounding tissues of applied pressure by ligature mark. Different compounds and gases produced by the breakdown of soft tissues during the decomposition and use them to locate the more suitable food resource for their offspring. Larval infestation for most of the blowflies is usually hindered by the rapid dehydration of the skin surface, facilitated in hanging bodies by the early putrefactive fluids falling on the drip zone. Due to gravity, the larvae may have fallen down in hanged bodies. Hence, there may be less internal maggots in totally suspended hanging body.

In decomposed body, it is challenging for autopsy surgeon to opine about cause of death and

manner of death. But in death due to ligature around neck the difference in changes under compression mark compared to surrounding tissue might be helpful to autopsy surgeon to opine about cause even if body found in early or moderately decomposed state. The rate of putrefaction is less in the tissue below the ligature as the blood was driven out due to compression.^{6,7}

Figure 3: suicide note found at crime scene



From the details of all police documents and reinvestigation of the crime scene is always helpful. In this case a suicide note was found [Fig. 3], no dragging marks or signs of struggle was observed at the crime spot. The writing in the note and the handwritten note found on deceased body were matched with her handwriting in the diary. The case study presented in this paper shared the manner of death (suicide by hanging) even with significant decomposition.⁸ Timely intervention and guidance by medicolegal expert facilitate to prevent erroneous conclusion.⁹

5. Conclusion

A visit to crime scene, careful documentation and analyzing the circumstantial evidences with meticulous autopsy helpful to guide the investigation officer to guide on the manner of death and helpful to resolve the case with positive conclusion.

6. Recommendations

Proper thorough investigation of crime scene or crime scene visit by forensic doctors should be done in a medicolegal case of decomposed deceased. Meticulous autopsy helpful to find out cause and manner of death in decomposed body.

Histopathological examination may helpful to rule out antemortem or postmortem injuries.

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Case Report

An Unusual Concealment of Homicide with Animal Attack: A Case Report

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Abstract

Homicide is the killing of a human being by another human being and is considered one of the most serious crimes. Perpetrators often attempt to conceal their crime through various means, which can lead to misinterpretation by inexperienced autopsy surgeons and consequently, miscarriages of justice. Therefore, our careful observation and analysis must be definitive in the pursuit of justice. This article presents a case where the deceased's body was brought by the police for a medicolegal postmortem, initially attributed to a suspected animal attack. However, following a thorough autopsy and crime scene investigation, the case was determined to be a homicide. The cause of death was identified as haemorrhagic shock resulting from injuries sustained during a struggle. No evidence of bite marks or puncture wounds typically caused by animal canines were found on the body. This study underscores the critical importance of meticulous autopsy procedures and comprehensive crime scene investigations in establishing both the cause and manner of death.

1. Introduction

Homicide is killing of a human being by another human being. This homicide may be lawful or unlawful. Lawful homicide includes justifiable and excusable homicides. Unlawful homicides include culpable homicide (S. 299 IPC), murder (S. 300 IPC), culpable homicide amounting to murder (S. 304A IPC), rash or negligent act leading to homicide (S. 304A IPC).¹ After committing a homicide, perpetrators may attempt to conceal or dispose of the victim's body, fabricate an alternate crime scene, or destroy critical evidence to delay or avoid detection of the corpse. In forensic pathology,

concealing a body following a homicide is a frequent challenge, exacerbated by increasing access to information, the fear of being caught, and advancements in technology that aid in evading detection and conviction.² Animals can inflict injuries capable of causing death, complicating forensic analysis. Some offenders obscure their crimes by manipulating the victim's remains to hinder identification, or by disposing of the body in locations that defy discovery. Some offenders conceal their crimes by manipulating the deceased person's body in such a way that it is impossible to

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determine the individual's identity, while others dispose of the body in a manner that makes it impossible to locate it.³ In certain cases, injuries caused by animal activity, whether blunt or sharp trauma, may be misinterpreted as post-mortem changes or assault-related injuries, and vice versa.⁴

Therefore, meticulous evaluation of injury patterns, comprehensive scene examinations, and thorough ancillary investigations are crucial in such scenarios.

2. Case report

A 32-year-old male deceased was brought to the mortuary of Saheed Hasan Khan Mewati Government Medical College, Nuh, Haryana on 1st November 2021. As per the history given by family members of deceased, the deceased had gone to graze his goat in a jungle area during the afternoon but had not returned by evening. He was discovered dead in the jungle near Pipaka village by the near passers, with a goat also found dead nearby, suspected to have been attacked by an animal. The initial investigation was conclusive of death of deceased as well as goat by the animal attack which was considered natural.

However, investigating officer along with crime scene experts suspected foul play upon visiting the crime scene. During the detailed investigation, the body was found smudged with sand, grass, and blood all over the body. Adjacent to the deceased, a brick-sized stone with a pointed edge stained with blood was discovered (Fig: 1). The case was recorded under section 302 IPC, demonstrating a homicide. Before conducting the postmortem examination, the deceased's body underwent radiological examination to identify any radio-opaque foreign objects, but none were detected on X-rays. External examination revealed torn areas on the shirt, which was also smeared with grass, sand, and blood. A white undershirt was similarly stained with blood in places. Additionally, a blue pair of trousers was secured with a black belt. Following injuries were noted on the deceased body on postmortem examination.

3. Autopsy Findings:

Multiple lacerated wounds were predominantly present over the head and face.

1. Multiple split lacerations about 9 in number of varying shapes and sizes ranging from 2cm X 1.5cm to 10cm X 1.5cm which were bone deep, present over an area of 13cm X 10cm over right frontotemporal and parietal region, extending from midline to 5cm above right mastoid. The

margins of wounds were irregular. On dissection, the underlying soft tissues and muscles were found ecchymosed. On further exploration, an oval shaped depressed fracture of size 4cm X 3cm was found over right parietal bone. The fractured margins showed infiltration of blood in their bony trabeculae. A fragment of stone of size 0.2cm X 0.1cm was found embedded in the outer table of right parietal bone near to midline and 5cm left to depressed fracture (Fig 2,3,4). On opening the skull cavity, minute dust and stone particles made of concrete were found in the fractured margins of skull.

2. Split lacerated wounds about 4 in numbers with sizes varying from 1cm X 0.5cm to 5cm X 2.5cm which were bone deep, present over an area of 11cm X 7cm over right forehead, extending from midline to 8cm above right tragus along the hairline. The margins of the wounds were irregular. On dissection, underlying soft tissues and muscles were found ecchymosed. On further dissection, a comminuted fracture was found over the right frontal region extending from midline up to right temporal bone, involving the right side of frontal bone, right sphenoid and right temporal bone. The fractured margins showed infiltration of blood in their bony trabeculae. (Fig:2)
3. Multiple split lacerated wounds about 5 in numbers of sizes varying from 0.3cm X 0.3cm to 2.5cm X 0.5cm which were bone deep, present over an area of 9cm X 4cm, extending from the medial end of left eyebrow to lateral end of right eyebrow. The margins of wound were irregular. On dissection, underlying soft tissues and muscles were found ecchymosed, right eye ball was deformed and partially depressed into the anterior cranial fossa. On further dissection, a comminuted fracture was found involving the orbit and anterior cranial fossa. The fractured margins showed infiltration of blood in their bony trabeculae.
4. An obliquely placed split laceration of size 9cm X 2cm which was cavity deep was present over nose, extending from 1.5cm below medial canthus of right eye to upper lip, 3 cm lateral to midline. The margins of the wound were irregular and underlying soft tissue and cartilage were found ecchymosed. On exploration of the wound, nasal bone was found fractured (Fig:5).
5. An obliquely placed split laceration was present over chin, measuring 5cm X 1cm which was bone

deep, situated 3cm below to lower lip. Margins of the wound were irregular. On dissection, underlying soft tissues and muscles were found ecchymosed (**Fig:5**).

6. Four reddish contused abrasions with sizes varying from 2cm X 0.5cm to 5cm X 0.5cm were present over posterior aspect of right wrist (**Fig:6**).
7. Multiple reddish contused abrasions about 20 to 25 in no. with sizes varying from 1cm X 0.5cm to 5cm X 1.5cm were present over an area of 27cm X 15cm over mid and lower back. On opening the thoracic cavity, posterior wall of right-side chest region was found contused with collection of about 300ml of blood in pleural cavity.

Fig 1: Dead body smudged with blood, sand and stone aside the left hand.



Fig 2: Multiple slit lacerated wounds over right frontoparietal region of skull.



4. Discussion

A murder may be committed due to several reasons and by several methods. This case focuses on not only the method of murder but also on the

manner of concealment of the crime. The motive in such cases is predominantly to escape conviction. In the above-described case report, the injuries described were not corresponding to the animal attack with lack of bite marks over the body.

Fig 3: Showing oval shaped fracture over right parietal region

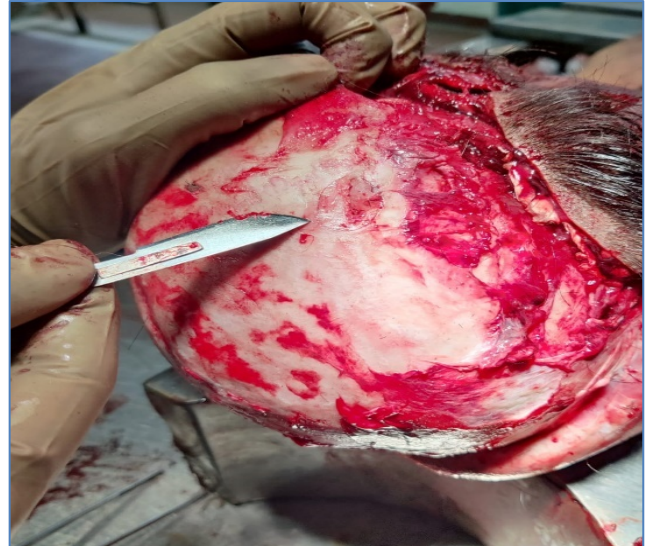


Fig 4: Showing fragment of stone embedded in right parietal region.



All the described injuries were mostly over the face, the perpetrator tried to concealed the identity of the deceased. A small fragment of stone was embedded into the outer table of skull which indicate the direct hit of stone over the skull to kill the deceased. A goat was also murdered near to the body to frame the crime scene as animal attack just to save from conviction for the crime.

Similar cases related to the unusual disposal of the dead body have been evidenced and documented in the past.

Fig 5: Showing multiple lacerated wounds over face.**Fig 6: Showing defence wounds over extensor surface of right hand.**

A young couple went to the market to buy a steel trunk to dispose of old religious items and since that date, the wife did not return home. Her husband on the evening of that date lodged a missing complaint. During the investigation police suspected some foul play on basis of call detail records of her husband and an unknown female. Police traced the unknown female and searched her house and found a steel trunk around which foul smell was noticed by them. On opening the trunk, a decomposed body of a female was recovered and on interrogation the female revealed the minutes of the case. It was the same steel trunk which was bought by the couple, on the same day she was murdered by her husband along with that female.³

Another case of concealment with animal attack was noticed in chena at a remote area of Ampara, Sri Lanka. A 36-year-old male attached to the Civil Security Défense Force was found dead in a hut. He was in a supine position in a pool of blood and a

locally made muzzle-loading shotgun lay on his left side. There was an extensive ripped injury on the left side of the face. There were multiple footprints stained with the dried blood of an adult human on either side of the body but no blood was seen on the soles of the deceased. There was a scrawl on the cement floor written with wood charcoal, stating that he was attacked by three bears in the jungle, fought and escaped with injuries and decided to commit suicide. CT scan was done before the autopsy. The pattern of metal pieces and pathway of pneumocephalus indicated that the direction of firing was from top of the head to the left side.⁵ Another case was proven where the victim's body was left in a sack loaded with vegetables and shipped from the wrongdoing site and tracked down deserted in a recreation area. Post Mortem Examination showed that it was a sexually motivated homicide combined the perpetrator's obliteration of his victim's identity along with his attempt at concealment of the corpse.⁶

Unusual patterns of injuries can indeed complicate the determination of the manner of death. In cases where the injuries are atypical or don't align neatly with common patterns of trauma, it becomes challenging for forensic experts to offer definitive opinions.⁷ It's crucial to approach all evidence, including Crime scene investigation, the deceased's medical history and findings from autopsies and toxicological analyses, with a critical mindset. This scepticism helps ensure that conclusions about the manner of death—whether it's natural, accidental, suicidal, or homicidal—are based on a thorough and unbiased evaluation of all available information.^{7,8,9,10,11,12}

5. Conclusion

In this case, thorough scene examination, careful evaluation of the pattern of injuries, and sufficient ancillary investigations revealed that the circumstances of death favour human attack over animal attack. The doctor's post-mortem examination may be more accurate if he or she has adequate knowledge of the potential method of modification.

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